CSC 402
Requirements Engineering

Fall Quarter, 2005

Clark S. Turner

Administration

- Instructor
  - Clark S. Turner
- Required Books
  - Wiegers, Software Requirements
  - Jackson, Software Requirements and Specifications
  - Yourdon, Death March
- Other References
  - Gause and Weinberg, Software Requirements
  - Weinberg, The Psychology of Computer Programming

- Office: 14-211
  - phone (805) 756 6133
  - Hours (tentative):
    - € Monday 1:10 pm - 3 pm
    - € Friday 12:10 pm- 3 pm
- Prerequisites
  - permission of instructor
    - € 205, 206, 305 (recommended!)
- Course website at:
  - www.csc.calpoly.edu/~csturner
  - course details and lecture slides
    - € updates mayl be weekly

Basic Overview of the Course

- We're going to elicit requirements
  - from a "rea"l customer: Trimble
    - € anyone in here experienced with GPS?
    - € the project involves customer interface with proprietary boards
      - some closed source
      - IP issues: expect an agreement and NDA's
        - we will have to be security conscious
        - we are at the edge of a real project - "proof of concept" prototype at the least
        - teams each need to initiate an agreement between members
- We'll form 5 teams (of 5 or 6 people)
  - with a manager, and other job titles
    - € all responsible for the work products (evaluations of personal effort)
- The course is about process and product:
  - our final deliverable is a Requirements Specification (to give to 405)
    - € we also plan a basic architecture

Basics (continued)

- This course requires personal responsibility
- This course requires teamwork, interpersonal skills
- This course requires clear, concise, precise writing
- There will be a steady workload
  - your process will determine the amount of pain :-)
    - DO read Yourdon “Death March” cover to cover (early!)
- It is a real project with real customers
  - and all that entails: the customers do NOT know all the answers
    - neither will I
  - we’re all in this together, ideally for the coming 3 terms
- We expect to be flexible but to create some working product

Basics (continued)

- Evaluation will be wholistic, based on a large picture
  - quality of deliverables
  - presentations and reviews
  - team performance
    - self evaluation and team evaluation of each member's performance
    - team dynamics are very, very important
  - homework
  - final exam
  - final team interview with instructor
- I expect to give "A's" but it will take serious committment

How to Use a Textbook

- Look at front and back covers
- Read Preface, Intro
- Review TOC, and look for glossary and index
- Ask questions
  - what is the pedigree of the author?
  - why did the author write this book?
  - why did the instructor choose this book?
  - what can I actually expect to get from this book?

My Background

- Mathematics - pure theory
- Law - contracts
- Requirements analysis at UC Irvine
  - worked on TCAS for FAA
  - worked on Therac-25 case with FDA
  - dissertation says that you can't objectively tell the difference between design and implementation for code
    - € continuing work in the area of software code defects involved in personal injury:
      - failure to satisfy specifications
      - specifications that take unreasonable risks with human lives

The Basic Definition of our Work

- Software Engineering is...
  - the study of software process, software development principles, methods and tools
    - € requirements elicitation and analysis
    - € requirements and design notations
    - € implementation strategies
    - € testing methods
    - € maintenance techniques
    - € management strategies
  - the production of *quality software*, delivered *on-time*, within *budget*, and *satisfying users' needs*

Find other definitions of "software engineering"

What is a "Program" (only one of the objects of Software Engineering…)

- A static description of a dynamic process to be instantiated in the future (Turner)
  - how strange is that?

Why This Course Though?

- IMPORTANT PRINCIPLE: you can't solve a problem unless you know what the problem is…
  - When stating solutions, be clear about the problem that is solved
- Why CSC 402? (why software engineering? … why anything …
  - what is the problem that needs a solution?
  - how do we attempt to solve the problem?
  - what are the benefits in concrete terms?
  - what are the limitations of the approach?

The problem and the response...

- Software is typically
  - late
  - over budget
  - faulty
  - hence... the “software crisis”
    - € go see the “Chaos Report” referenced on my website
- Software Engineering
  - software production should use established engineering principles
  - history: coined in 1967 and endorsed by a NATO conference in 1968

What type of software?

- Small single-developer projects can typically get by without Software Engineering
  - typically no deadlines, small budget (freeware), not safety-critical
- Software Engineering is required for
  - large projects (100,000 lines of code and up)
  - multiple subsystems
  - teams of developers (often geographically dispersed)
  - safety-critical systems (software that can kill people...)

Software Engineering is still young

- Traditional engineering disciplines have been around for hundreds, if not thousands, of years
- Software Engineering still needs
  - standard definitions that make sense (check the IEEE definition of "requirement" - I might fail you for writing that!)
  - standard specification and design techniques
  - formal analysis tools
  - established processes
- Currently experimenting in
  - techniques, notations, metrics, processes, architecture, etc.
  - some success has been reported
    - € and occasionally overreported (See Watts Humphrey's work?)
  - a foundation is being formed...

What is Engineering?

- Engineering is
  - sequence of well-defined, precisely-stated, sound steps, which follow method or apply technique based on some combination of
    - € theoretical results derived from a formal model
    - € empirical adjustments for un-modeled phenomenon
    - € rules of thumb based on experience
- This definition is independent of purpose ...
  - "engineering" can be applied to many disciplines
    - € however, does software have the formal models, rules of thumb...?
- Are software "engineers" employees or professionals?
  - are we independent in our employ?
    - € do we have obligations to society?
      - go look at the Software Engineering Code of Ethics (ref on my website)

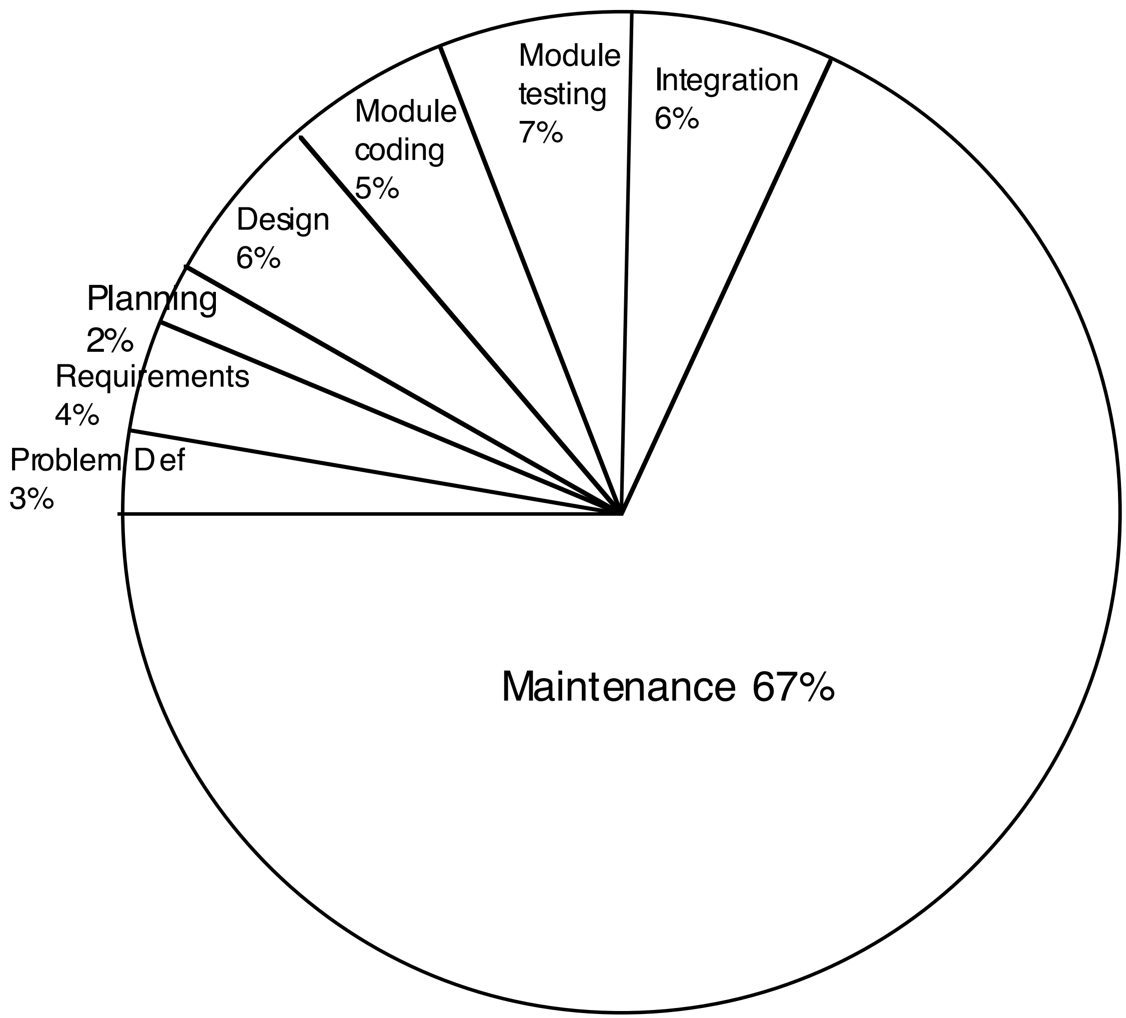
Software Engineers require ...

- a broad range of skills
  - Mathematics
  - Computer Science
  - Economics
  - Management
  - Psychology
- applied to all phases of software production

Software economics...

- Software Production = development + maintenance
  - maintenance accounts for approximately 67% of the overall costs during the lifecycle of a software product (Boehm)
    - € faster development is not always a good thing
      - may result in software that is difficult to maintain
      - resulting in higher long-term costs
    - € any of you familiar with Xtreme programming or JIT methods?

Lifecycle Costs (Schach data from Boehm)



What was that?

- Can you interpret the pie chart and explain it?
  - what ***should*** the chart look like?
    - € what do we know about software projects in general?
- One researcher claims we'll avoid maintenance costs by buying new software more frequently
  - we'll avoid the "rare errors" in the short run
    - € he's in the safety-critical domain!
- What is "maintenance" anyway? Is this part of the problem we're looking at?
  - was it a requirements failure or a change due to a new understanding of the problem…..

Maintenance Data

- All products undergo maintenance to account for *change* ...
- Three major types of maintenance
  - Perfective (60.5%)
    - € Changes to improve the software product
      - an interesting figure!
        - why is this so high???
  - Adaptive (18 %)
    - € Responding to changes in a product’s environment
  - Corrective (17.5 %)
    - € Fixing bugs...

“Real world” is constantly changing

Maintenance is a necessity

Requirements and Design Aspects

- User needs and perceptions are difficult (impossible?) to assess
  - functionality isn't enough
- Requirements specification is a contract with the customer
- Requirements must provide a definitive basis for testing
- Requirements is about the problem domain (Jackson)
- Design suggests a solution in the software domain

Requirements addresses the problem domain only

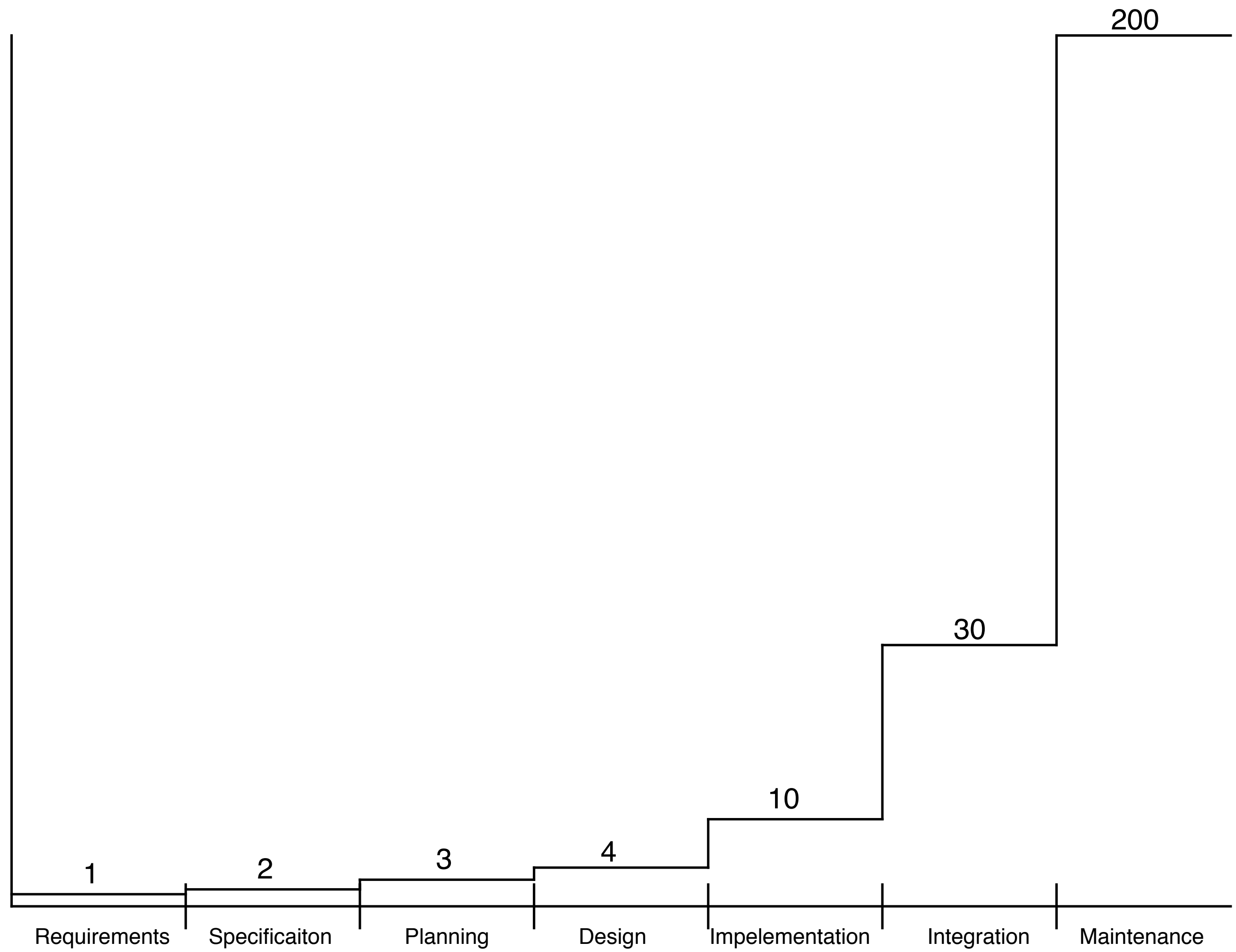
Design addresses the programming solution

Verification and Validation Aspects

- The longer a “fault” exists in software
  - the more costly it is to detect and correct
  - the less likely it is to be fixed correctly
    - € e.g. fixing it “breaks” something else!
      - BUT, think about this one! See Beizer, “Software IS Different” QW 1996
- 60-70 % of all faults detected in large-scale software products are introduced in its specification and design
  - data regarding “requirements” defects shows LOTS of problems start there.
- Thus...faults should be found early (or prevented!)
  - requires specification and design V&V
  - validate first description and verify each phase with respect to previous
  - evaluate testability and develop test plans at each phase

Verification and validation must permeate the software lifecycle

Relative cost of fixing a fault (Boehm data)



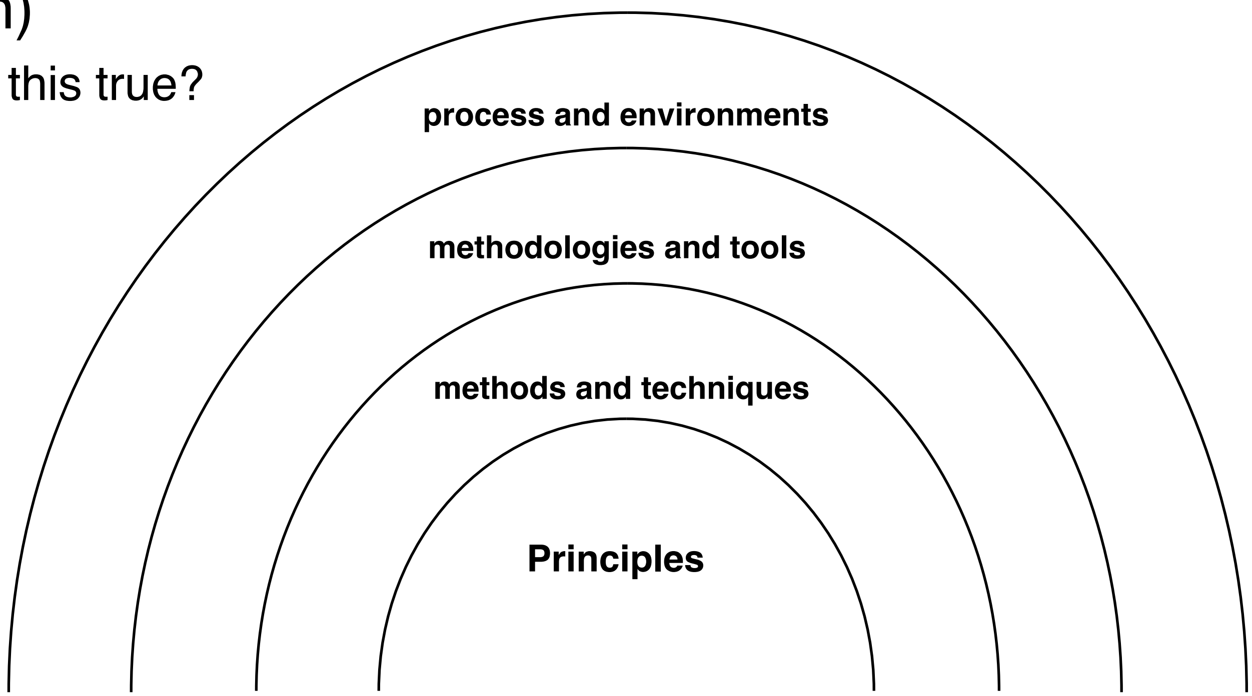
Team Programming Aspects

- Reduced hardware costs afford hardware that can run large and complex software systems – products too complex for an individual to develop
- Most software is produced by a team of software engineers, not an individual
  - Team programming leads to interface problem between components and communications problems between members
  - Team programming requires good team organization to avoid excessive communication (a nontrivial problem)
  - Teams may be distributed geographically and temporally (even in this class)

Team programming introduces real communication overhead

Software Engineering Principles

- Deal with both *process and product* (big issues here!)
- Applicable throughout the lifecycle
- Need abstract descriptions of desirable properties
- Same principles as other engineering disciplines (witness Leveson)
  - € is this true?



Rigor and Formality

- Rigor is a necessary complement to creativity
  - enhances understandability, improves reliability, facilitates assessment, controls cost
- Formality is the highest degree of rigor
- Engineering = sequence of well-defined, precisely-stated, sound steps, which follow method or apply technique based on some combination of
  - theoretical results derived from formal model
  - empirical adjustments for un-modeled phenomenon
  - rules of thumb based on experience

Separation of Concerns

- Enables mastering of inherent complexity
- Allows concentration on individual aspects
  - product features: functions, reliability, efficiency, environment, user interface, etc.
  - process features: development environment, team organization, scheduling, methods,
  - economics and management
- Concerns may be separated by
  - time (process sequence)
  - qualities (e.g., correctness vs. performance)
  - views to be analyzed separately (data vs. control)
  - components
- Leads to separation of responsibility
- Sometimes an intuitive exercise to separate concerns

Modularity and Decomposition

- Complex system divided into modules
- Modular decomposition allows separation of concerns in two phases

bottom-up ↓ **aspects of modules in isolation** ↑ top-down
overall characteristics of integrated system

- Modularity manages complexity, fosters reusability, and enhances understandability
  - composibility vs. decomposibility
  - high cohesion and low coupling quality metrics
    - € for great discussion see Perrow, “Normal Accidents”

Abstraction

- Identify important aspects and ignore details
- Abstraction depends on the purpose or view
- Models are abstractions of reality
  - what does this really mean?
- Abstraction permeates software development
  - from requirements to code
  - from natural language descriptions to mathematical models
  - from products to process
- One specification but many realizations

Anticipation of Change

- Constant change is inevitable in large software systems
  - software repair & error elimination
  - evolution of the application (users get a new view via the app)
  - evolution of the social order (business and legal requirements)
- Identify likely changes and plan for change
  - software requirements usually not entirely understood
  - users and environments change
  - also affects management of software process
- Maintenance is process of error correction and modification to reflect changing requirements
  - regression testing with maintenance
  - configuration management of versions
- Is this one of the distinctions from other standard Engineering disciplines?

Generality

- Focus on discovering more general problem than the one at hand
  - fosters potential reuse
  - facilitates identification of OTS solution
- Trade-offs between initial costs vs. reuse savings
- General-purpose, OTS products are general trend in application domains
  - standard solutions to common problems
  - how far can this be taken?

Incrementality

- Step-wise process with successively closer approximations to desired goal
- Identify and “deliver” early subsets to gain early feedback
  - fosters controlled evolution
- Incremental concentration on required qualities
- Intermediate deliverables may be prototypes
- Requires careful configuration management and documentation

Sample Software Qualities

- Correctness
- Reliability
- Robustness
- Performance
- Usability
- Testability
- *What the heck do these terms mean?*
  - what are the relationships between these qualities?
  - what about safety? Is this a property of software itself?
    - € Is it subsumed under “reliability”???
      - See Leveson, Safeware

Uniqueness of Software

- What are we dealing with?
  - The stuff doesn't "wear out" (but does exhibit a bathtub curve …)
  - The stuff has no "tolerance" - it is binary
  - The stuff weighs nothing, and you can't really "see" it.
  - It is very plastic, we can always "change" it in place
    - € try that with your automobile!
- Why don't other engineering principles apply?
  - For example, statistical reliability methods?
    - € No mean value theorem applies
    - € No accurate user profile or operational distribution
  - So, when we test, what do we find out about software?
    - € Can't tell for sure if our software is good or not.

Get Your Own Definitions

- Requirement
- Engineering
  - including the purpose for it!
- Process
  - See Osterweil's "Software Processes are Software Too"
- Tools
- Methods
- Design
- Function
  - distinguish "feature"

Readings

- Wiegers, Part 1 (Ch 1 - 4 inclusive)
- Read Jackson on “Machines” and “Descriptions”
- Look over Yourdon, “Death March”

Written Homework

- Create your resume for this course today in lab:
  - experience, relevant classes (gpa?), other relevant facts, email
    - € you'll be "hired" on the basis of this resume. Make it 1 page please
  - management candidates: I will choose managers
    - € we'll need 5 or maybe 6 managers for as many teams

Journal Creation

- Begin your Journal in good quality loose-leaf notebook so that you can use dividers
  - Keep space (by divider or a separate journal) for your team notes, copies of assignments, documents, sketches, and other things relevant to the project.

- I recommend that you begin with working definitions, one per page, with room to refine as the project progresses:
  - € Software Engineering
  - € Engineering (find one that emphasizes the social aspects!)
  - € Requirement
  - € Design (to distinguish the two!)
  - € Tools
    - analytical, software
  - € Process
    - (go find Osterweil's "Software Processes are Software Too!" article and look it over at some point.)
  - € Abstraction
  - € Function (versus "feature")

Journal (cont'd)

    - € Constraint
    - € Attribute
    - € Preference
    - € Expectation
    - € Geek
- Note that the journal should be brought to each class and lab.
  - purpose - record your engineering experience
  - document your work and progress
  - record references for use later
  - prove to instructor that you're not a slacker
  - "play with" ideas (even bad ones…)
- Most every document, note and idea for the project must appear in the journal
  - please organize it well
    - € I need to be able to see how good it is in order to give you the grade you deserve!

Teams (we'll form this or next class)

- Plan a social activity over the weekend
- Make a report, oral and summary in writing, for next week: Monday during lab
- Produce a document due on Monday in class:
  - Cover sheet for my folder containing your team documents and notes
    - € what do I need to know?
      - your team structure, member names, contact information
      - team name on front, motto, other relevant information
      - done professionally, make it "useful" to me as a manager of teams