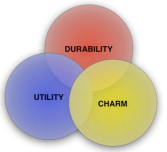
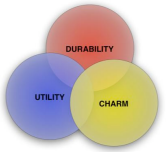


Class 2 CIS 573

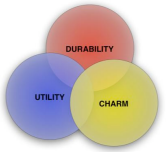
Gregg Vesonder
University of Pennsylvania
Penn Engineering - Computer & Information Science

Penn CIS



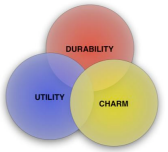
Roadmap

- Onward with lecture 1
- Requirements elicitation and representation
- Software project estimation
- Risk management
- Case study
- Readings:
  - S chapters 5-8, 26, Brooks chapters 2 & 8
  - next session: S chapters 11, Brooks chapters 5 & 6



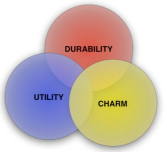
Critical Dates

- Every class project review
- July 23rd Mid Term
- August 6th log books due
- August 11th project presentations
- August 13th Final



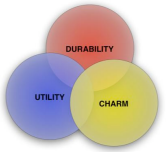
Teams?

- Team 1 – Klein Keane, Beck, Buchman, Richardson, Nunez
- Team 2- Wilmarth, Caputo, Xiang, Francis, Nanda?
- Team 3- Noronha, Fang, Treatman, Han, Huang
- Team 4-Whitehead, Liu, Chang, Ratnakar



Log Book

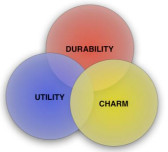
- Stone Soup
- Your turn?



Differences

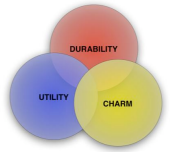
- TSP has detailed process control, quality and performance metrics
- TSP has large number of scripts, forms roles and exit criteria
- TSP has established reports for tasks and phases and keeps history of activity
- TSP formal/contractual relationship with customer

- XP metrics are product oriented estimating progress and future iterations -- performance and quality responsibility of pairs
- Few guidelines and strict practices
- XP reporting informal and has historian but rather than activity focus it is a post mortem focus (newspaper vs analysis)
- XP collocated, collegial relationship with customer



Project Management

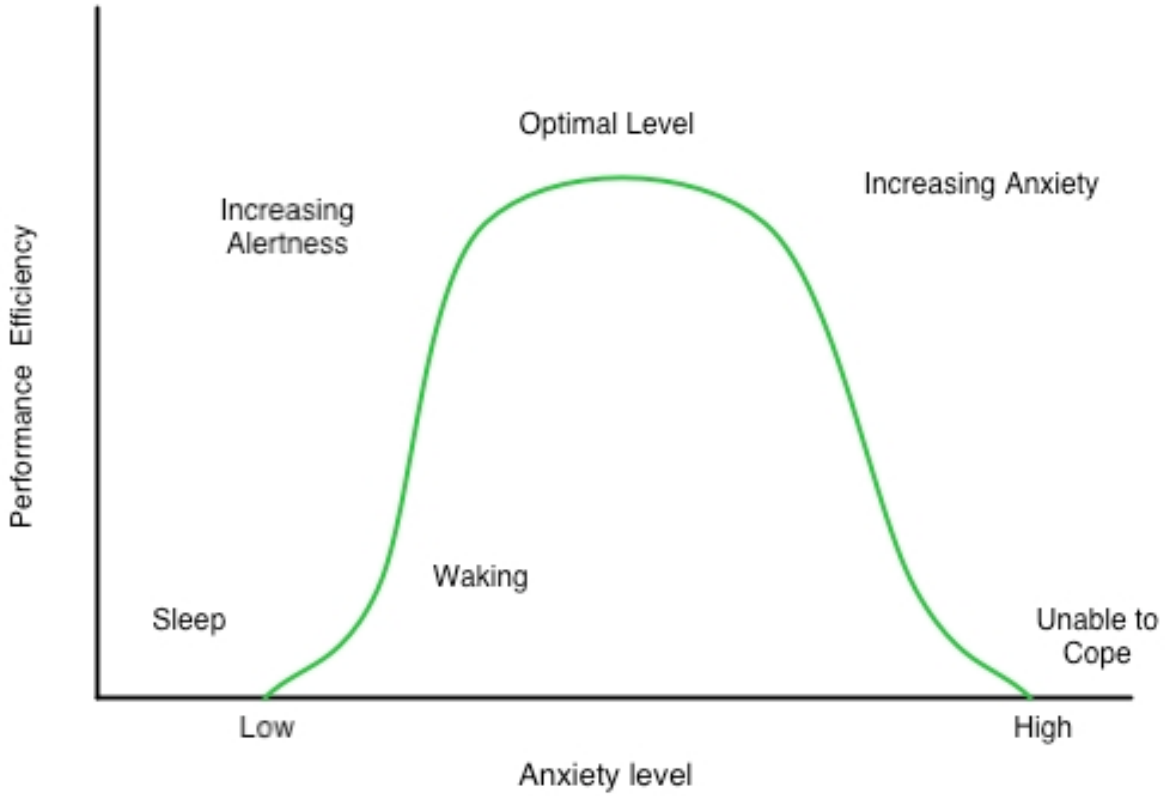
- Focus on the team
- Motivation?
- Communication
- Management heuristics and wisdom

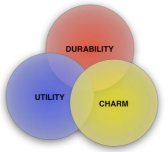


Why? (Brooks)

- Making things
- Making things useful to others
- Joys of grappling with complexity
- Always learning
- Mind stuff
- (some downside: perfection, control, debugging)
- Applies to most systems, not just large systems, especially today since we are building "large" systems with small teams
- Tracy Kidder, Soul of a New Machine, Pulitzer Prize

Yerkes Dodson

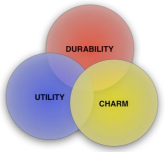




IT IS ALL ABOUT PEOPLE!

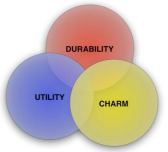
Hardware follows Moore's Law human's often do not.

-Moore's law is the empirical observation that at our rate of technological development, the complexity of an integrated circuit, with respect to minimum component cost will double in about 24 months - Wikipedia



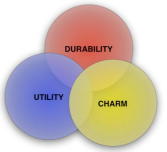
Project Planning and Control

- Control is THE KEY for the lead manager
- Requires clearly defined Roles and Responsibilities
- Must be able to measure the progress of the product and the quality and requirements covered in the product
- Communication
- Documentation



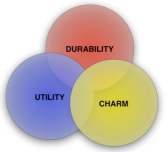
Why did the Tower of Babel Fall?

- Babel had all the prerequisites for success:
  - Clear mission
  - Adequate manpower
  - Adequate materials
  - Lots of time
  - Appropriate technology
- BUT lacked communication and organization
- How should teams communicate? In as many ways as possible! Informal, regular meetings (group and project) and project work book



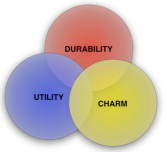
The Project Workbook

- (easier with the web and wiki's http://www.wiki.org)
- Structure is imposed on documents that all documents use
- Control material (number it) but make it available to entire team
- A change summary should highlight what is new



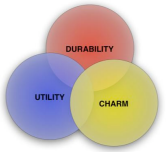
All Projects Should

- Use a Development Plan Approach (write and follow):
  - What will you do? Project Description
  - How will you do it? Process, Tools, Techniques, Methods…
  - What do you depend on? Related Projects, Partners, Teams, Systems, Competitors…
  - When will you be done? Schedule
  - Who will do what? Roles and Responsibilities
  - What will you measure, how will you use it? Metrics



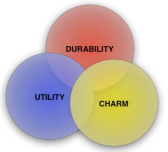
Wiki

- A web site on which anyone can contribute pages, a wiki page also can be edited by anyone
- Produced by collaborative software called wiki
- WikiWiki comes from Hawaiian meaning quick or superfast
- Wiki pages have very simple markup and can be edited in web pages
- Links are created using a link pattern initially CamelCase (e.g.TableOfContents)
- Software available on web - google WikiWikiWeb, the 1st wiki.



Chapter 10, The Documentary Hypothesis

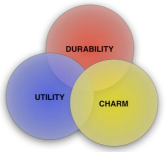
- In praise of certain aspects of bureaucracy
- Engineering manager as a flywheel absorbing energy from market and management aka "air cover"
- Documents for a software project:
  - What1? - goals, constraints priorities
  - What2? - product specification, starts as a proposal, ends as a manual and internal documentation
  - When? - Schedule
  - How Much? - Budget
  - Where? - Space allocation (a killer)
  - Who? - organization chart



Conway's Law

- Organizations must be flexible
- Manager's task - develop a plan and realize it
- Formal Documentation helps:
  - Writing clarifies for all
  - Communicates decisions to others, lightens load for manager whose job is communication

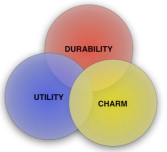
Organizations which design systems are constrained to produce systems which are copies of the communication structure of these organizations.



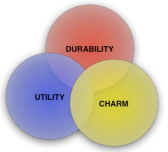
The Organization

- Tree like structure of organization
- The producer and the technical/director-architect
  - Producer: assembles team, divides work and establishes schedules
  - Tech/director architect is surgeon - the job worst done by management is to use technical genius not strong on management talent
- Small projects, same person
- Larger projects separate. Producer as boss, Director as right hand man - large projects
  - Establishing director's authority is difficult - symbols / dual ladder
- Director boss, producer right hand man - Brooks okay for small teams - "inhomogeneity of technical understanding" issue

Penn CIS



3 Little Bears and Documentation



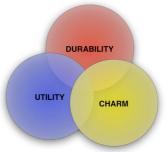
Brooks 14
Hatching a Catastrophe

"None love the bearer of bad news"

"How does a project get to be a year late?"

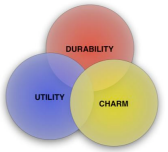
"… one day at a time"

- Most software disaster are due to "termites" not "tornadoes"
- Major calamities are easier to handle
- But snow, jury duty, illness, late hardware delivery, …



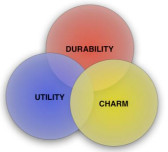
Brooks -14

- Control
  - Have a schedule - I force it!
  - List events, milestones as concrete, specific, unambiguous, measurable events and are "100%" events
  - Chronic schedule slippage is a morale killer at all levels
  - Hustle provides the cushion
  - Get excited about one day slips
  - Critical event/path charts are useful, all tasks and events are not equal
- Every manager needs 2 kinds of information:
  - Exceptions to plan requiring action
  - Status picture for education



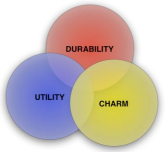
Micro and Macro Software Engineering

- Micro - deals with the individual software engineer or small team.
  - Agile methodology, much more
- Macro deals with team structure, organization structure, industry structure
  - Much of what we discussed today



Software Engineering Certification/Licensing

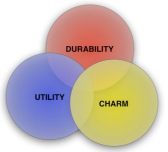
- Always a topic that causes debate
  - Certification is a voluntary process administered by a profession
  - Licensing is a mandatory process administered by a government authority - state level in US
- Y2K problem in 90's stimulated the debate
- Texas has licensing



Most Engineers are not Licensed

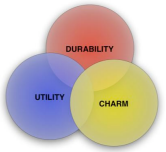
- Nancy Mead, "Issues in licensing and certification of software engineers," SEI

Discipline	Licensed
Civil	44%
Mechanical	23%
Electrical	9%
Chemical	8%
All Engineers	18%



Certification/Licensing

- Pros
  - Provide companies a basis for hiring
  - It will happen anyway, we should guide the process (control it)
  - Protect public from harm
  - Regularize the field
  - Force CS departments to teach good engineering practices
  - Awareness of professional and legal responsibilities
- Cons
  - Premature - no accepted body of knowledge
  - Beware of the certification bodies - vested interest (general malaise)
  - Many companies (Microsoft …) are quite competent in knowing what they need, market should certify
  - Issue is decertification - people who do not have degrees - sorry Bill Gates!
  - Licensing (MD) single person does task, teams in software
  - Process takes so long - 10 year old technology

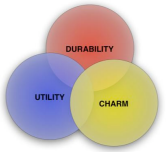


Survey of Computing Professionals in mid '90's

- Value of certification:
  - Very valuable 50.3%
  - Fairly valuable 31.9%
  - Somewhat valuable 16.6%
  - Not valuable 1.2%

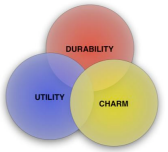
From Mead SEI paper

- Reasons for seeking certification:
  - Advancement in profession 41.7%
  - Advancement in current job 17.2%
  - Prepare for new job 9.4%
- Perceived results of certification - more credibility with organization, 24.2% and customers, 23.6%



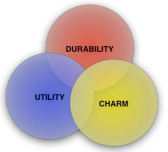
Why I Waver

- Generally against licensing but:
  - Meager prospects for continuing education in an economically squeezed corporate environment
  - Unknown effect of outsourcing on software profession
    - Regulating our suppliers, but then what about us? Especially the "handlers" - issue of education and experience.
  - Lack of a forum for practitioners and theorists on what should be happening
  - Issue of who controls the licensing if it is inevitable
- However it is rough to legislate the above
- And then there is the issue of Professional Unionization



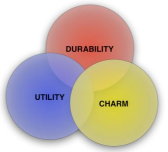
Software Engineering Ethics

- Book describes disasters due to failures in software engineering.
- Software projects are pressure filled
- Software projects rely on relationships and trust
- IEEE Computer Society and ACM have developed a software engineering code of ethics with eight principles
- Think of the roles software plays in your life - health, transportation, finances, …



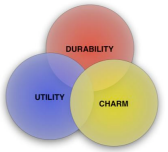
SE Code of Ethics

1. Public - shall act consistently with the public interest
2. Client and employer - shall act in a manner that is in the best interests of their client and employer and that is consistent with the public interest
3. Product - shall ensure that their products and related modifications meet the highest professional standards possible
4. Judgment - shall maintain integrity and independence in their professional judgment
5. Management - shall subscribe to promote an ethical approach to the management of software development and maintenance
6. Profession - shall advance the integrity and reputation of their profession consistent with the public interest
7. Colleagues - shall be fair to and supportive of their colleagues
8. Self - shall participate in lifelong learning regarding the practice of their profession and promote an ethical approach to the practice of the profession



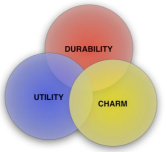
Thought Problems

- You are part of an off shore development organization that has just been assigned a project from a new company in a new domain. There is a 12 hour time difference. What model?
- You are part of NASA's program for making cost effective interplanetary, multiuse robotics platforms - what CMM level should you chose?



So Far

- Mechanics
- Software Engineering
- Software Process Models
- SEI & CMM
- Project management
- Software Engineering certification and responsibility



Onto

- Requirements elicitation and representation
- Risk management
- Software project estimation

You may recall …

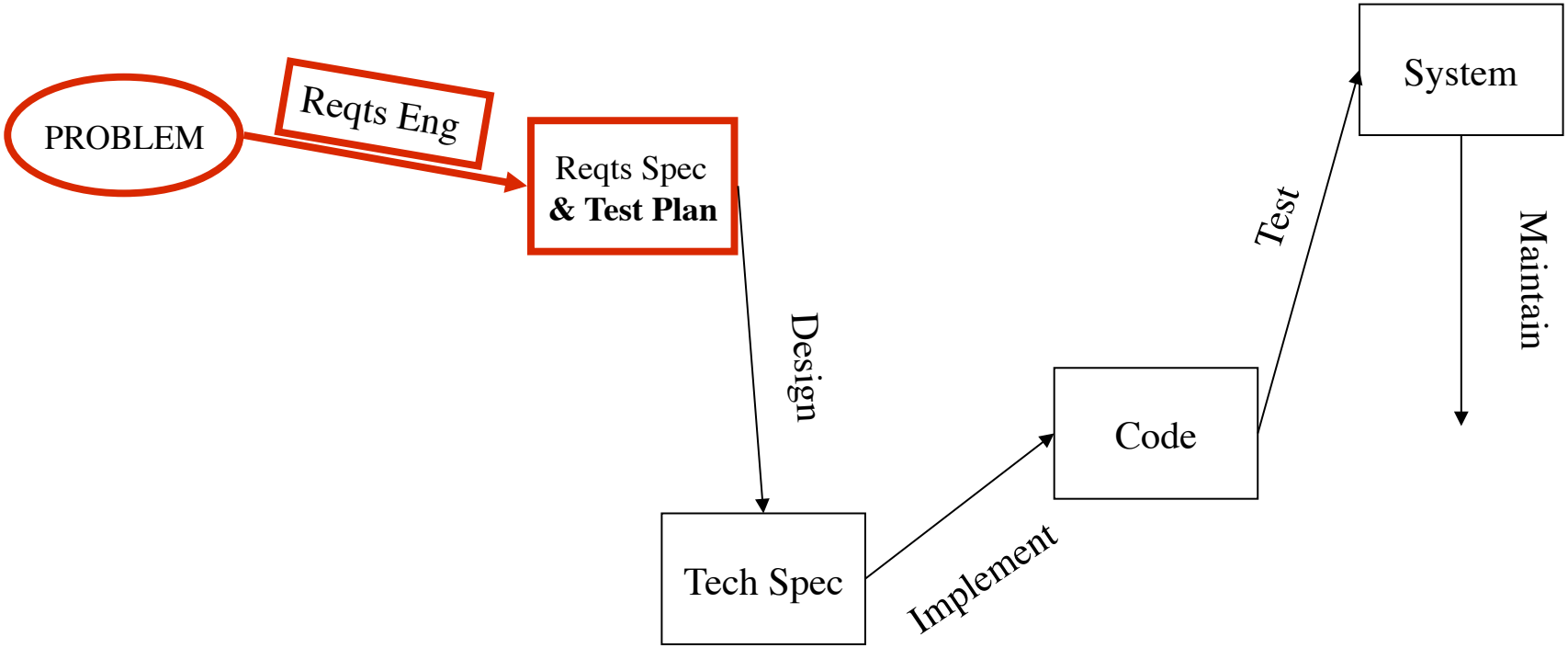
Project Space - van Vliet, p186

	Realization	Allocation	Design	Exploration
Product Certainty	HIGH	HIGH	HIGH	LOW
Process Certainty	HIGH	HIGH	LOW	LOW
Resource Certainty	HIGH	LOW	LOW	LOW

Waterfall

Proto

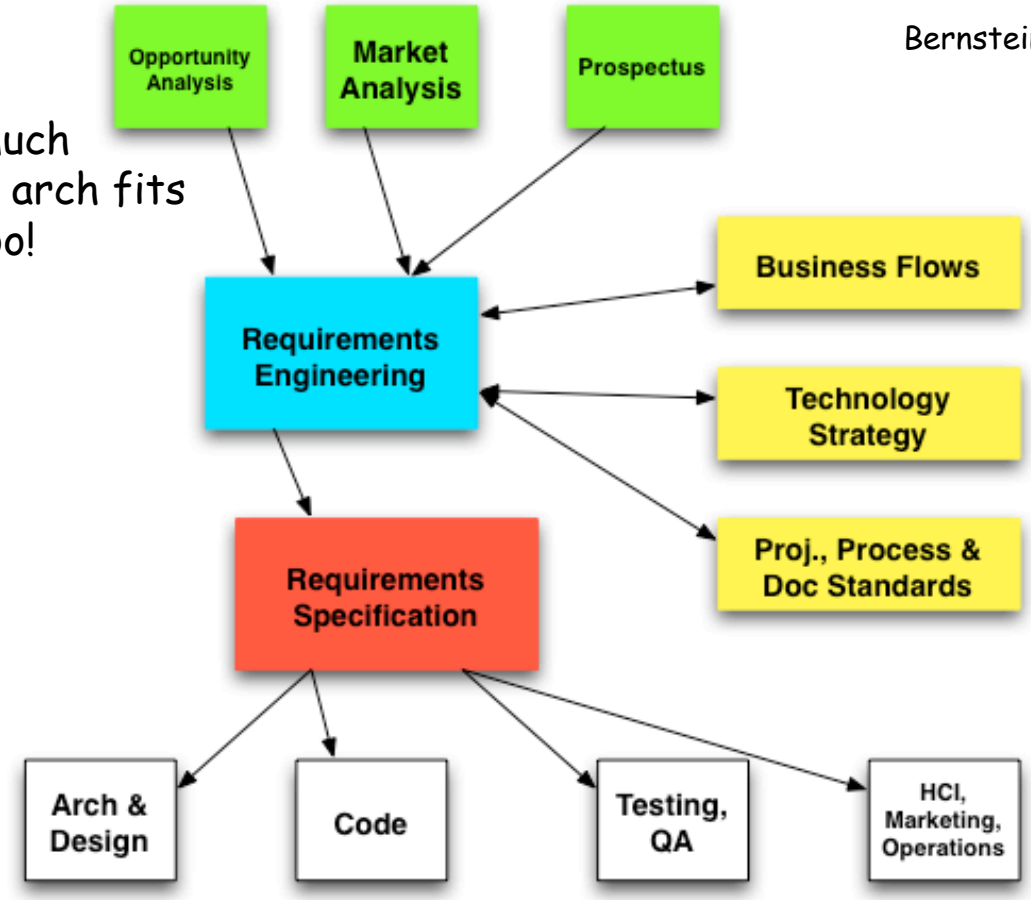
Simplified Model



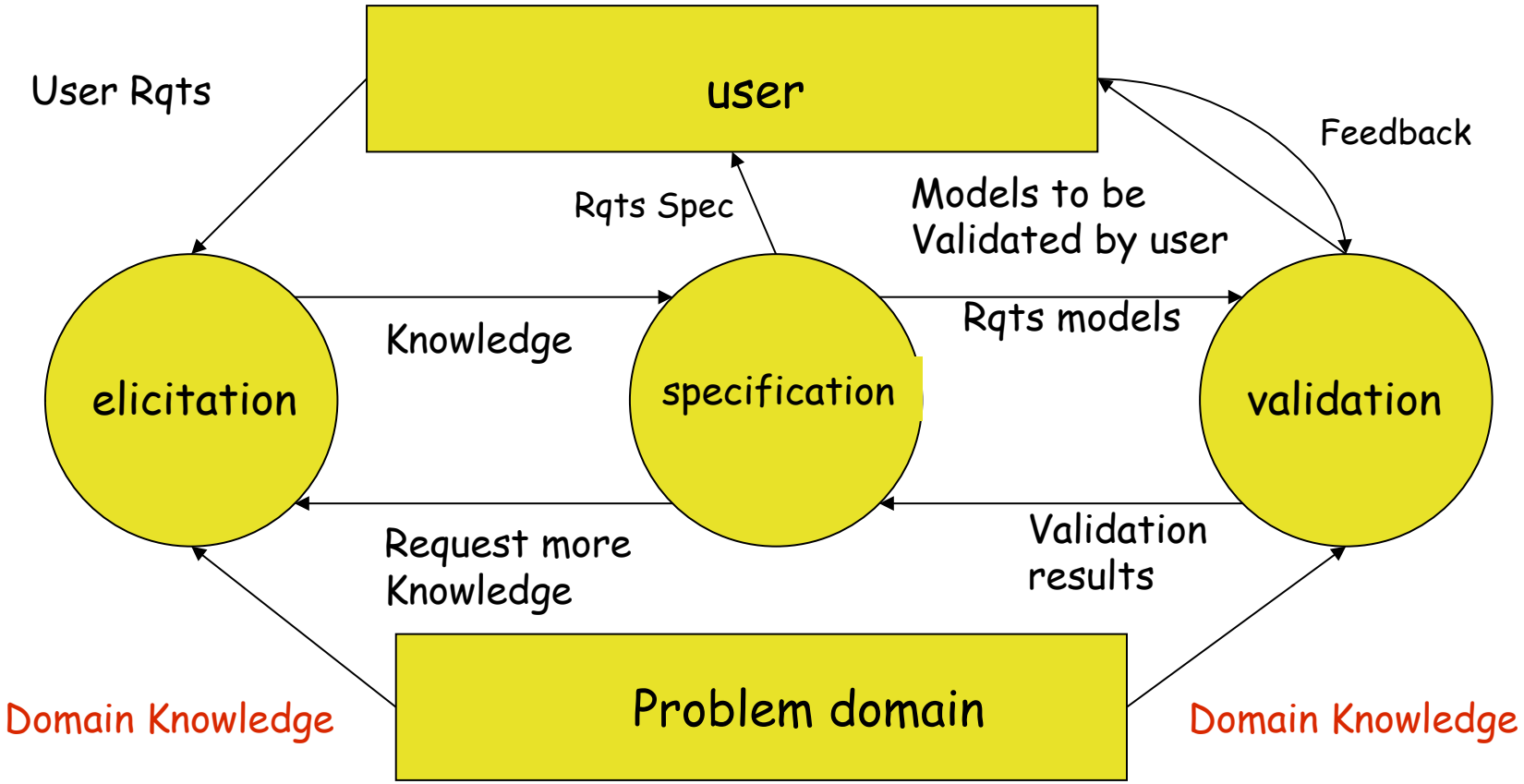
Requirements Engineering

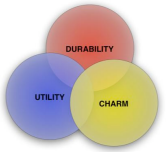
Bernstein & Yuhas, 2005

Just so much involved – arch fits in here too!



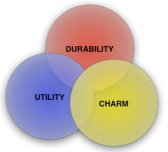
Requirements Engineering (van Vliet, p.209)





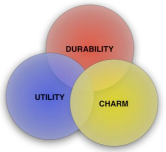
The Requirements Process

- Elicit feature or functional requirements from the user (Boehm -as much as 40% of final features not in requirements specification)
- Understand constraints and non-functional requirements - many are 'ilities
- Analyze the requirements (use cases) to make sure they flow and make sense
- Develop prototype, model or user documentation
- Produce and control a requirements specification



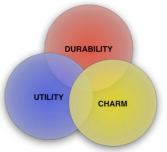
More on Requirements

- Requirements are the what and why but …
  - "… it is an illusion to expect that perfect requirements can be formulated ahead of time" - (Endres & Rombach, p. 15)
  - Outsourced products require careful requirements - key in today's world
  - All stakeholders must participate



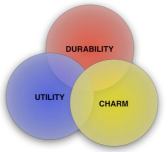
Importance of Requirements

- Glass: "Requirements deficiencies are the prime source of project failures." (Endres & Rombach)
- Some studies:
  - Denver airport baggage handling no longer operational!
  - FAA air traffic control system
- Too many, unstable due to late changes, ambiguous, incomplete
- Boehm: "Errors are most frequent during the requirements and design activities and are more expensive the later they are removed." (E&R) - cost of errors is high the longer they stay in the project.



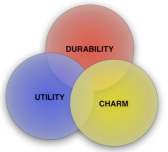
Some Success Points

- Should expend 15-30% of effort on requirements
- Requirements should be assigned priorities
- Traceability should be enforced throughout
- Validation! (and verification before)
- Strong architecture role helps!



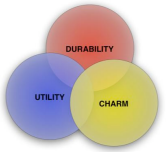
The Requirement Space

- Functional Requirements - what the system should do
- Non Functional Requirements
- Domain Requirements
- User Requirements - understandable by users
- System Requirements
- Interface Specification
- ...
- = Software Requirements



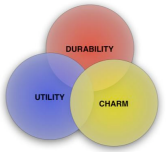
What Can Go Wrong

- Miss or misunderstand a majority of the essential requirements - prototyping and other elicitation techniques are helpful
- Endless requirements - requirements tries to have a cutoff point
- Sales team (or management) interferes and confuses what is desired with what is required
- Spend little time on user interface requirements - what does the user see in the end, eh?



View on Requirements

- How long do you spend? 5%, 10%, 30%
- Let's build it, not talk about it!
  - Move to the left

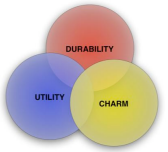


Modeling Framework

- Different communities require different perspectives and provide challenges for requirements:

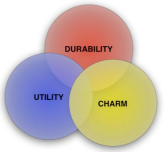
3 Bears!

Business	Description of business aspects- business rules	Customer, management, marketing
Information	Information needed for tasks	Same as business
Functionality	External behavior of system	End users, db admin, general OA&M …
Implementation	Internal functioning of system	Developers,maintenance



Requirements Process (one view)

1. ICED-T analysis: Intuitive, Consistent, Efficient, Durable, Thoughtful
2. Simplified Quality Functional Deployment
3. Compute effort (Function points one way)
4. Estimate staff and development time
5. Revise requirements to meet above (if exceeds cost, time)
6. Redo 1-4
7. Replan with GANTT chart (optional)
8. Review MOV (Measurable Operational Value) to see if it is worth it

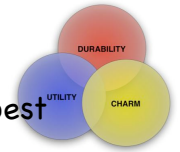


How easy is it to specify MOV?

What genre of MOV do you use?

How easy is it to get stakeholders to agree that this is a measure of worth?

Penn CIS

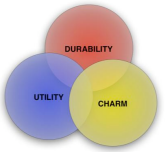


Wideband Delphi, worst to best I have ever seen.

ICED-T

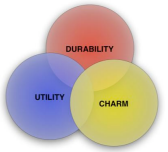
Intuitive	Does (or will) the use of this product make sense?	Quantify, prototype
Consistent	Does (or will) the product operate in a uniform manner?	Prototype, user manual
Efficient	Is the product quick and agile to use?	Models, analysis, prototype (computing and network
Durable	Does the product respond reliably without breaking?	Reliability measures, MTTF, how much damage
Thoughtful	Does the product anticipate user's needs?	Pts to future, possibility to delight, use cases

Penn CIS



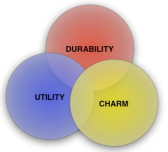
sQFD

- Essentially rate degree of technical difficulty and degree of customer importance
- Easy WinWin
- Wideband Delphi



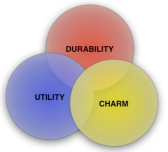
EasyWinWin

- Requirements are a negotiation among parties about "goods." -recurring theme in modern literature
- EasyWinWin builds on this and uses collaborative technology
- Stakeholders use win-win negotiation techniques to collect, elaborate and assign priorities to requirements
- Resolve issues with mutually satisfying and fair agreements



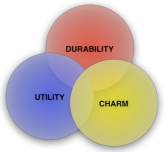
EasyWinWin

- (a common approach we will see this basic technique repeated)
- Review and expand negotiation topics based on a domain taxonomy of software requirements
- Brainstorm stakeholder interests - electronically list their desired
- Converge on win conditions - crisp requirements based on ideas in brainstorming
- Capture glossary of terms
- Assign priorities to win conditions by business importance and ease of realization



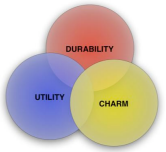
Win Conditions

	Business Importance High	Business Importance Low
Feasibility Easy	Low hanging fruit	Maybe later
Feasibility Difficult	Important with hurdles	Forget them



EasyWinWin - 2

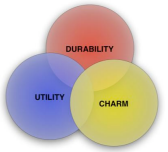
- Reveal issues and constraints - discuss items with low consensus at the last step
- Identify issues and options on the current list (hopefully discussion clarified)
- Negotiate agreements - win conditions w/o issues are declared agreements - negotiate the rest
- COMMUNICATE
- Groupware helps this process



Achieving agreement and consensus. Facts often set you free - the press to collect history and push Quantitative Software Engineering.

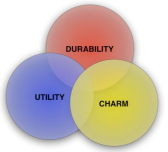
Penn CIS

Drilling Down!



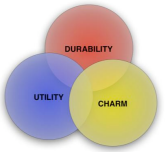
Requirements Elicitation

- Implicit conceptual model of users becomes explicit
- Universe of Discourse (UoD) part of reality we are interested
  - Domain Driven Design - Evans, Ubiquitous Language
- Requires us to become quick learners but
- Much of knowledge is
  - Knowledge taken for granted
  - Tacit-knowledge skillfully applied in the background, not verbalized
  - Involves habits, customs, inconsistencies
  - Influenced by frequency and recency
  - What's needed may be different from what exists



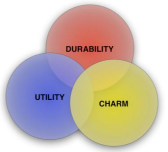
Requirements Elicitation Techniques

- Asking: interview, questionnaire, structured interview, Delphi (group based)
- Task analysis: hierarchical decomposition
- Scenario based analysis: instances of tasks, use-case (not only for OO)
- Ethnography: studying folks in natural setting



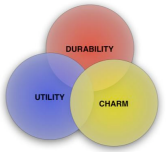
Ethnography

- Discover the way folks actually work
- Discover aspects of cooperation and awareness - information ecology
- Use side by sides, prototyping
- Very important



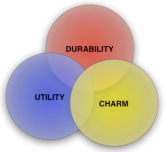
Situated Action and Distributed Cognition

- A simple experiment may not always be diagnostic because:
  - Complex interactions between people, electronic devices and paper resources
  - Physical and social resources are intertwined with use of computer and information technologies
  - Design cannot be separated from patterns of use
  - Users change plans in response to circumstances
- Distributed cognition - knowledge not only in the minds but also distributed in the environment
- Therefore users have to be participants in the design process not just experimental subjects (rigid definition): ethnography, longitudinal studies



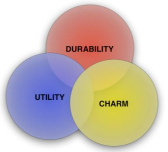
Requirements Elicitation Techniques (cont'd)

- Form analysis: existing forms (may carry over in DTFs)
- Natural language descriptions: training, manuals, …
- Derivation from existing system
- Domain analysis: study existing systems w/ in domain, reusable components



Requirements Elicitation Techniques (cont'd)

- Business Process Redesign - radically redesign the processes, information processing systems should enable
  - At the very least rethink the existing process
- Prototyping
- Usually it is a mixture of these
- PMO/FMO present vs. future method of operation



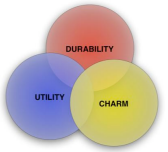
The most important outcome of product definition … a team of stakeholders with enough trust and shared vision …"

Can you build and Succeed w/o great relationships?

Team relations with customers twice as productive as contractual relations (Bernstein & Yuhas, 2005)

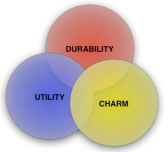
NOT EASY!

COMMUNICATION is the key



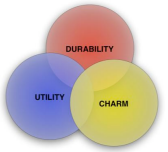
More on Prototyping

- Boehm: "Prototyping (significantly) reduces requirements and design errors, especially for user interfaces." (p 19, Endres & Rombach)
- Types of prototypes:
  - Demonstration prototype - clarifies user requirements, impresses user (GUI)
  - Decision prototype - helps select design alternatives, answers particular questions (design/construction phase)
  - Educational prototype - used to understand technology and its characteristics (performance). Differs from Pilot projects that test a new technology that may or may not be included in the product



Still more on prototyping

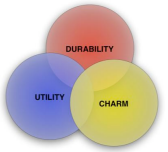
- All three are throwaways - recall from last week that after proto design can begin (and you may use decision protos to help)
- In ENGINEERING most prototypes use different materials that clearly separate it from final proto, e.g. wind tunnel models … only in software are folks tempted



Expert System Process

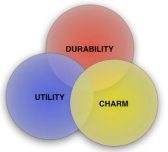
- AKA Knowledge Engineering
  - Knowledge Engineer becomes familiar with domain, architecture and operation
  - KE meets with experts to understand operations and issues
  - Team uses knowledge to create first (and subsequent) passes at rules
  - Experts critique results, provide new knowledge and iterate on previous step until a satisfactory (or best possible) conclusion is achieved

Key to many new Requirements & Design techniques



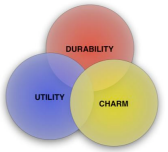
Use Cases - Ivar Jacobson

- Capturing requirements from the user's point of view (and then we adapt) in manageable chunks (OO motivated)
- Actors are entities that reside outside the system and should not be other use cases
- Use case example - "withdraw a book" following normal path and alternate paths
- Need a comprehensive set



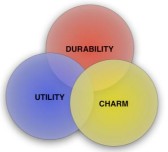
Human Actors (from Wirfs-Brock)

- Who uses the system?
- Who installs the system?
- Who starts up the system?
- Who maintains the system?
- Who shuts down the system?
- Who gets information from the system?
- Who provides information to the system?
- Systems too are actors- use actual system names



Requirements Advice

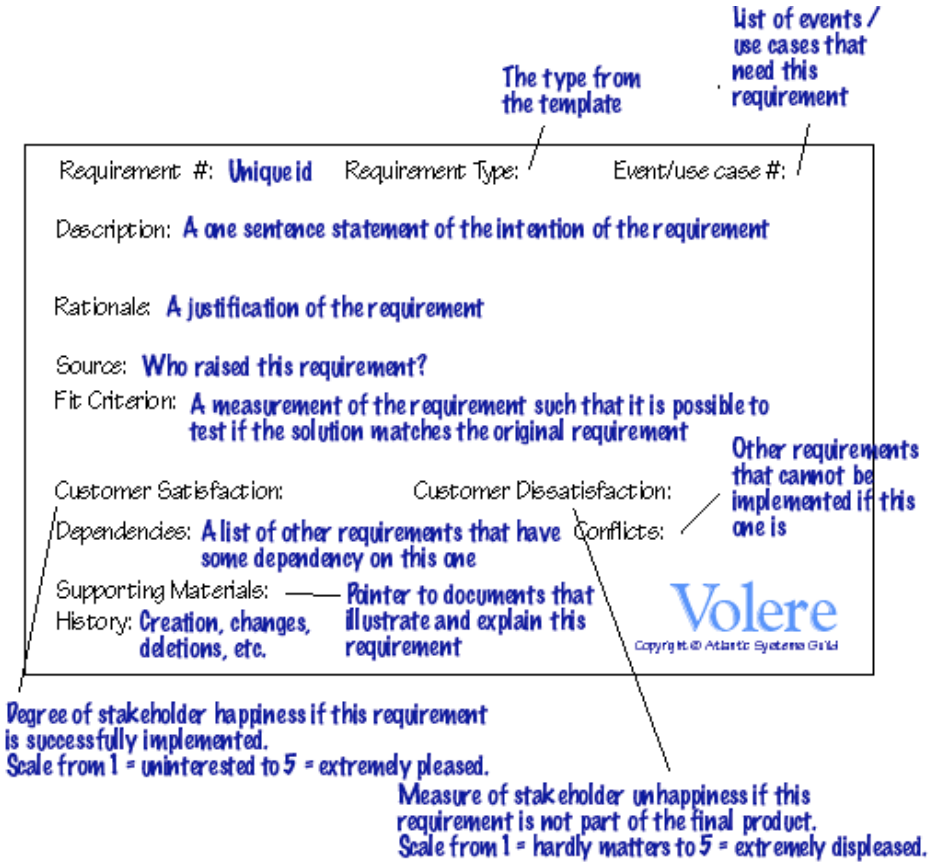
- Invent or borrow a standard format (Volere)
- Use language consistently - glossary
- Highlight key parts of requirements



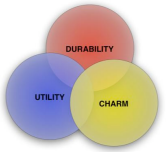
The Requirements Specification

- Key output of the process
- Must be baselined -- it will change and this must be measured
- Requirements spec should be readable, understandable, correct (validated against other docs), complete, internally consistent, ranked for importance or stability, verifiable, modifiable and traceable
- Used even in prototyping to describe outcome
- Serves at least two groups, the user and the designer
- More later since it must be managed

Recording Requirements

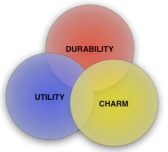


http://www.systemsguild.com/GuildSite/Robs/Template.html



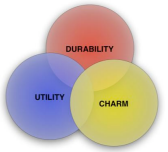
Volere Requirements Specification Contents

- One method, a useful checklist
- Card approach will be seen in several areas
- Focuses on:
  - Product Constraints- restrictions and limitations that apply to project and product
  - Functional Requirements- the functionality of the product
  - Non-Functional Requirements - the product's qualities
  - Product Issues- apply to the project that builds the product



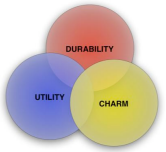
Volere Product Constraints

- Purpose of the product
  - User problem
  - Goals of product
- Client, customer and other stakeholders
  - Client = pays and owns
  - Customer buys
  - Other stakeholders, e.g., management, business SMEs
- Users of the product
  - Users
  - Priorities assigned to users (key, secondary, unimportant) see also what Volere calls stakeholders



Product Constraints (cont'd)

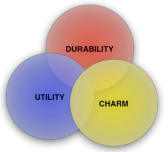
- Requirements constraints
  - Solution constraints –Vista vs. Windows 7
  - Implementation environment
  - Partner applications
  - COTS-commercial off the shelf software (early)
  - Anticipated workplace environment
  - Known deadlines -how long
  - budget
- Naming conventions and definitions
- Relevant facts
- Assumptions



Volere Functional Requirements

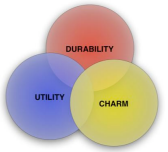
- The scope of the product
  - -context of work, domain knowledge
  - Work partitioning, event list with inputs and outputs
  - Product boundary(users: active, autonomous, cooperative)
- Functional and data requirements
  - Functional - fit criterion (as many place as possible - did I do what I said I'd do)
  - Data (model)

(simple, eh?)



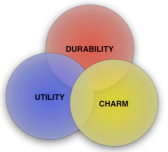
Volere Non-Functional Requirements -"ilities"

- Look and Feel Requirements
- Usability Requirements
  - Ease of use
  - Ease of learning
- Performance Requirements
  - Speed
  - Safety critical (robotics)
  - Precision
  - Reliability and availability
  - Capacity throughput, volume, cpu/memory load



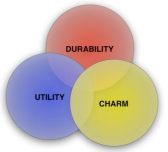
Non Functional (cont'd)

- Operational Requirements
  - Expected physical environment
  - Expected technological environment
  - Partner applications
- Maintainability and Portability Requirements
  - How easy? {how much effort or budget}
  - Special conditions for maintenance
  - portability
- Security Requirements
  - Confidentiality - restricted access
  - File integrity/ system integrity (sync'd)



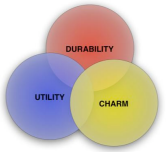
Non Functional (cont'd)

- Cultural and Political Requirements
- Legal Requirements
  - Law pertaining to product
  - Standard compliance



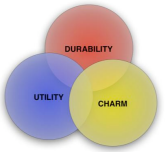
Volere Project Issues

- Open issues
- Off-the-shelf Solutions (early)
  - Existing product
  - Ready made components
  - Copy or model
- New Problems
  - Problems the new system can cause
  - Affect on current systems
  - Users adversely affected by system
  - Limitations in the anticipated environment that inhibit new system
  - Other problems?



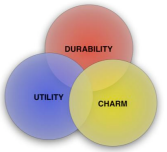
Project Issues (cont'd)

- Tasks
  - Steps to deliver product
  - Development phases {Development Plan}
- Cutover
  - Special requirements to get data and procedures
  - Data modification/translation necessary
- Risks
  - What are they
  - How do you address them



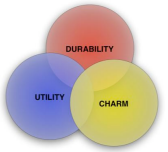
Project Issues (cont'd)

- Costs
- User Documentation
- Waiting Room
- {Worry Beads} - daily, weekly, monthly
- And then there is the inevitable negotiation



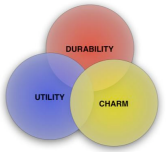
Interface Specification

- Procedural interfaces: APIs, signatures
- Data structures: passed from one subsystem to the other
- Representations of data - e.g., bit packing - the "hidden" information that may change
- Extraordinarily important! Sometimes it waits until (early!) design



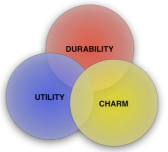
Thought Problems

- You are building a customer care application for a personal computer company with 400 customer care positions in 6 states. The customers can call from around the globe -- what techniques should be used for requirements elicitation and why?
- You are a manager responsible for 2 projects and you have been handed requirements documents for each project, one document is 10 pages long and the other is 200 pages long, what is your approach for V&V?



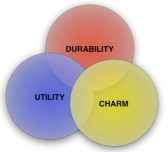
Meyer's Approach

- Natural language has problems: noise, silence, over-specification, contradictions, ambiguity, forward references and wishful thinking
- Sommerville: lack of clarity, requirements confusion (not properly categorized), requirements amalgamation
- Use formal techniques then translate to natural language
- Some formal techniques: entity-relationship modeling, Finite state machines, Structured Analysis and Design Technique (SADT)
- Less formal: Structured natural language, graphical notations



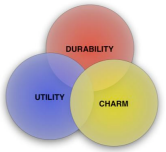
Formal Methods

- Formality = degree of mathematical rigor during analysis and design
  - Mathematically based techniques for describing system properties
  - Strive for consistency, completeness and lack of ambiguity - the usual suspects
  - Issues with less formal approaches: contradictions - statements at variance with each other, usually separated by substantial text in the requirements, ambiguities, vagueness, incompleteness, mixed levels of abstraction
- Mathematics provides a high level of validation



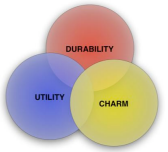
Formal Method Concepts

- Data invariant is a set of conditions that are true throughout the execution of the system that contains a collection of data
  - Example: constraint on table size in a symbol table = maxids and all items are unique names
- State - stored data that the system accesses and alters
- Operator - an action that reads or writes data to a State, e.g. adding and removing names to a symbol table. Operator is associated with two conditions:
  - Precondition - defines circumstances in which a particular operation is valid
  - Postcondition - defines what happens when an operator has completed its action defined by its affect on state
- Brainstorming techniques are useful to develop a data invariant for a complex function, e.g., bounds, restrictions and limitations



Set Preliminaries

- Set - collection of objects and elements, all elements are unique and order is immaterial
- Cardinality - number of items in a set
- Sets are defined by enumerating elements or using a constructive set specification
  - $\{n{:}\mathbb{N} \mid n < 3 \cdot n\}$
    - $n{:}\mathbb{N}$ is signature, specifies range of values considered
    - $n < 3$ is predicate defines how set is constructed
    - n is term provides general form of the item of the set, when n is obvious it can be omitted
  - {0, 1, 2}



More Set Prelims

$\in$ $x \in X$ denotes membership in a set

$12 \in \{6, 1, 2, 12, 22\}$

$x \notin X$ x is not a member of X

$\emptyset$ is empty set

$\emptyset \cup A = A$ and $\emptyset \cap A = \emptyset$

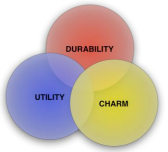
union, cup

intersection, cap

contained in relationships

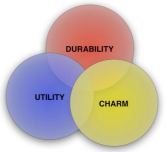
Union combines both sets with duplicates eliminated

Intersection provides list of common elements



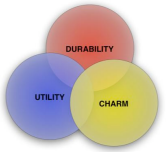
Yet More Set Prelims

- \ is set difference operation removes elements of 2nd from 1st
- X is cross product, each of the elements of the 1st combined with each of the elements of the 2nd
- Powerset is collection of subsets of set
- Logical operators
- Universal quantification
- Sequence, elements are ordered, 1st element is domain, 2nd element is range
- Sequence operators: concatenation, head, tail, front, last



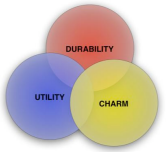
Example: Block Handling

- Blocks of storage held on a file storage device
- State is collection of free blocks, collection of used blocks and queue of returned blocks
- Data Invariants:
  - No block will be marked as used and unused
  - All sets of blocks held in the queue will be subsets of the collection of currently used blocks
  - No elements of the queue will contain the same block numbers
  - Collection of used and unused blocks is the collection of blocks that make up files
  - The collection of {used, unused} blocks have no duplicate block number
- Operations: adds a collection of blocks to the end of queue, checks whether queue of block is empty



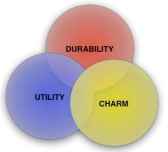
Formal Specification Language

- Three components:
  - Syntax defining specific notation of specification
  - Semantics to help define a universe of objects used to describe the system
  - Set of relations that define the rules indicating which objects properly satisfy the specification
- Syntax is usually derived from formal set theory
- Semantics abstraction usually are things such as states, state transitions, …



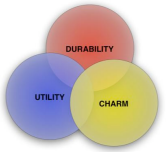
10 Commandments of Formal Methods

- Choose the appropriate notation - that is good match for application
- Formalize but not overformalize - not necessary for every (most) aspects of the system
- Estimate costs - formal methods have high startup, training costs
- Know a formal guru - for consultation
- Keep your standard development methods
- Document sufficiently including natural language commentary



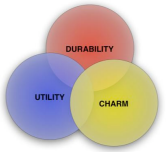
10 Commandments (cont'd)

- Maintain quality standards - Formal Methods do not supplant quality efforts
- Do not be dogmatic - you will still get bugs
- Test, test and test again - does not replace testing
- reuse



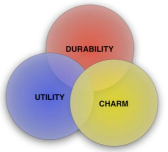
Modeling Approaches

- None are truly comprehensive, usually done to model aspects of the problem.
- Very time intensive
- Some require buying into a full methodology
- Difficult to reflect change and therefore keep synchronized
- Entity-Relationship (Chen), FSMs and SADT (Ross), Data Flow modeling
- Surveying blackboards and white boards usually the pictures are much less formal
- Davis: "The value of a model depends on the view taken, but none is best for all purposes" (E&R)



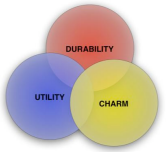
Requirements Validation

- At this stage everything is (usually) informal and incomplete (Boehm's 40%)
- Prototyping/iteration
- Requirements reviews: Sentence by sentence review of document helps as does baselining
- Test case generation -> leads to test plan



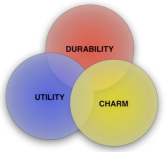
Key Factors for the Review

- Verifiability: testability
- Comprehensibility
- Traceability: source of requirement
- Adaptability: is requirement independent or will changing it affect the rest of system?
- Relationship to other requirements: conflicts, contradicts, contentious, …



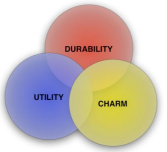
Requirements Management

- Change is inevitable
- Therefore:
  - Automated system to manage it
  - Baselined requirements
    - Enduring vs volatile (best guess)
    - Identified and traceable (maybe)
      - Source, requirements and design traceability
  - Link dependent requirements
  - Change management process



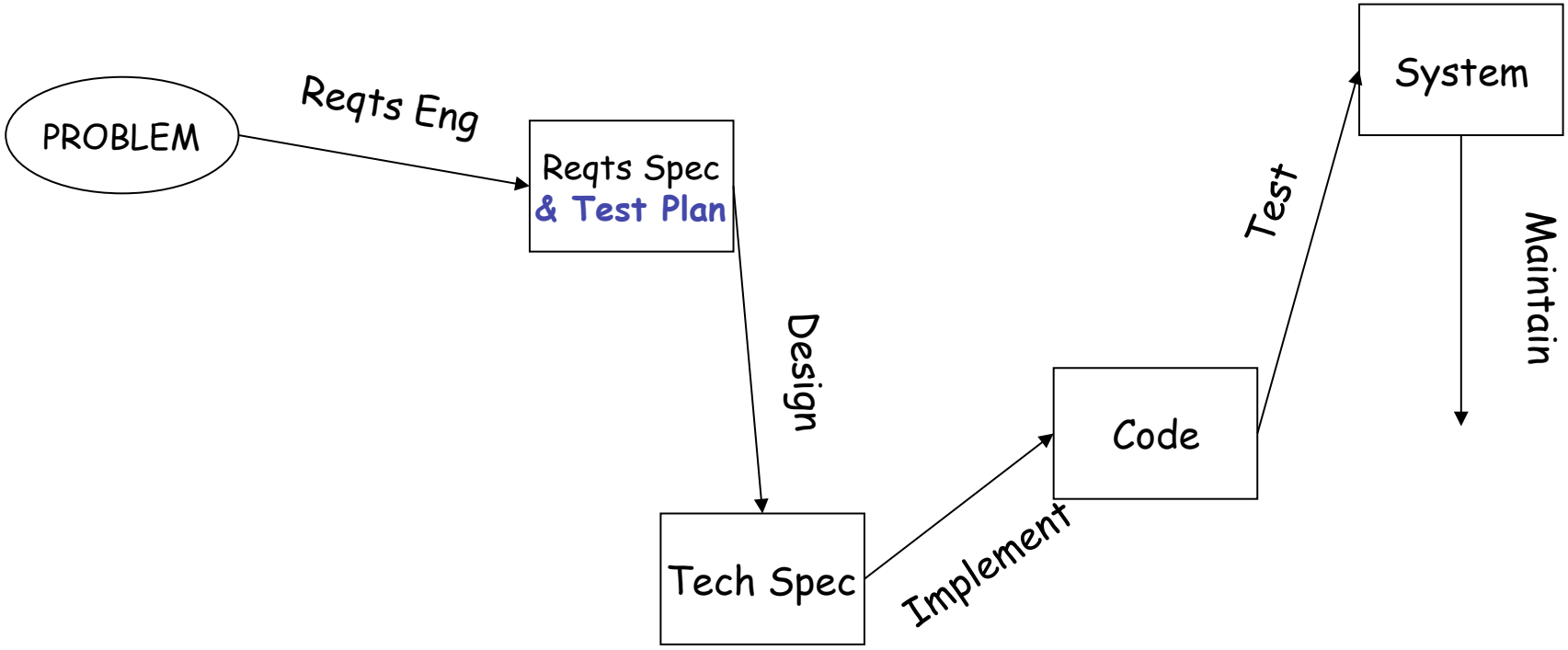
Heuristics to Reengineer Requirements

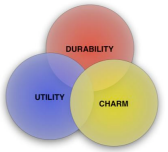
- Move some of the desired functionality into version 2
- Deliver product in stages 0.6, ..
- Cut features
- Refine some features less
- Relax the detailed requirements for some features.



Your Heuristics for reengineering requirements and preventing feature creep

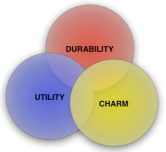
Simplified Model





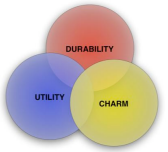
Test Plan

- (more later during testing lecture)
- Get testers involved as early as possible
- Includes scope, approach, resources necessary and schedule
- Lists and describes items and features to be tested
- Testing tasks to be performed
- Roles and Responsibilities - who does what



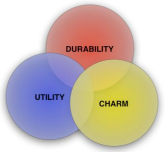
Project Metric Estimates

- Fortunate if requirements are partially done before estimation!
- Used for cost prediction and project monitoring
- Predicting size of system should get easier as project continues - stable specs and fewer tasks remaining
- Two steps:
  - Estimate size
  - Estimate effort and cost from sizing (coding necessary to fulfill requirements). Effort includes resources + calendar time + staff budget constraints
- Cost Prediction usually based on either expected effort or elapsed time



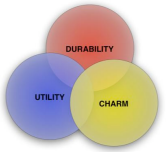
Cost Estimation

- Cost estimation falls into these categories (Kitchenham, 1994):
  - Expert - Delphi Method
  - Analogy
  - Decomposition
  - PERT Models - Delphi Method
  - Mathematical Models - COCOMO, Rayleigh Curve, Function Points
  - Parkinson's Law- work expands to fill time available
  - Pricing to win- cost and effort is whatever customer has to spend
  - Top-Down/Bottom-Up



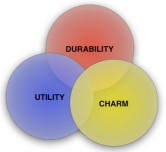
Brooks Chapter 2

- Projects fail usually for lack of calendar time
  - Estimation is optimistic, last bug syndrome
  - Costs vary by staff months, progress does not
  - Sequential nature of some tasks
  - Communication is key difference, farm workers vs. developers
  - Each new worker must be trained by experienced staff
  - Communication rule of thumb n(n-1)/2
- Testing most mis-scheduled part
- Brooks heuristics:
  - 1/3 planning
  - 1/6 coding
  - 1/4 component and early system test
  - 1/4 system test, whole system



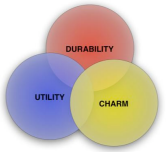
Brooks, Chapter 2 (cont'd)

- "Gutless estimating … urging of patron"
- Solutions:
  - Industry wide need to publish data
  - "Take no small slips"
  - Trim the task
- **Brook's Law: "Adding manpower to a late software project makes it later"**
- Caveats:
  - #of months depends on sequential constraints
  - #of staff depends on # of independent subtasks (and ability to match talent to task)



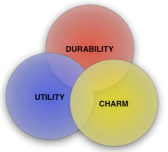
Brooks, Chapter 8, Calling the shot

- Do not estimate the whole task by estimating coding and multiplying by 6!
- Small programs : large programs :: 100 yard dash : 1 mile
  - Effort increases as a power of size w/o factoring communication
- Unrealistic assumptions as to how much of a Developer's time is allotted to development - studies show only 50% of the time
- Productivity is also related to complexity of the task, more complex, less lines/year - high level languages help (still relevant today)



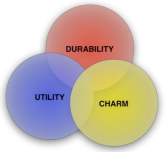
Software Estimation

- Begins by designating a unit of estimation:
  - Initially KLOC and then divide by LOC/month figures (3KLOC/yr, average programmer productivity rate -- Futrell, et.al.)
  - In addition to LOC, function points, feature points, object (application) points, number of bubbles on Data Flow Diagram, objects, classes, number of pages of user documentation, …
- Some data was collected by IBM - regression analyses
- Evolved to an estimate through regression analyses adjusted by unique characteristics of the project
  - assessed by 10 to n factors that weight the final estimate



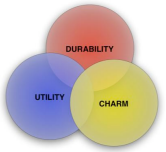
Easy?

- 15% of all software projects fail to meet their goals, overruns of 100-200% are common.
- "When performance does not meet the estimate, there are two possible causes: poor performance or poor estimates. In the software world, we have ample evidence that our estimates stink, but virtually no evidence that people in general don't work hard enough or intelligently enough." -- Tom DeMarco
- Boehm - no project can finish in less than 75% of theoretical time



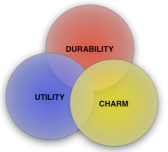
Capers Jones Table

Language	Ratio-Source:Executable
Assembler	1:1
Macro-Assembler	1:1.5
C	1:2.5
ALGOL	1:3
COBOL	1:3
FORTRAN	1:3
Pascal	1:3.5
RPG	1:4
PL1	1:4
MODULA-2	1:4.5
Ada	1:5
PROLOG	1:5
LISP	1:5
FORTH	1:5
BASIC	1:5
LOGO	1:6
4th-GLs	1:8
APL	1:9
OBJECTIVE-C	1:12
SMALLTALK	1:15
Query-Languages	1:20
Spreadsheets	1:50



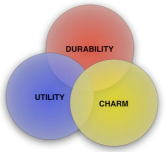
SLOC!

- Source Lines Of Code (basis for KLOC):
  - Make sure single statement, not two separated by semicolon
    - Syntax issue
  - All delivered, executable statements (OA&M, test harness)
  - Count data definitions only once
  - No Comments?
  - Count all instances of calls, subroutines, …
  - Class project once - an extra credit adventure
- No industry standards
- This can be toyed with if you base compensation on it!
- Of course LOC is a "results measure"



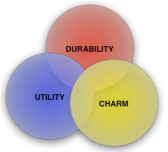
COCOMO

- COnstructive COst MOdel
- Initially based on Boehm's analysis of a database of 63 projects - models based on regression analysis of these systems
- Linked to classic waterfall model
- Effort is number of Source Lines of Code (SLOC) expressed in thousands of delivered source instructions (KDSI) - excludes comments and unmodified utility software
- Model has 3 versions and considers 3 types of systems:
  - Organic - simple business systems
  - Embedded - avionics
  - Semi-detached - management inventory systems



COCOMO System Types

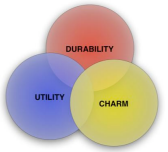
	SIZE	INNOVATION	DEADLINE	CONSTRAINTS
Organic	Small	Little	Not tight	Stable
Semi-Detached	Medium	Medium	Medium	Medium
Embedded	Large	Greater	Tight	Complex hdw/ customer interfaces



COCOMO Formula

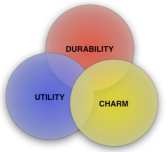
Effort in staff months $= b * KDLOC^c$

	b	c
organic	2.4	1.05
semi-detached	3.0	1.12
embedded	3.6	1.20



A Retrospective on the Regression Models

- They came to similar conclusions:
  - Time:
    - Watson-Felix $T = 2.5E^{0.35}$
    - COCOMO(organic) $T = 2.5E^{0.38}$
    - Putnam $T = 2.4E^{0.33}$
  - Effort:
    - Halstead $E = 0.7\ KLOC^{1.50}$
    - Boehm $E = 2.4\ KLOC^{1.05}$
    - Watson-Felix $E = 5.2\ KLOC^{0.91}$

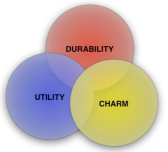


Intermediate COCOMO

- Adds 15 attributes of the product that has to be rated on a six point scale from Very Low to Extra High
- There are 4 categories of attributes: product, computer, personnel and project.
- The ratings are reflected in P of the equation
  - P < 1, less effort; P > 1 more effort

Effort in staff months $=(b*KDLOC^{C})*P$

Effort = $A * Size^{B} * M$ (Sommerville)

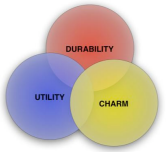


Intermediate COCOMO Attributes

- PRODUCT:
  - RELY - required reliability
  - DATA- data bytes per DSI (smaller db)
  - CPLX - code complexity (VH= real time)
- COMPUTER:
  - TIME - execution time, % used
  - STOR - storage requirements, % used
  - VIRT - changes made to hdw and OS
  - TURN- Dev turnaround time, batch vs interactive
- PERSONNEL
  - ACAP - analyst capability, skills
  - PCAP - programmer capability
  - AEXP- applications experience
  - LEXP - language experience
  - VEXP- virtual machine experience
- PROJECT
  - MODP - Modern Development Practices
  - TOOL - use of sfw tools
  - SCED - amount of schedule compression - recall Boehm quote, 75% limit

Intermediate COCOMO Attributes

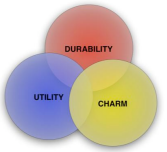
http://www.cs.unc.edu/~stotts/COMP145/cocomo6.gif



Project Characteristics Table

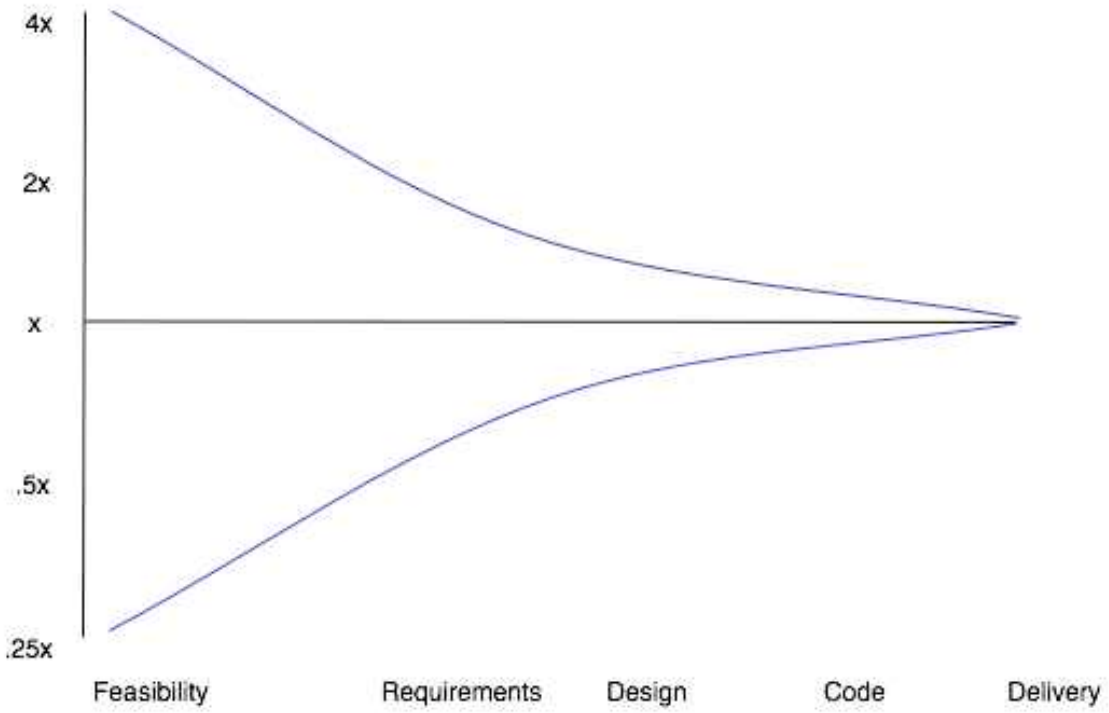
Cost adjustments for computing the EAF (Effort Adjustment Factor)

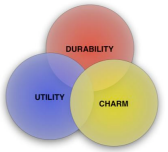
	v.low	low	nominal	high	v.high	ex.high
product attributes						
required software reliability	0.75	0.88	1.00	1.15	1.40	
database size		0.94	1.00	1.08	1.16	
product complexity	0.70	0.85	1.00	1.15	1.30	1.65
computer attributes						
execution time constraints			1.00	1.11	1.30	1.66
main storage constraints			1.00	1.06	1.21	1.56
virtual machine volitility	0.87	1.00	1.15	1.30		
computer turnaround time		0.87	1.00	1.07	1.15	
personnel attributes						
analyst capability	1.46	1.19	1.00	0.86	0.71	
applications experience	1.29	1.13	1.00	0.91	0.82	
programmer capability	1.42	1.17	1.00	0.86	0.70	
virtual machine experience	1.21	1.10	1.00	0.90		
programming language experience	1.14	1.07	1.00	0.95		
project attributes						
use of modern programming practices	1.24	1.10	1.00	0.91	0.82	
use of software tools	1.24	1.10	1.00	0.91	0.83	
required development schedule	1.23	1.08	1.00	1.04	1.10	



Estimate Uncertainty

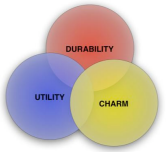
(by stage in life cycle)





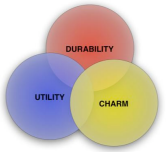
COCOMO II

- Mapped to life cycle, three phases:
  - Application Composition Model -based on counting Object points where objects are screens, reports and 3GL (C, FORTRAN,BASIC) modules weighted by difficulty. Object points are easier to determine at an earlier time.
  - Early Design Model uses unadjusted function points which are converted to SLOC based on language. Rather than Function Point cost structures, uses its own cost drivers which are related to third model, the Post Architecture Model. Cost drivers are: product reliability and complexity, required reuse, platform difficulty, personnel experience, personnel capability, facilities and schedule. Rated on 7 point scale.



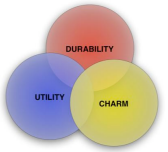
COCOMO II-2

- Post Architecture Model is most detailed model. Differs from original *COCOMO* in set of cost drivers, and range of values to parameters. New cost drivers are:
  - Documentation needs
  - Personnel continuity
  - Required reusability
  - Multi-site development
  - (-) computer turnaround time
  - (-) use of modern programming practices



Application (Object) Points

- Count of separate screens displayed, range from 1 to 3 points as function of complexity
- Count of reports produced, range from 2 to 8 points as function of difficulty to do
- Count of modules in programming language, each 10 points



Project Duration

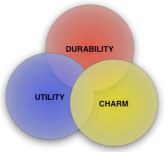
- *COCOMO II* =

$$TDEV = 3 * (PM)^{(0.33+0.2*(B-1.01))}$$

PM is effort computation

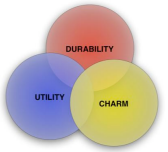
B reflects size of project

TDEV is duration of development in months



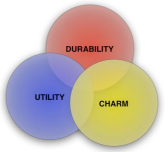
The COCOMO Family

- COCOMO II - estimates cost, effort and schedule of a perspective project
- COCOTS - estimates cost, effort and schedule associated with using commercial off-the-shelf components (COTS) in a software development project. (research project)
- COQUALMO - explores relationship between cost, schedule and quality
- CORADMO - estimates cost of developing software using rapid application development techniques.
- COPROMO - predicts the most cost effective allocation of investment resources in new technologies intended to improve productivity
- COPSEMO - estimates cost of developing software as distributed over development activity stage
- COSYSMO - estimates the system engineering tasks in software intensive projects
- http://sunset.usc.edu/research/cocomosuite/suite_main.html



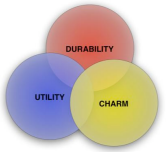
Function Points

- A break from KLOC - important because estimates can be based on design data vs. results based measures
- Albrecht and Gaffney, '70s, IBM
- Based on counting data structures
- Great for business apps or any that are data dependent, not as good for apps that have a heavy algorithmic component, e.g., compilers
- Five factors in the Function point Analysis Model:
  - I # of input types that are user inputs changing data structures.
  - O # of output types
  - E # of inquiry types, input controlling execution. E.g., menu selection
  - L # of logical internal files, internal data used by system such as index files
  - F # of interfaces data output or shared with another app



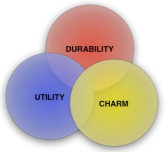
Function Point Calculations

- Unadjusted Function Points
  - UFP= 4I + 5O + 4E + 10L + 7F
- The constants can be altered if we know more about the data (next slide)
  - Each input type has a number of data element types (attributes) and refers to other file types. As these increase, the complexity level increases, resulting in changes to the constants
- Also "backfiring" - Capers Jones relating FP to LOC



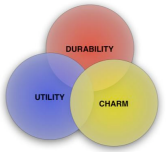
Complexity Table

TYPE:	SIMPLE	AVERAGE	COMPLEX
INPUT (I)	3	4	6
OUTPUT(O)	4	5	7
INQUIRY(E)	3	4	6
LOG INT (L)	7	10	15
INTERFACES (F)	5	7	10



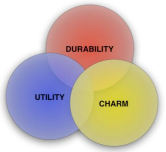
Adjusted Function Points

- Application characteristics are considered
- Considers 14 characteristics (environmental factors)on a 6 point scale (0-5)
- Total Degree of Influence (DI) is sum of scores.
- DI is converted to a technical complexity factor (TCF)
  - TCF = 0.65 + 0.01DI
- Adjusted Function Point is computed by
  - FP = UFP * TCF
- For a given language there is a direct mapping from Function Points to LOC
- COUNTING FUNCTION POINTS IS NOT EASY!
- Feature points - extension of function points to deal with expanded set of applications, such as embedded and real time systems.
- And Object points- at a higher level than function points, one object point to each unique class or object



Application Characteristics for Function Point Analysis

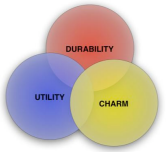
- Data Communications
- Distributed Functions
- Performance
- Heavily used configuration
- Transaction rate
- Online Data Entry
- End-user efficiency
- Online update
- Complex processing
- Reusability
- Installation ease
- Operational ease
- Multiple sites
- Facilitate change



Initial Conversion

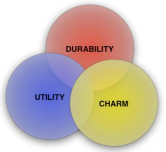
http://www.qsm.com/FPGearing.html

Language	Median SLOC/function point
C	104
C++	53
HTML	42
JAVA	59
Perl	60**
J2EE	50
Visual Basic	42



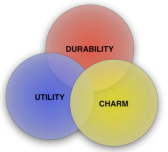
Delphi Method

- A group of experts can give a better estimate
- The Delphi Method (aka Wideband Delphi):
  - Coordinator provides each expert with spec
  - Experts discuss estimates in initial group meeting
  - Each expert gives estimate in interval format: most likely value and an upper and lower bound
  - Coordinator prepares summary report indicating group and individual estimates
  - Group iterates until consensus



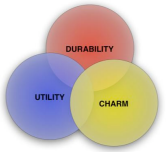
Other Estimation Models/Products

- KnowledgePlan - Capers Jones
- SLIM - Putnam
- SEER - Jensen (worked with Putnam)
- Your favorite here
  - Earned Value Analysis/Management-track how you are doing (COCOMO-II has elements of that)
  - In 2002 ~50 software estimation tools available
- Other: interface screen counts, classes and methods (nouns and verbs), …
- History of success/feedback, inter and intra product is essential!



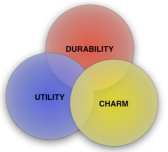
Requirements Process & Estimates

1. ICED-T analysis: Intuitive, Consistent, Efficient, Durable, Thoughtful
2. Simplified Quality Functional Deployment
3. Compute effort
4. Estimate staff and development time
5. Revise requirements to meet above (if exceeds cost, time)
6. Redo 1-4
7. Replan with GANTT chart (optional)
8. Review MOV (Measurable Operational Value) to see if it is worth it



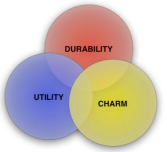
Heuristics to do Better Estimates

- Decompose Work Breakdown Structure to lowest possible level
- Review assumptions with all stakeholders
- Do your homework - past organizational experience
  - HISTORY: organization -> corporation
- Retain contact with Developers
- Update estimates and track new projections (and warn)
- Use multiple methods
- Reuse makes it easier (and more difficult)

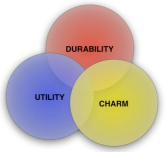


Heuristics to Cope with Estimates

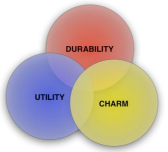
- (from S. McConnell, "How to defend an unpopular schedule, IEEE Software, 13(3), 1996.)
- More developers, if it is early enough
- Higher output developers (order of magnitude difference)
- More admin support
- Increase degree of developer support (faster machines, …)
- Eliminate red tape (50% issue)
- Devote full time end user to project
- Increase level of exec sponsorship to break new ground (new tools, techniques, training)
- Set a schedule goal date but agree to reassess after detailed design
- Use broad estimation ranges rather than single point estimates



Your Heuristics to do and Cope with Estimates?

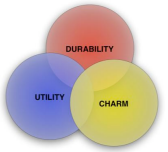


How many of you do risk management, to what extent and is it throughout the life cycle?



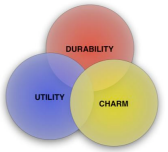
Some Risks

- Staff turnover
- Management change
- Hardware unavailability
- Requirements change
- Specification delays
- Size underestimate
- Failing/ Lack of support software
- Technology change
- Product competition
- Environmental factors



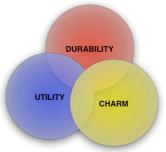
Risk Management

- General signals: new domain, new developers, new management, dictated schedules …
- Risk Management process
  - Identify risk factors
  - Determine risk exposure
  - Develop strategies to handle risks (avoidance, transfer, acceptance)
  - Handle it



Top 10 Risk Factors (Boehm)

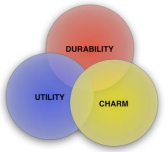
- Personnel shortfall
- Unrealistic schedule or budget
- Wrong functionality
- Wrong user interface
- Gold plating (fun and games)
- Requirements volatility
- Bad external components
- Bad external tasks (subcontracts)
- Real time shortfalls
- Capability shortfall (bleeding edge)



Software Risk Management

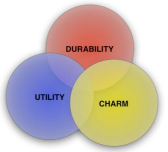
- (much of this adapted from http://www.eas.asu.edu/~riskmgmt/intro.html and the SEI)
- Risk is defined as exposure to harm or loss, not only probability but effect as well.
- NOT RISK AVOIDANCE
- The SEI (and others) phases of risk analysis are:
  - Identify
  - Analyze
  - Plan
  - Track
  - Control

COMMUNICATION



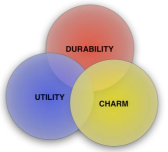
Identify Risk

- Risks can be known, unknown and unknowable or known knowns, known unknowns (apply to this project), unknown unknowns :-)!
- SEI method of risk identification (and management) based on following assumptions:
  - Risks are often known by tech staff but poorly communicated
  - A repeatable method is necessary for risk management
  - Must cover all areas
  - Attitude must be non-judgmental and supportive so that controversial views can be heard
  - Success or failure of the project can not be based solely on risk assessment

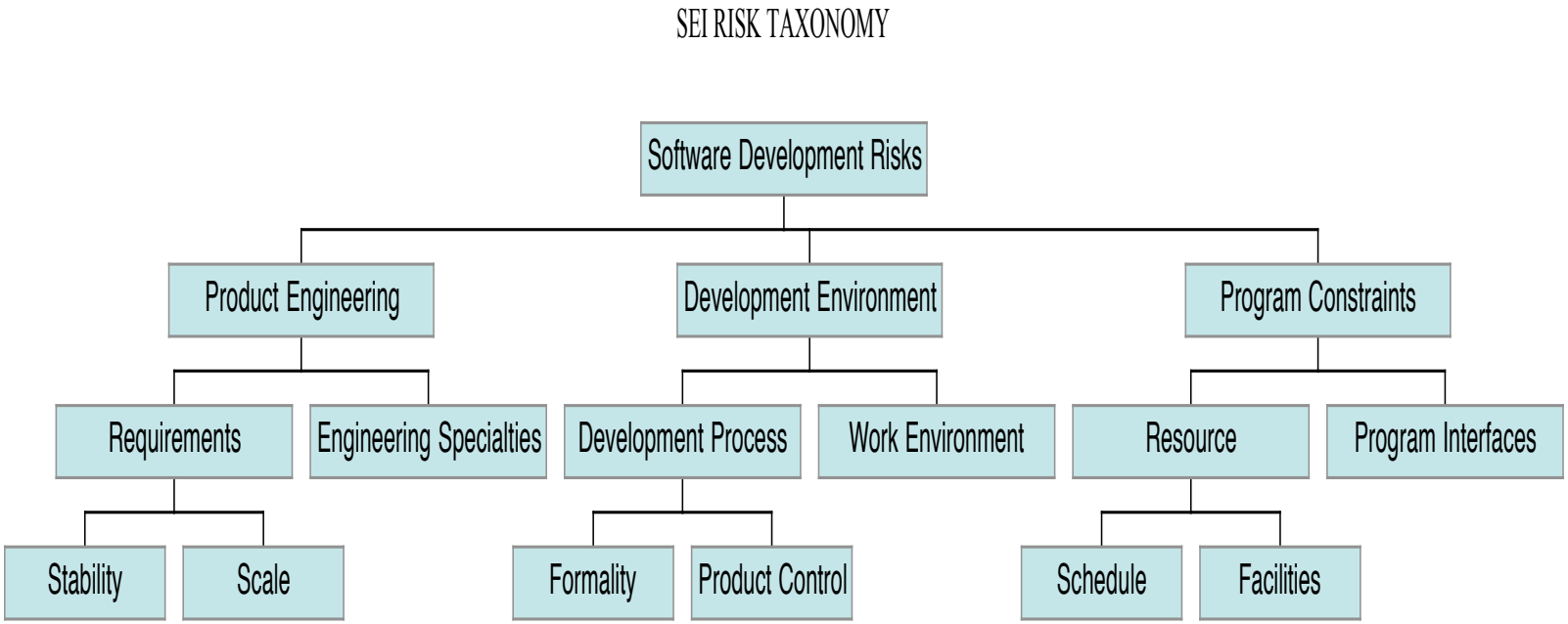


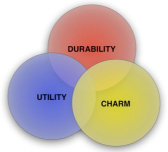
SEI Development Risk Taxonomy

- 3 major categories:
  - Product engineering - what is being developed
  - Development Environment - how it is being developed
  - Program constraints - contractual, organization and operational factors



Taxonomy Expanded
(adapted from CMU/SEI-93-TR-6)



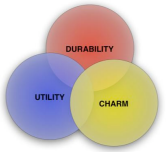


A. Product Engineering
   1. Requirements
      a. Stability
      b. Completeness
      c. Clarity
      d. Validity
      e. Feasibility
      f. Precedent
      g. Scale
   2. Design
      a. Functionality
      b. Difficulty
      c. Interfaces
      d. Performance
      e. Testability
      f. Hardware Constraints
      g. Non-Developmental Software
   3. Code and Unit Test
      a. Feasibility
      b. Testing
      c. Coding/Implement-ation
   4. Integration and Test
      a. Environment
      b. Product
      c. System
   5. Engineering Specialties
      a. Maintainability
      b. Reliability
      c. Safety
      d. Security
      e. Human Factors
      f. Specifications

B. Development Environment
   1. Development Process
      a. Formality
      b. Suitability
      c. Process Control
      d. Familiarity
      e. Product Control
   2. Development System
      a. Capacity
      b. Suitability
      c. Usability
      d. Familiarity
      e. Reliability
      f. System Support
      g. Deliverability
   3. Management Process
      a. Planning
      b. Project Organization
      c. Management Experience
      d. Program Interfaces
   4. Management Methods
      a. Monitoring
      b. Personnel Management
      c. Quality Assurance
      d. Configuration Management
   5. Work Environment
      a. Quality Attitude
      b. Cooperation
      c. Communication
      d. Morale

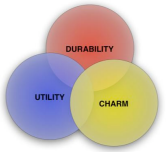
C. Program Constraints
   1. Resources
      a. Schedule
      b. Staff
      c. Budget
      d. Facilities
   2. Contract
      a. Type of Contract
      b. Restrictions
      c. Dependencies
   3. Program Interfaces
      a. Customer
      b. Associate Contractors
      c. Subcontractors
      d. Prime Contractor
      e. Corporate Management
      f. Vendors
      g. Politics

Figure A-1 Taxonomy of Software Development Risks



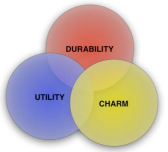
Analyze Risk

- Probability of risk, USAF Handbook categories are very low, low, medium, high and very high
- Impact of risk, USAF Handbook categories are negligible, marginal, critical and catastrophic
- Risks are rarely independent
- A matrix is used to determine overall risk for different categories (e.g., effort, performance, schedule, cost, support)



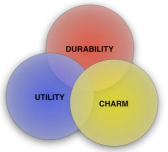
Sample Impact/Probability Matrix
(used to calculate overall risk)

Impact/Probability	V. High	High	Medium	Low	V. Low
Catastrophic	H	H	M	M	L
Critical	H	H	M	L	0
Marginal	M	M	L	0	0
Negligible	M	L	L	0	0



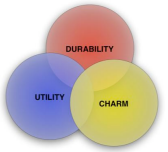
Plan for the Risks

- What can you do:
  - Mitigate impact by developing a contingency plan should risk occur and identify the trigger to initiate the contingency plan
  - Avoid the risk by changing something
  - Accept the risks and the consequences if it occurs
  - Study the risk further so that you can decide on one of the above
- In addition:
  - Specify why risk is important
  - What info is need to track status of risk
  - Who is responsible for Risk Management and what is the cost



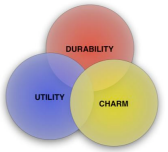
Risk Tracking and Control

- Track like everything else in the project monitoring status of risks and actions taken to address them. Appropriate risk metrics should be in place.
- Control, the risk process should be in place in the beginning, deviations to the plan should be corrected, triggering events should be handled and the process should be assessed for effectiveness.



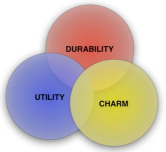
So Far

- Software Process Models
- Software Project Planning (woosh!)
- Requirements
- Estimation
- Risk Analysis
- Next
  - Software Architecture



Thought Problems

- What mechanism would you establish to provide better estimates of time and effort for software projects in your group, division and company
- You've just been promoted and now head a new team (with all new hires, none that you know) that has been assigned to do a high risk project - what is your plan of attack for risk management?



References

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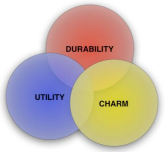
- Wirfs-Brock and Schwartz - http://www.wirfsbrock.com/pages/resources/pdf/the_art_of_writing_use_cases_slides_and_notes.pdf
- Others embedded in text



Resources

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- E. Evans. Domain-Driven Design: Tackling complexity in the heart of software, Addison-Wesley, 2004, ISBN 0-321-12521-5
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