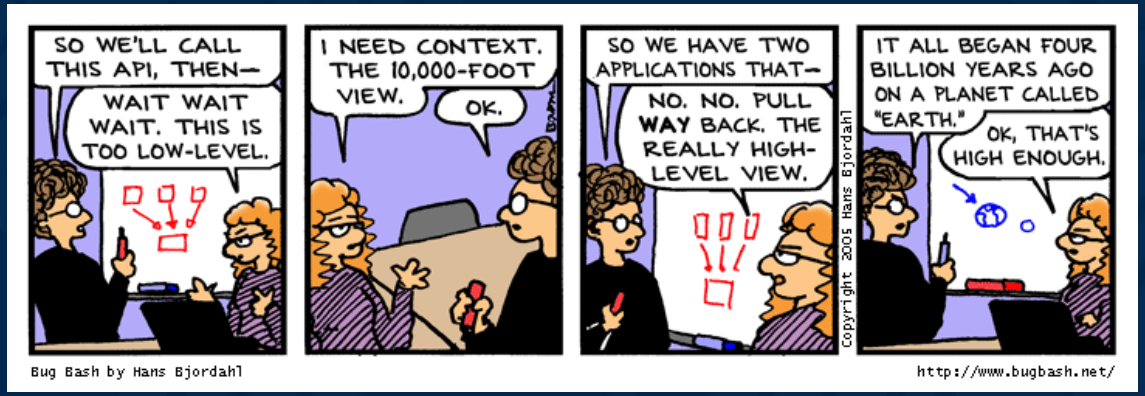

Process, Risk, and Scheduling

Outline

- Software Process Concept and Context
- Trivia
- Software Processes
  - Estimating Effort
  - Risk and Uncertainty
  - Planning and Scheduling
- The Story so far… (aka a summary)

Learning Objectives: by the end of today's lecture you should be able to…

1. (*knowledge*) explain why estimating is hard
2. (*knowledge*) explain sources of risk in a software project
3. (*knowledge*)
4. (*value*) believe there is a better way

One-Slide Summary

- A **software development process** organizes activity into distinct phases (e.g., design, coding, testing, etc.). Processes can increase efficiency, but are often implemented poorly.
- **Effort estimation** is based on historical information (models, experience). It is complicated by **uncertainty**, which stems form **risk**, which can be managed (identified, minized).
- A project **plan** (milestones, deliverables) includes all of these considerations. Measuring progress is difficult.

Software Process Concept and Context

Process

- A software development process (also known as a software development life cycle or software development model) divides software development into distinct phases to improve design, product, and project management.
- Process is “the set of activities and associated results that produce a software product”.
- Examples include waterfall model, spiral development, agile development and extreme programming.

Richard Feynman's Problem Solving Algorithm

1. Write down the problem.
2. Think real hard.
3. Write down the solution

- As facetiously suggested by Murray Gell-Mann, a colleague of Feynman, in the New York Times

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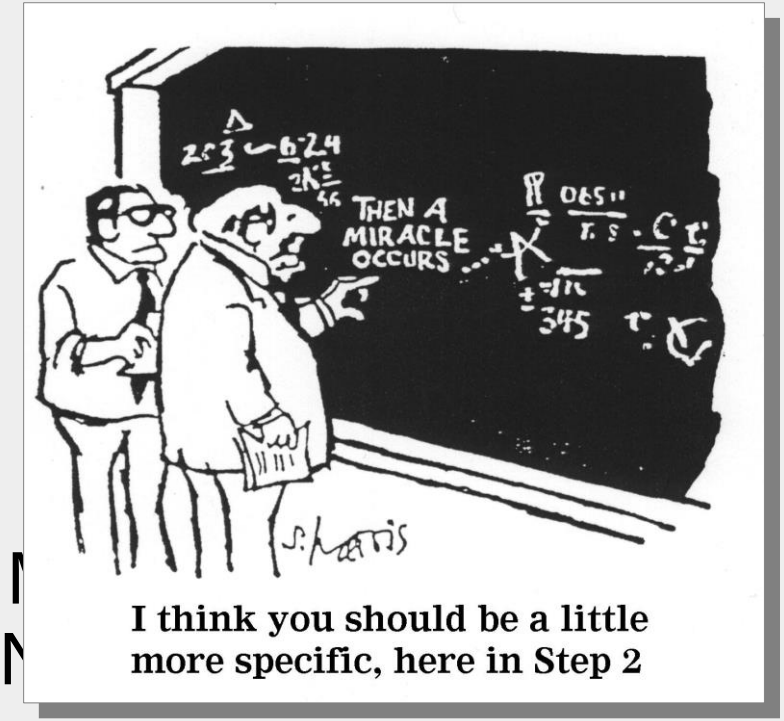

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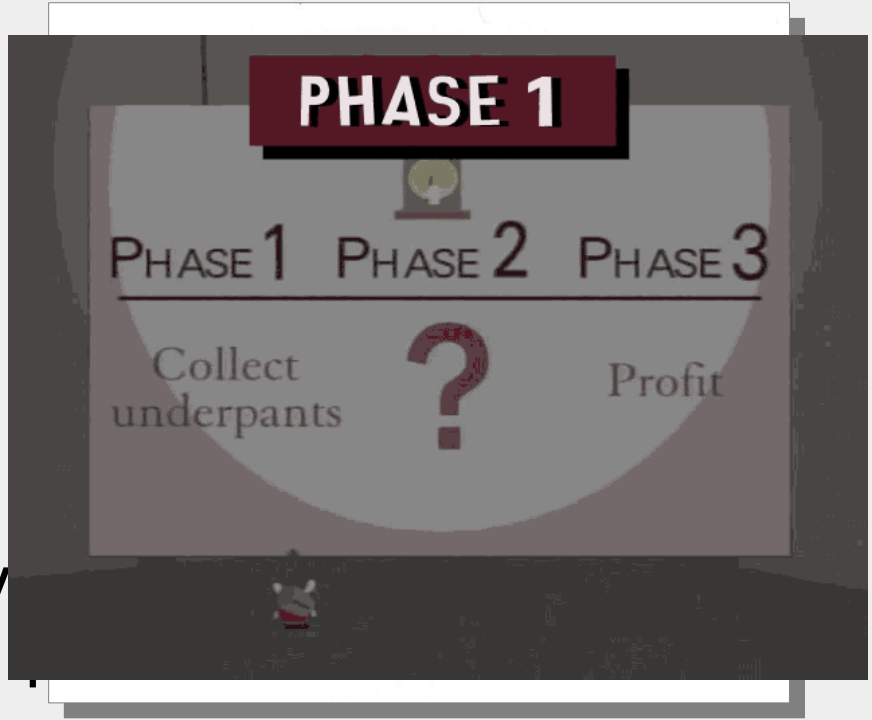
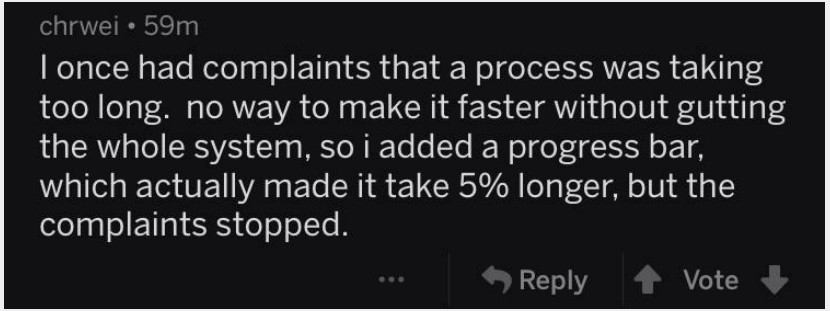


A Straw Software Process

1. Discuss the software that needs to be written
2. Write some code
3. Test the code to identify the defects
4. Debug to find causes of defects
5. Fix the defects
6. If not done, return to step 1

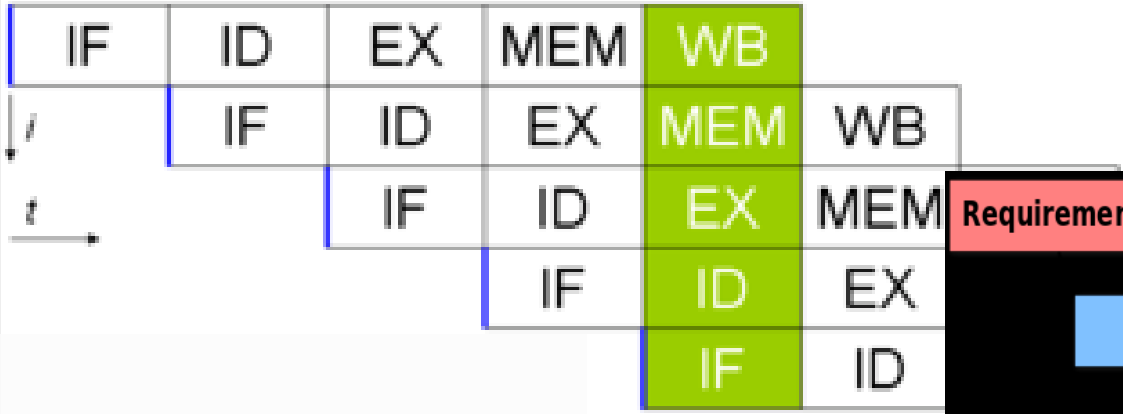


Waterfall Model

- In the **waterfall** software development model, the following phases are carried out *in order*:
  - System and software requirements: captured in a document
  - *Analysis*: resulting in models, schema, and business rules
  - *Design*: resulting in the software architecture
  - *Coding*: the development, proving, and integration of software
  - *Testing*: the systematic discovery and debugging of defects
  - *Operations*: the installation, migration, support, and maintenance of complete systems.

…Tell Me *Lies*


Pretty Little Liars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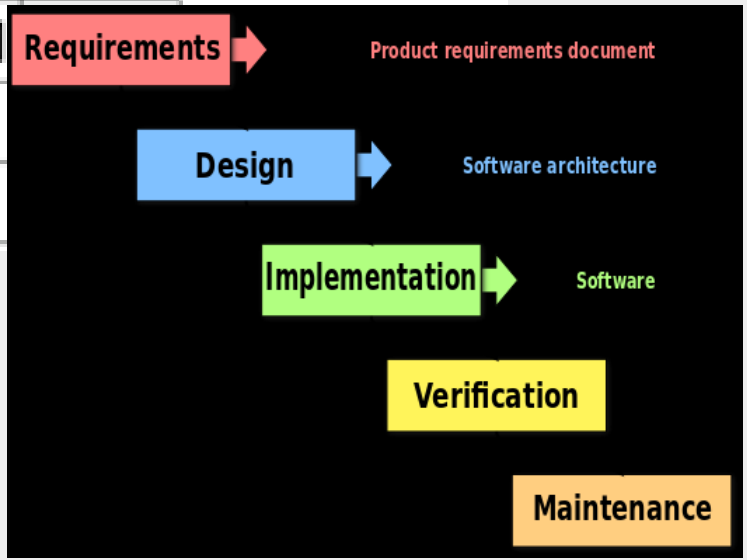
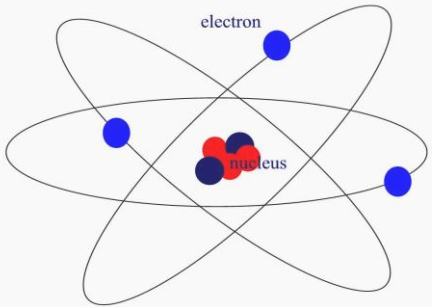
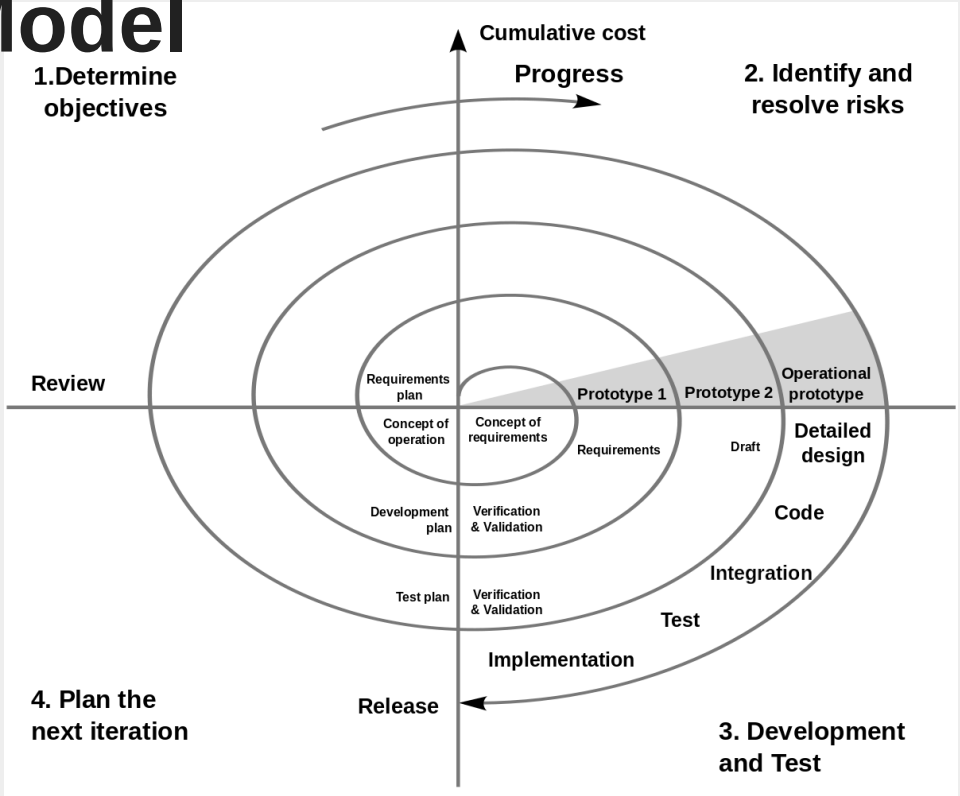

Requirements
Product requirements document
Design
Software architecture
Implementation
Software
Verification
Maintenance

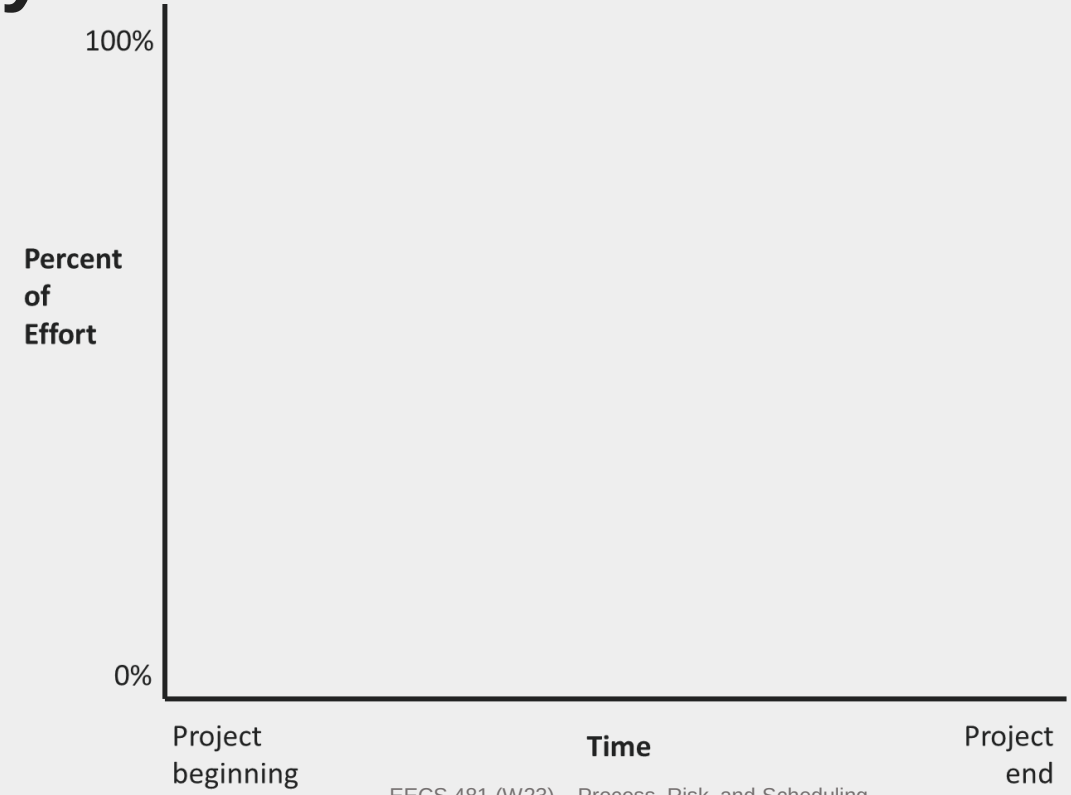

electron
nucleus

Spiral Development Model

- The **spiral** software process model focuses on the construction of an increasingly-complete series of prototypes while accounting for risk

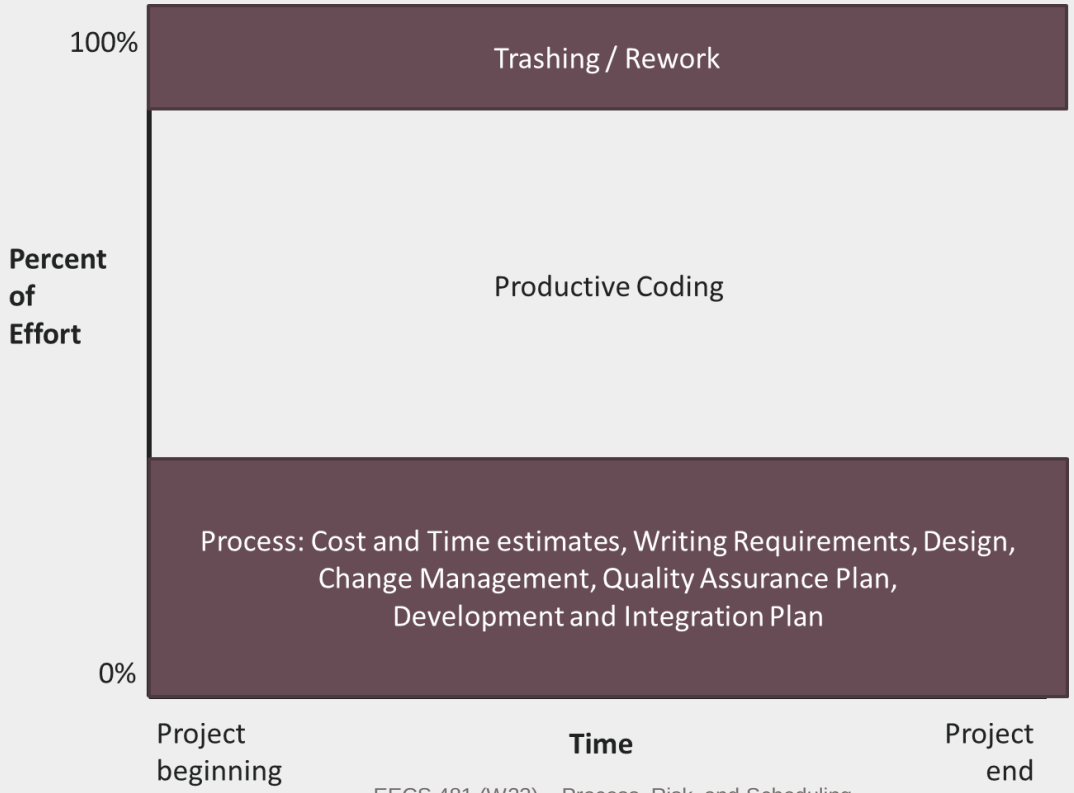


Activity Effort over Time

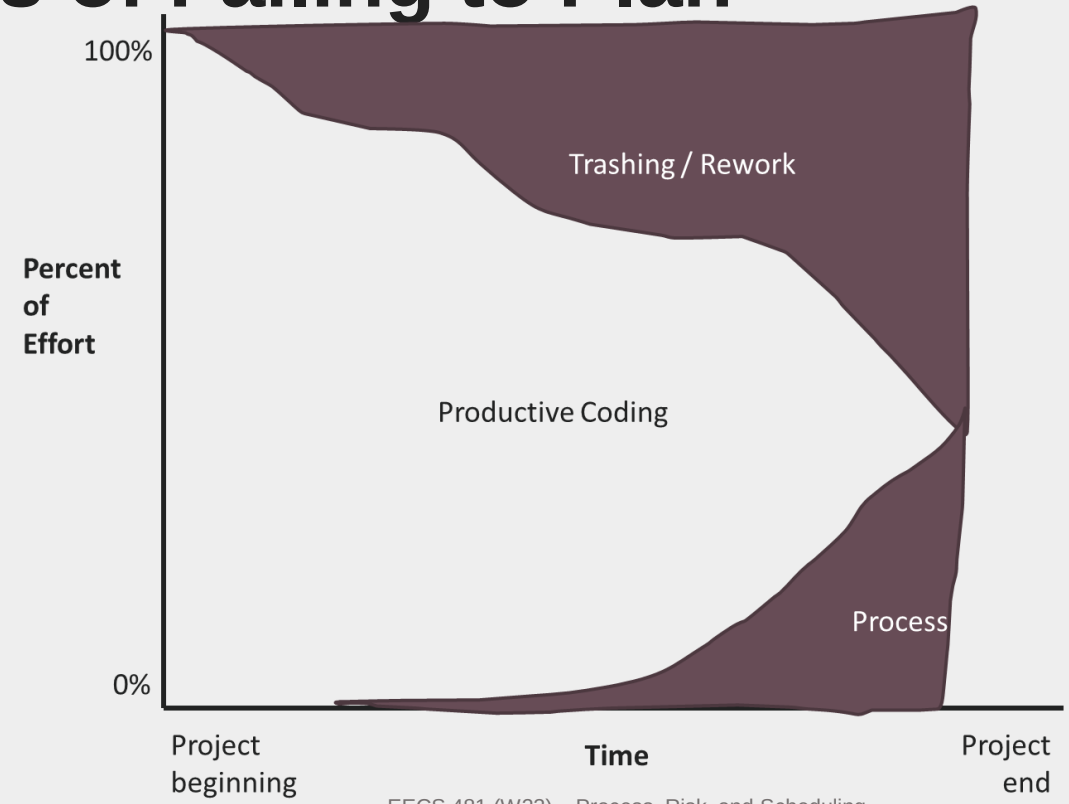


Activity Effort over Time

Idealized View



Results of Failing to Plan



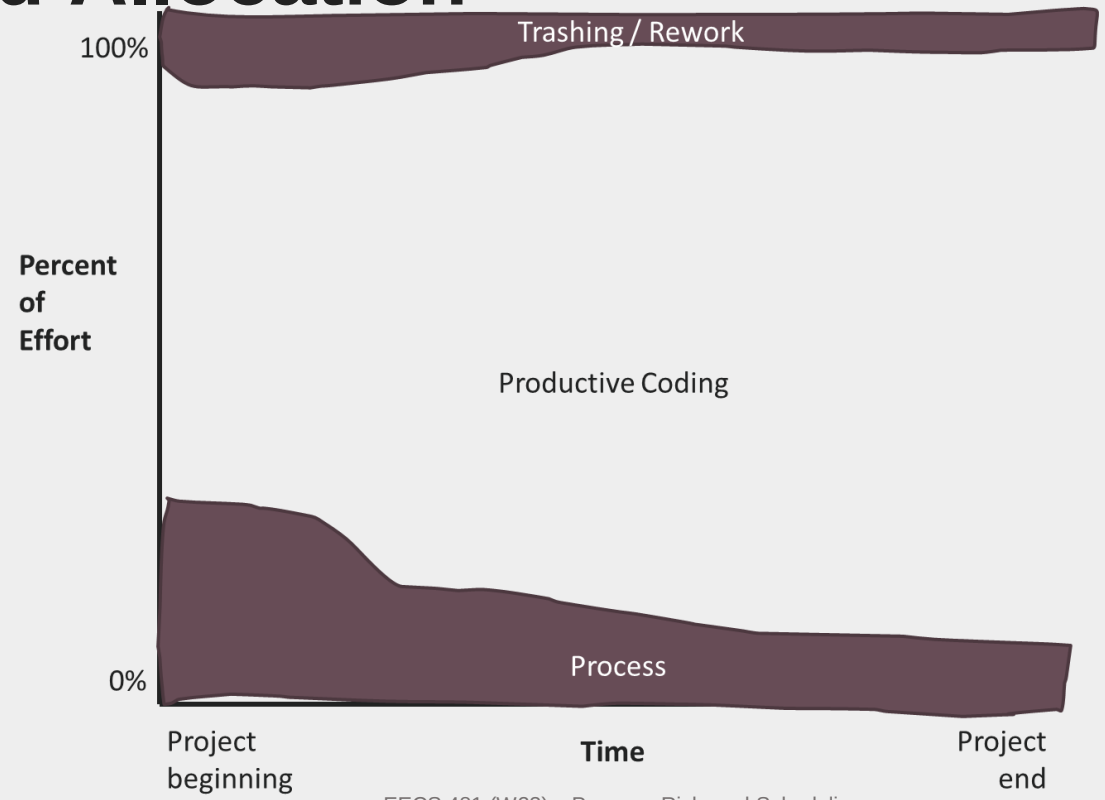
Example Process Issues and Outcomes

- **Requirements**: Mid-project informal agreement to changes suggested by customer or manager. → Project scope expands 25-50%
- **Quality Assurance**: Late detection of requirements and design issues. Test-debug-reimplement cycle limits development of new features. → Release with known defects
- **Defect Tracking**: Bug reports collected informally. → Bugs forgotten
- **System Integration**: Integration of independently developed components at the very end of the project. → Interfaces out of sync
- **Source Code Control**: Accidentally overwritten changes. → Lost work
- **Scheduling**: When project is behind, developers are asked weekly for new estimates. → Project falls further behind

Survival Mode

- Missed deadlines → "solo development mode", developers stop interacting with testers, technical writers, managers, etc.
- "The producers even set a deadline; they gave a specific date for the end of the crunch, which was still months away from the title's shipping date, so it seemed safe. That date came and went. And went, and went. When the next news came it was not about reprieve; it was another acceleration: twelve hours six days a week, 9am to 10pm.
- Weeks passed. Again the producers had given a termination date on this crunch that again they failed. Throughout this period the project remained on schedule. The long hours started to take its toll on the team; people grew irritable and some started to get ill. People dropped out in droves for a couple of days at a time, but then the team seemed to reach equilibrium again and they plowed ahead. The managers stopped even talking about a day when the hours would go back to normal." *–EA: The Human Story*

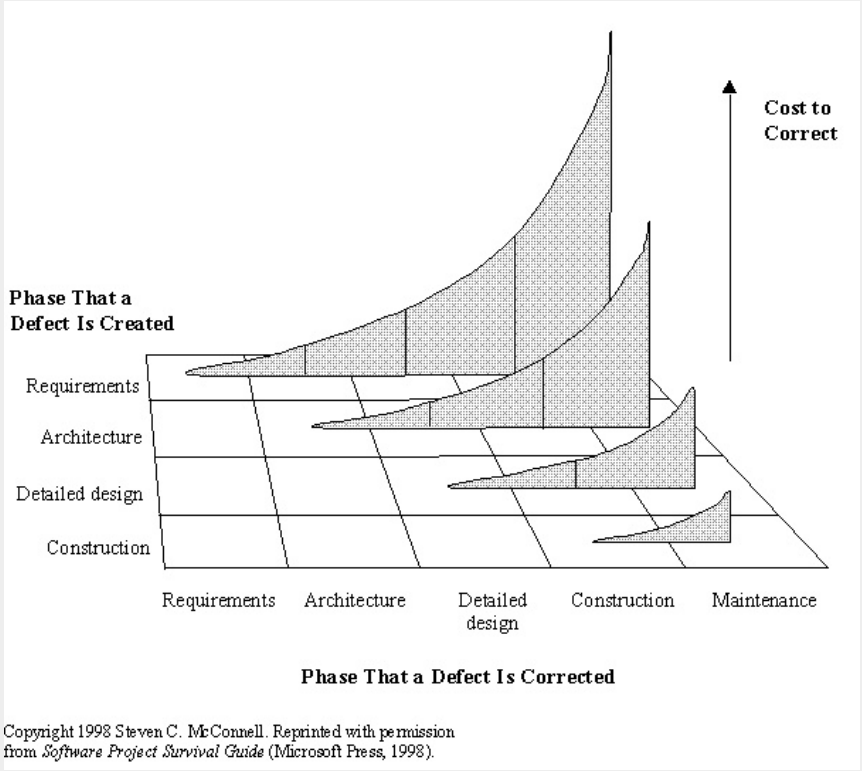
Desired Allocation



Process Hypothesis

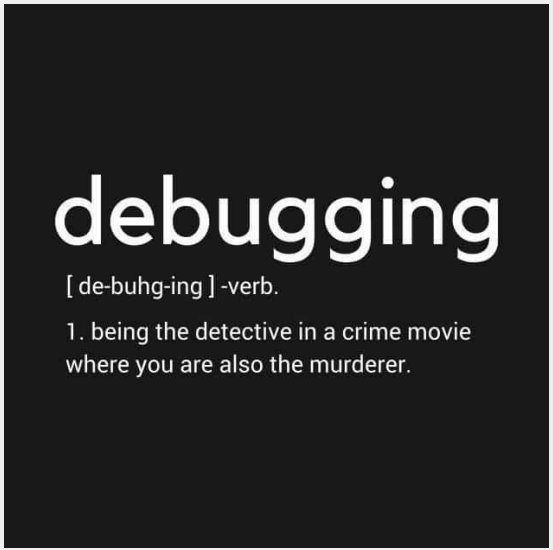
- A process can increase flexibility and efficiency for software development.
- If this is true, an up-front investment (of resources, e.g., “time”) in process can yield greater returns later on.

Efficiency: Defect Cost vs. Creation Time



Efficiency: Defect Cost vs. Creation Time

- An IBM report gives an average defect repair cost of
  - $25 during coding
  - $100 at build time
  - $450 during testing / QA
  - **$16,000** post-release



[L. Williamson. *IBM Rational software analyzer: Beyond source code*. 2008.]

Efficiency: Defect Cost vs. Creation Time

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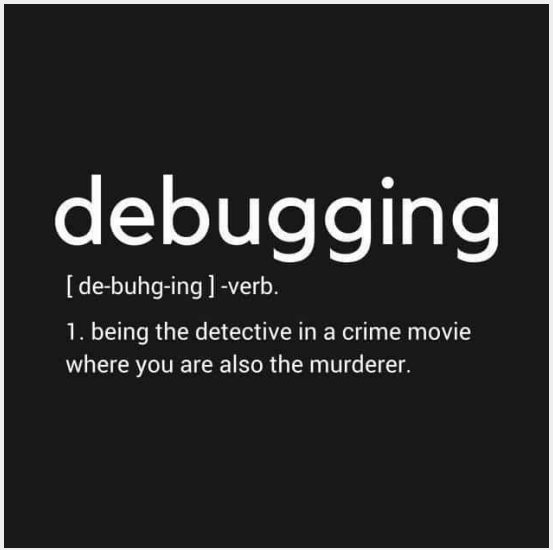
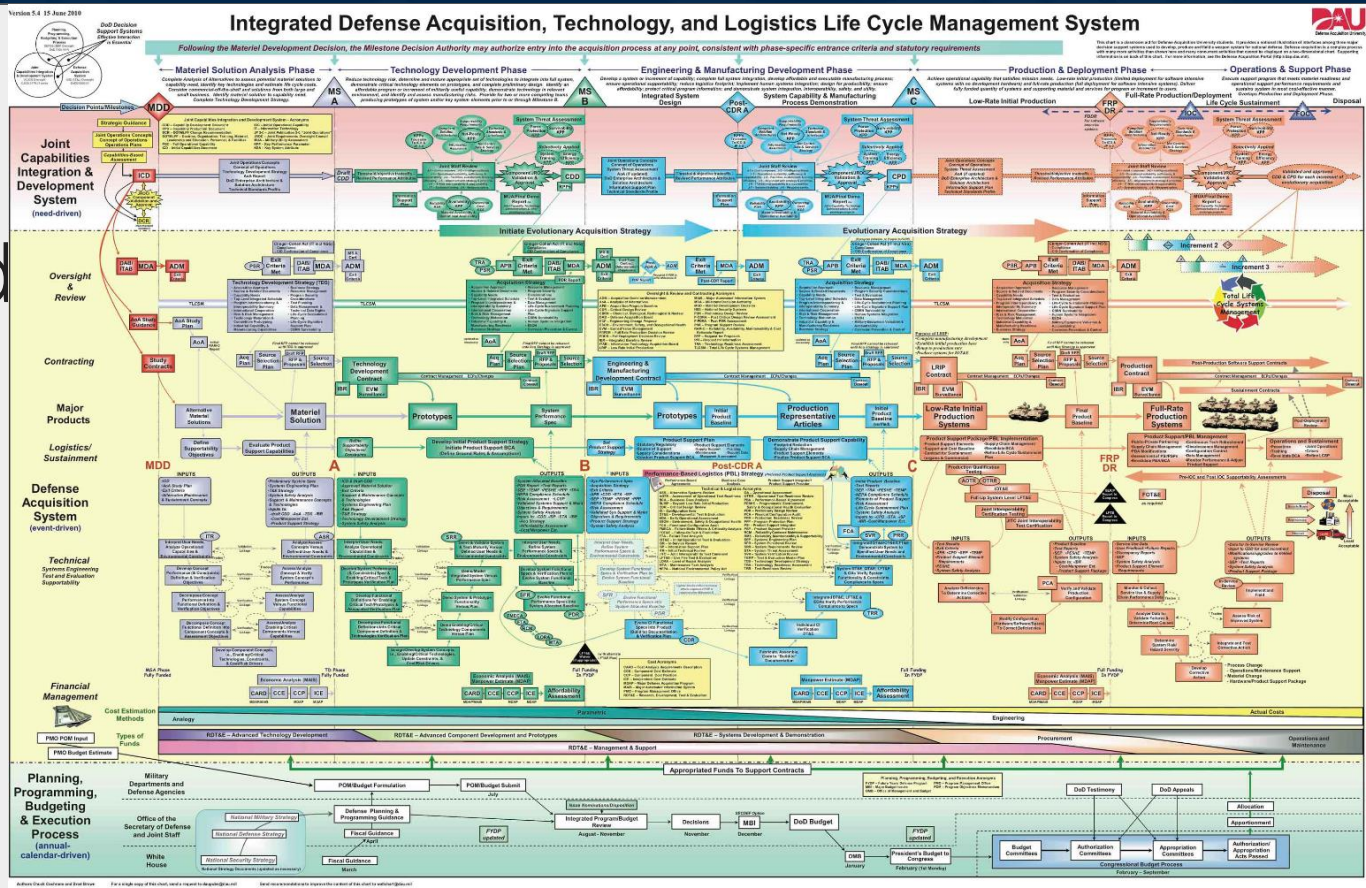


Processes Can be Complicated



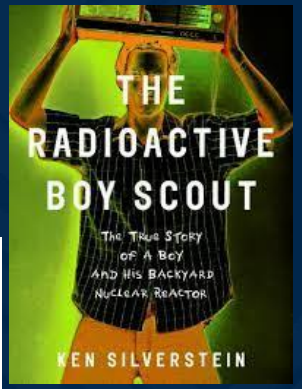
Trivia

Trivia: Nuclear Science and Chemistry

- *Which of these experiments would be the most difficult to carry out as a hobbyist?*
  a) Nitrating cellulose to produce guncotton
  b) Reacting thermite with iron oxide (2500 °C)
  c) Building a fast breeder fission reactor
  d) Cross-linking polyvinyl alcohol with sodium borate

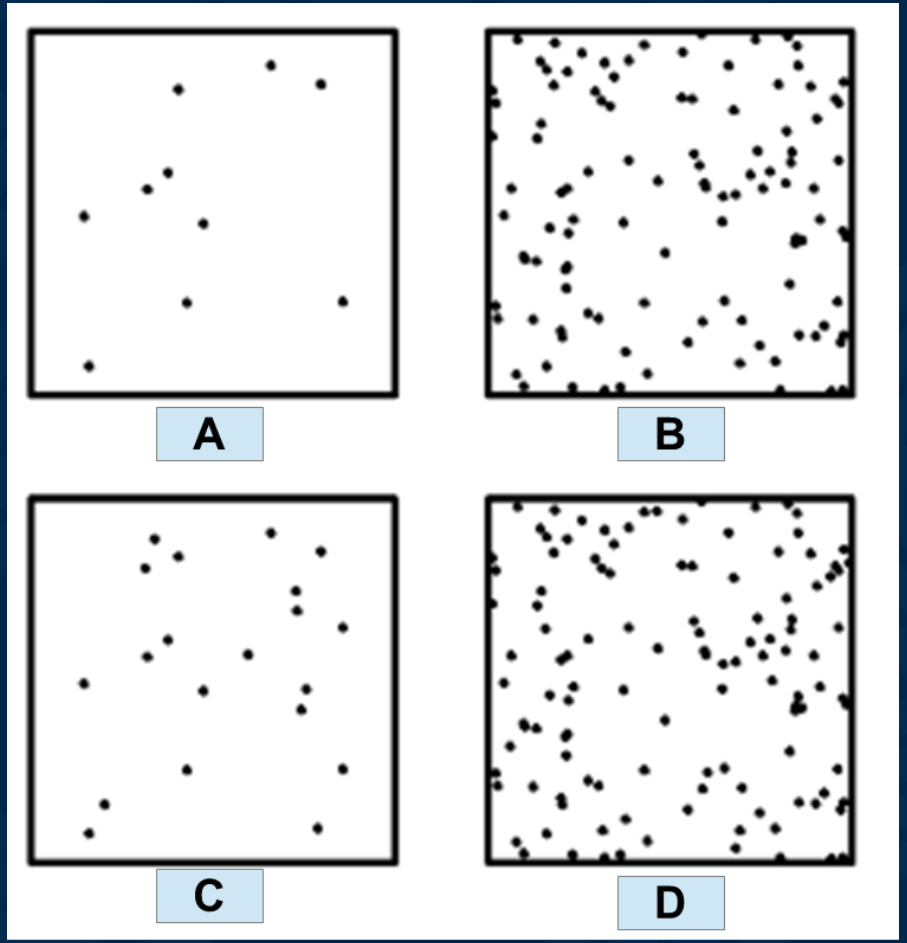
Trivia: Nuclear Science and Chemistry

- Building a fast breeder reactor (although not for lack of trying)
- “A scout in the Boy Scouts of America, [David] Hahn conducted his experiments in secret in a backyard shed at his mother's house in Commerce Township, Michigan. Hahn's goal was to build and demonstrate a homemade breeder reactor.”
- “Hahn diligently amassed radioactive material by collecting small amounts from household products, such as americium from smoke detectors, thorium from camping lantern mantles, radium from clocks, and tritium from gunsights. His "reactor" was a bored-out block of lead, and he used lithium from $1,000 worth of purchased batteries to purify the thorium ash using a Bunsen burner.”
- On June 26, 1995, the EPA, having designated Hahn's mother's property a Superfund hazardous materials cleanup site, dismantled the shed and its contents and buried them as low-level radioactive waste in Utah.



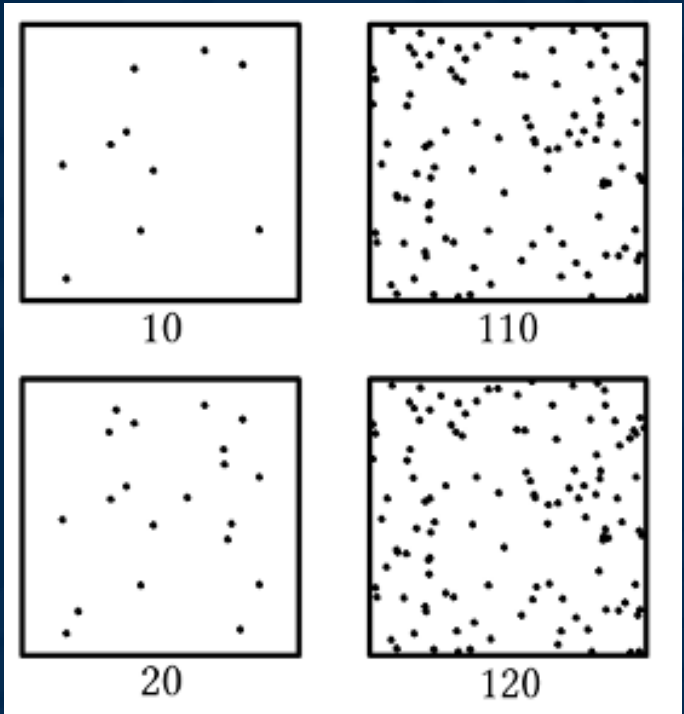
Psyhophysics

Which two figures
have the same # of dots?



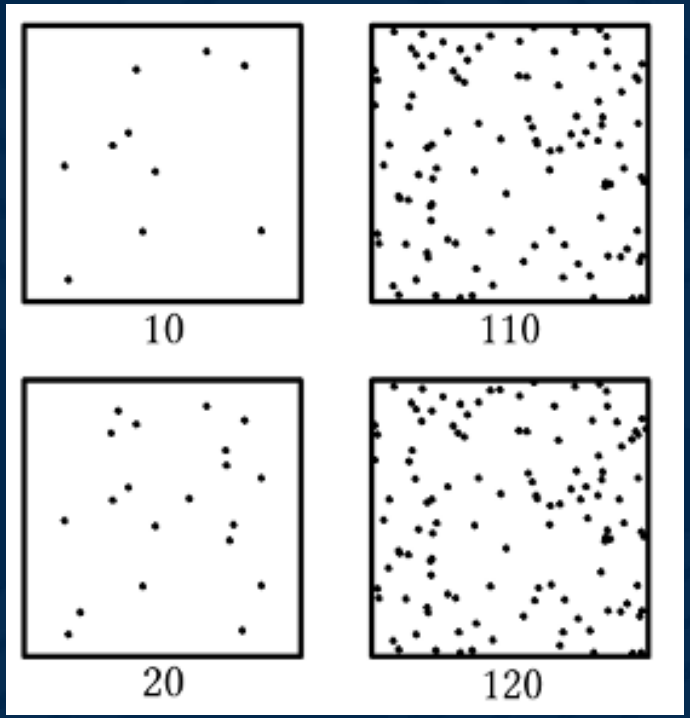
Psychophysics: Weber's Law

- Weber's Law states that "simple sensitivity is inversely proportional to the size of the components of the difference; relative differential sensitivity remains the same regardless of size."
- That is "the perceived change in stimuli is proportional to the [size of] initial stimuli."



Psychophysics: Weber's Law

- That is "the perceived change in stimuli is proportional to the [size of] initial stimuli."
- Implication for SE: Things you could notice on small-scale projects are harder to notice on large-scale projects. Your intuitions ("I can spot bugs in this") from small class projects do not carry over.



Pyschology

- Consider a hypothetical cleanup scenario involving two hazardous waste sites X and Y.
- X causes 8 cases of cancer annually (large city)
- Y causes 4 cases of cancer annually (small city)
- Rank these three cleanup approaches:
  a) X→4 and Y→2
  b) X→7 and Y→0
  c) X→3 and Y→3

Psychology: Zero-Risk Bias

- Rank these three cleanup approaches:
  a) X→4 and Y→2
  b) X→7 and Y→0
  c) X→3 and Y→3
- "The bias was defined as not ranking the complete-reduction option [b] as the worse of the 3 options. (It should be ranked worst because it saves fewer cancer cases.) 42% of the subjects exhibited this `zero-risk' bias."

[Baron; Gowda; Kunreuther (1993). "Attitudes toward managing hazardous waste: What should be cleaned up and who should pay for it?". Risk Analysis. 13: 183–192.]

Psychology: Zero-Risk Bias

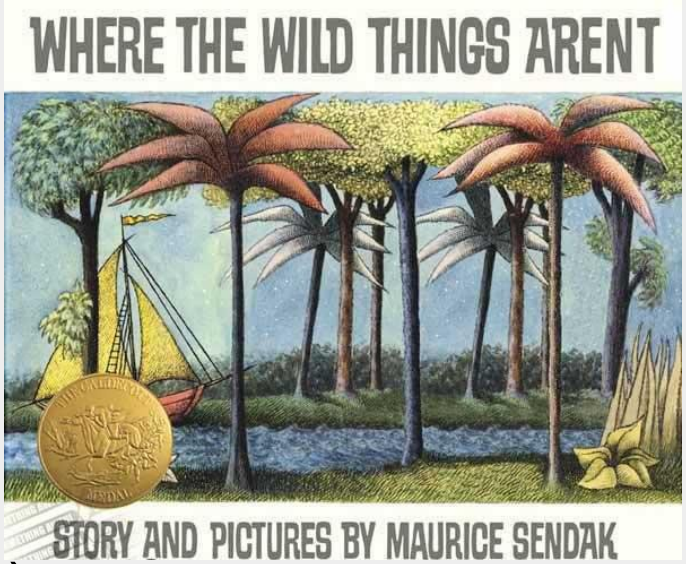
- Zero-risk bias is a tendency to prefer the complete elimination of a risk even when alternative options produce a greater reduction in risk (overall).
- “42% of the subjects exhibited this `zero-risk’ bias.”
- Who? 60 CEOS of Oil and Chem companies, 57 Economists, 94 Environmentalists, 29 Experts on Hazardous Waste, 89 Judges, 104 Legislators.
- Implications for SE: Your managers (and you) are likely to mistakenly favor risk-reduction strategies that reduce a risk to zero, even to the overall detriment of the company/product.

Outline

- ~~Software Process Concept and Context~~
- ~~Trivia~~

- **Software Processes**
  - **Estimating Effort**
  - **Risk and Uncertainty**
  - **Planning and Scheduling**

- The Story so far… (aka a summary)



Topics in Software Processes: Estimating Effort

Estimating Time Costs

- How long would you estimate to develop a …
  - Java Monopoly game (you alone)
  - Bank smartphone app (you with a team of four developers, one with iPhone experience, one with a security background)
- Estimate in eight-hour workdays (20 in a month, 220 per year)
- Approach: break down the task in ~5 smaller tasks and estimate them. Repeat.

Basic Plan: Learn from Experience

Constructive Cost Model

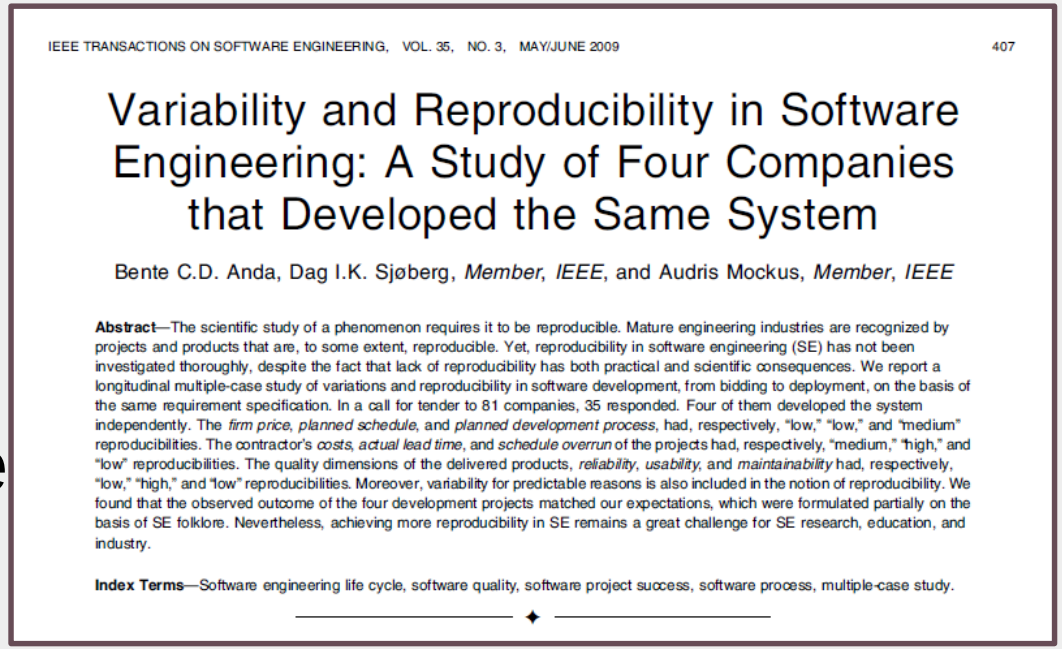
- A constructive cost model (cocomo) is a predictive model of time costs based on project history.
- This requires experience with similar projects.
- This rewards documentation of experience.

- Basically, it's an empirically-derived set of "effort multipliers". You multiply the time cost by some numbers from a chart:

Cost Drivers	Ratings					
	Very Low	Low	Nominal	High	Very High	Extra High
Product attributes						
Required software reliability	0.75	0.88	1.00	1.15	1.40	
Size of application database		0.94	1.00	1.08	1.16	
Complexity of the product	0.70	0.85	1.00	1.15	1.30	1.65
Hardware attributes						
Run-time performance constraints			1.00	1.11	1.30	1.66
Memory constraints			1.00	1.06	1.21	1.56
Volatility of the virtual machine environment		0.87	1.00	1.15	1.30	
Required turnabout 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	
Software engineer 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						
Application of software engineering methods	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	

Can Companies Estimate?

Study in which 35 companies bid to produce a web information system. Fourteen submitted a schedule and four were contracted to build it.



IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, VOL. 35, NO. 3, MAY/JUNE 2009 407

Variability and Reproducibility in Software Engineering: A Study of Four Companies that Developed the Same System

Bente C.D. Anda, Dag I.K. Sjøberg, *Member, IEEE*, and Audris Mockus, *Member, IEEE*

Abstract—The scientific study of a phenomenon requires it to be reproducible. Mature engineering industries are recognized by projects and products that are, to some extent, reproducible. Yet, reproducibility in software engineering (SE) has not been investigated thoroughly, despite the fact that lack of reproducibility has both practical and scientific consequences. We report a longitudinal multiple-case study of variations and reproducibility in software development, from bidding to deployment, on the basis of the same requirement specification. In a call for tender to 81 companies, 35 responded. Four of them developed the system independently. The *firm price*, *planned schedule*, and *planned development process*, had, respectively, "low," "low," and "medium" reproducibilities. The contractor's *costs*, *actual lead time*, and *schedule overrun* of the projects had, respectively, "medium," "high," and "low" reproducibilities. The quality dimensions of the delivered products, *reliability*, *usability*, and *maintainability* had, respectively, "low," "high," and "low" reproducibilities. Moreover, variability for predictable reasons is also included in the notion of reproducibility. We found that the observed outcome of the four development projects matched our expectations, which were formulated partially on the basis of SE folklore. Nevertheless, achieving more reproducibility in SE remains a great challenge for SE research, education, and industry.

Index Terms—Software engineering life cycle, software quality, software project success, software process, multiple-case study.

What patterns can you spot?

Company	Firm price without VAT (Euro)	Time schedule (days)	A&D in bids	Planned effort on A&D (%)	Emphasis on A&D
1	2630	14	Brief (2)		
2	4380		Brief (2)		
3	4880		Very brief (1)		
4	4970	28	Brief (2)	30	5.0
5	8750	18	Detailed (3)	7	3.7
6	9940		None (0)	40	4.0
7	11810		Brief (2)	0	2.0
8	11880	94	Detailed (3)	26	5.6
9	12190	77	Very detailed (4)	5	4.5
10	16630		Brief (2)	12	3.2
11	18130		Very brief (1)		
12	18510	91	Brief (2)	20	4.0
13	20000	30	Detailed (3)	28	5.8
14	20020		Very brief (1)	50	6.0
15	21090		Very brief (1)	44	5.4
16	25310		Very detailed (4)	11	5.1
17	33250	49	Detailed (3)	26	5.6
18	25810		Very brief (1)		
19	25940		Brief (2)	20	4.0
20	25980		Very detailed (4)	8	4.8
21	26880	45	Detailed (3)		
22	28700	77	Very detailed (4)	10	5.0
23	28950	42	Brief (2)	30	5.0
24	29000		Brief (2)		
25	33530		Brief (2)		
26	33880	77	Detailed (3)	10	4.0
27	33900		Detailed (3)	11	4.1
28	34500		Very brief (1)	36	4.6
29	38360	63	Detailed (3)	20	5.0
30	45380		Detailed (3)	10	4.0
31	52310		Brief (2)	27	4.7
32	56900		Detailed (3)	14	4.4
33	60750		Brief (2)	43	6.3
34	69060	49	Detailed (3)	23	5.3
35	69940		Detailed (3)	6	3.6

Results

	Company A	Company B	Company C	Company D
Nationality	Norwegian	Norwegian	Norwegian	International
Ownership	Private	By employees	By employees	Listed on exchanges
Location	Oslo	Oslo	Bergen	Oslo + 20 countries
Size	Appr. 100	Appr. 25	Appr. 8	Appr. 13,000 worldwide
Firm price	€20,000	€45,380	€8,750	€56,000
Agreed time schedule	55 days	73 days	41 days	62 days
Planned effort on A&D	28%	20%	7%	23%

Dimensions		Company A	Company B	Company C	Company D
Project	**Contractor-related costs**	90 hours	108 hours	155 hours	85 hours
	Actual lead time	87 days	90 days	79 days	65 days
	Schedule overrun	58%	23%	93%	5%
Product	**Reliability**	Good	Good	Poor	Fair
	Usability	Good	Fair	Fair	Good
	Maintainability	Good	Poor	Poor	Good

"We found little reproducibility in the firm price of bids, and in particular, we showed that the variation in firm price was about three times greater than in the more mature domain of road construction. … due partly to the paucity of standards for describing process and product quality."

Activities that are typically overlook in estimation

Table 4-2. Functional and Nonfunctional Requirements Commonly Missing from Software Estimates

Functional Requirements Areas	Nonfunctional Requirements
Setup/installation program	Accuracy
Data conversion utility	Interoperability
Glue code needed to use third-party or open-source software	Modifiability
Help system	Performance
Deployment modes	Portability
Interfaces with external systems	Reliability
	Responsiveness
	Reusability
	Scalability
	Security
	Survivability
	Usability

[S. McConnell. *Software Estimation*. 2009.]

Table 4-3 lists software activities that estimators often overlook.

Table 4-3. Software-Development Activities Commonly Missing from Software Estimates

Ramp-up time for new team members	Technical support of existing systems during the project
Mentoring of new team members	Maintenance work on previous systems during the project
Management coordination/manager meetings	Defect-correction work
Cutover/deployment	Performance tuning
Data conversion	Learning new development tools
Installation	Administrative work related to defect tracking
Customization	Coordination with test (for developers)
Requirements clarifications	Coordination with developers (for test)
Maintaining the revision control system	Answering questions from quality assurance
Supporting the build	Input to user documentation and review of user documentation
Maintaining the scripts required to run the daily build	Review of technical documentation
Maintaining the automated smoke test used in conjunction with the daily build	Demonstrating software to customers or users
Installation of test builds at user location(s)	Demonstrating software at trade shows
Creation of test data	Demonstrating the software or prototypes of the software to upper management, clients, and end users
Management of beta test program	Interacting with clients or end users; supporting beta installations at client locations
Participation in technical reviews	Reviewing plans, estimates, architecture, detailed designs, stage plans, code, test cases, and so on
Integration work	
Processing change requests	
Attendance at change-control/triage meetings	
Coordinating with subcontractors	

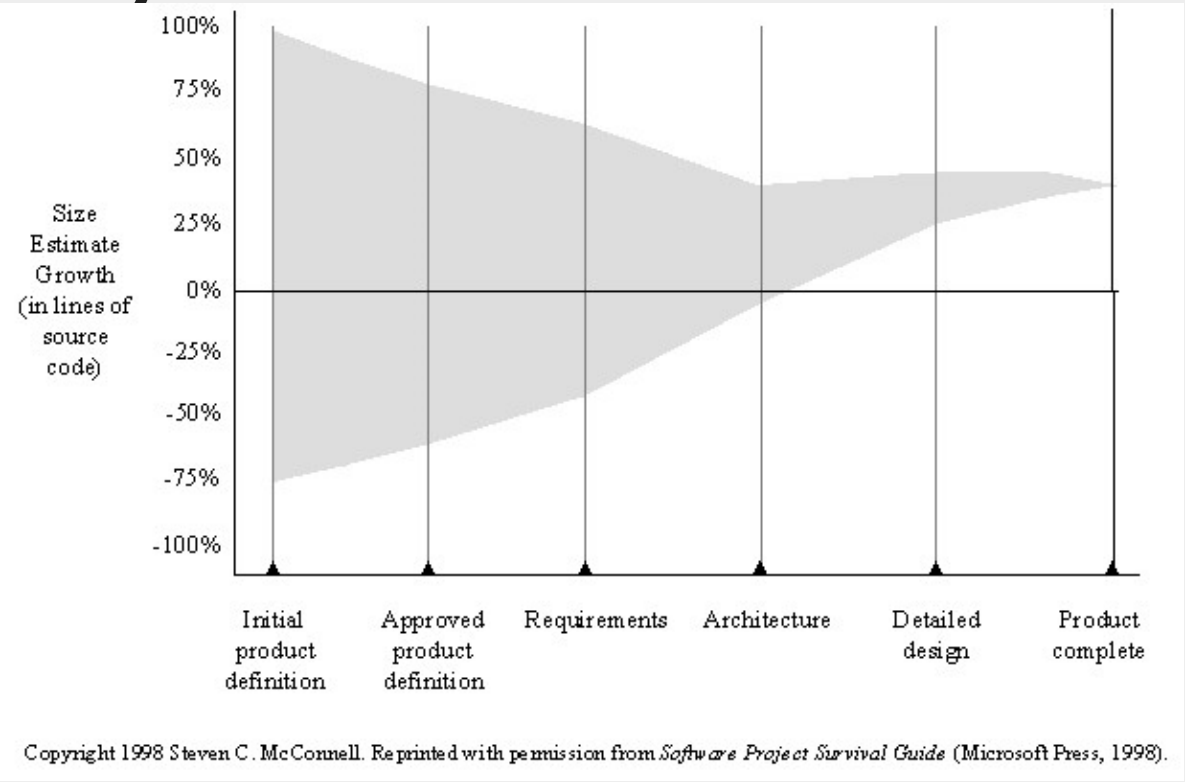
Topics in Software Processes: Risk and Uncertainty

Risk and Uncertainty

- Risk management is the identification, assessment, and prioritization of risks, followed by efforts to minimize, monitor, and control unfortunate event outcomes and probabilities.
- Risk management is a key project management task. Examples:
  - Staff illness or turnover, product is too slow, competitor introduces a similar product, etc.


THIS ROAD MAY
OR MAY NOT BE
CLOSED
ON OR ABOUT
MAY 22, 2012 FOR
APPROX 3 WEEKS

Uncertainty Reduction Over Time



Innovation and Risk

- Most software projects are innovative
  - Google, Amazon, eBay, Netflix
  - Autonomous vehicles, robotics, biomed
  - Natural language processes, graphics
- Routine projects (now, not ten years ago)
  - E-Commerce website, adaptive control systems (e.g., thermostat), 2D sprite games, etc.
- As part of the innovation cycle, routine tasks are automated … leaving only innovative ones!

No Catch-All Solution

- Address risk early
- Selectively innovate to increase value while minimizing risk (i.e., focus risk where needed)
- Use iteration and feedback (e.g., prototypes)
- Estimate likelihood and consequences
  - Requires experienced project leads
  - Rough estimates (e.g., <10%, <25%) are OK
  - Focus on top ten risks
- Have contingency plans

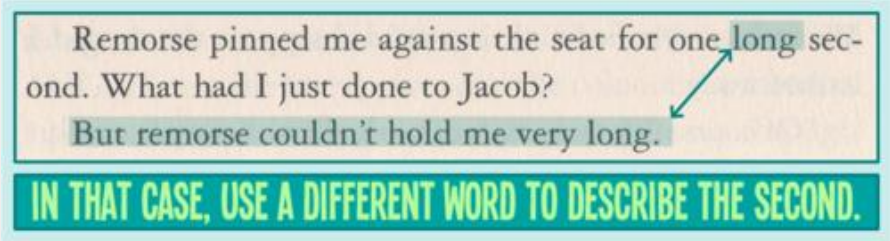
Examples of Risk Management Strategies

Organizational financial problems	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business and presenting reasons why cuts to the project budget would not be cost-effective.
Recruitment problems	Alert customer to potential difficulties and the possibility of delays; investigate buying-in components.
Staff illness	Reorganize team so that there is more overlap of work and people therefore understand each other's jobs.
Defective components	Replace potentially defective components with bought-in components of known reliability.
Requirements changes	Derive traceability information to assess requirements change impact; maximize information hiding in the design.
Organizational restructuring	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business.
Database performance	Investigate the possibility of buying a higher-performance database.
Underestimated development time	Investigate buying-in components; investigate use of a program or test generator.

Topics in Software Processes: Planning

Planning

- A project should plan time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution.
- This includes scoping the work, estimating time costs, developing the schedule and budget, mitigating risks, developing quality assurance measures, etc.



Difficulties in Software Planning

- Typically a one-time endeavor (unique wrt. goals, constraints, organization, etc.)
- Typically involves an innovative technology
- **Intangible** results (intermediate or final) mean progress may be hard to measure
- Software projects tend to fail more often than other industrial projects
- (See the structured activity for a way to practice this and get a head start on HW6!)

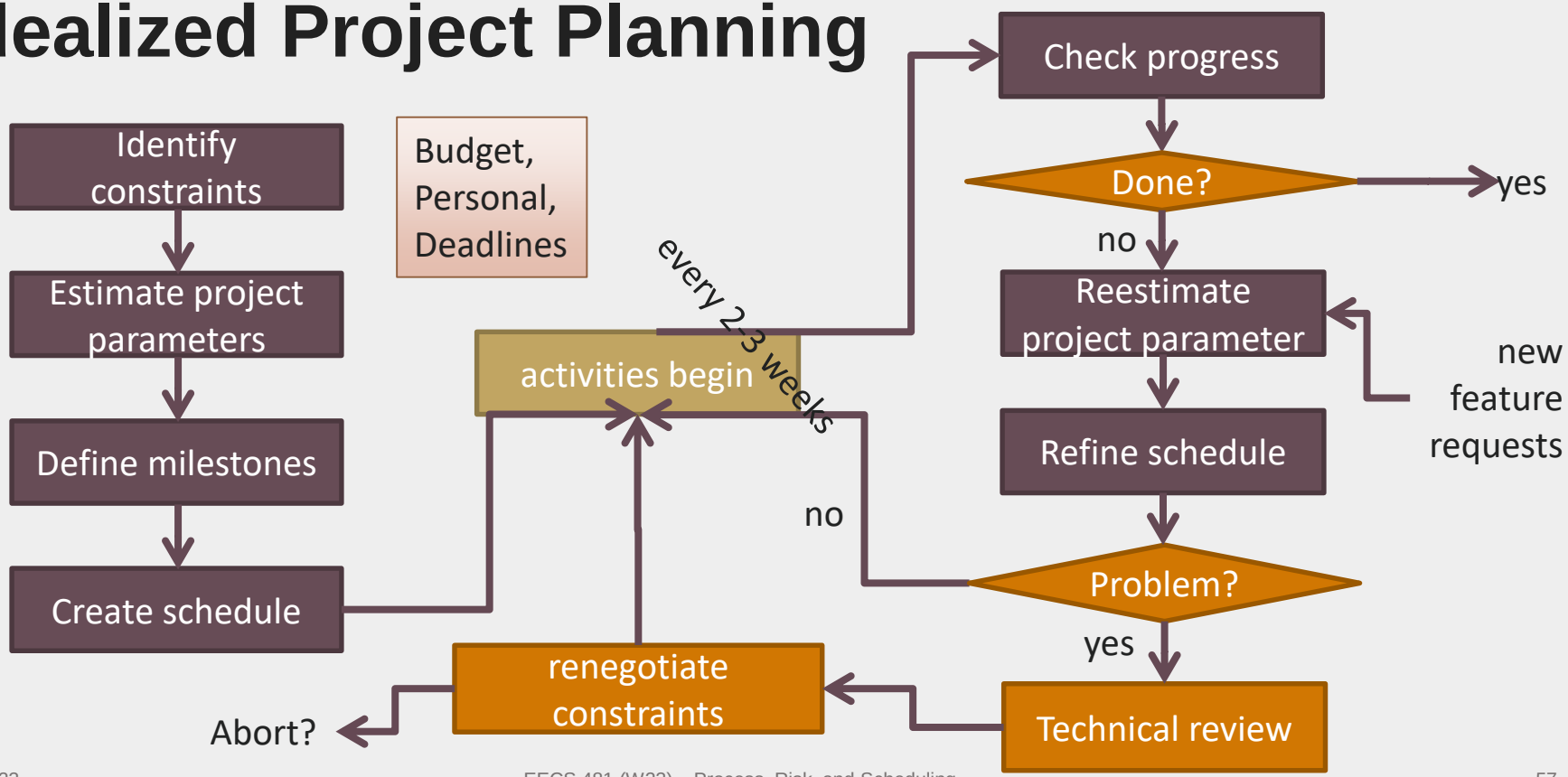
Measuring Progress

- “I’m almost done with the app. The frontend is almost fully implemented the backend is fully finished except for the one stupid bug that keeps crashing the server. I only need to find the one stupid bug, but that can probably be done in an afternoon. We should be ready to release next week.”

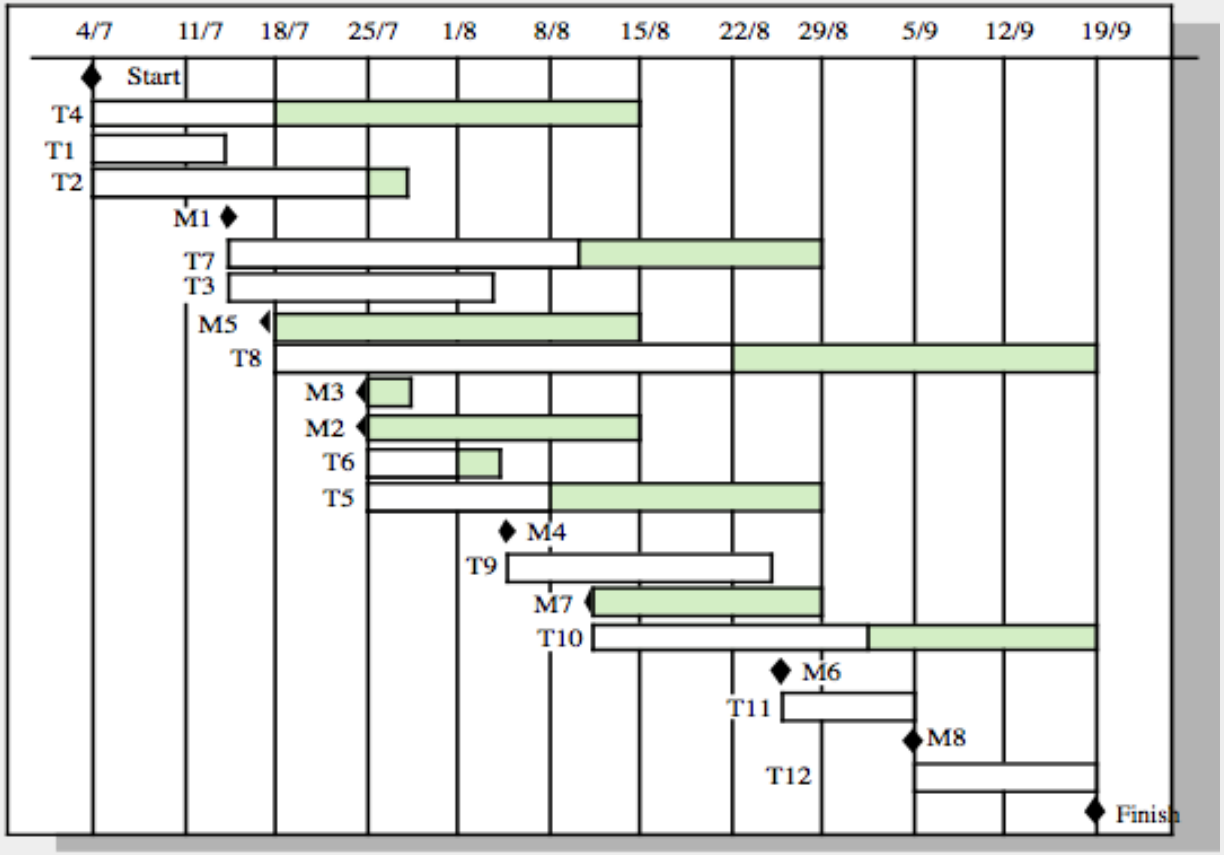
Milestones and Deliverables

- Milestones and deliverables make intermediate progress observable, especially for software
- A **milestone** is a clean end point of a (sub)task
  - Used by the project manager
  - Reports, prototypes, completed subprojects, etc.
  - “80% done” is not a suitable milestone
- **Deliverables** are results for the customer
  - Used by the customer, outward facing

Idealized Project Planning

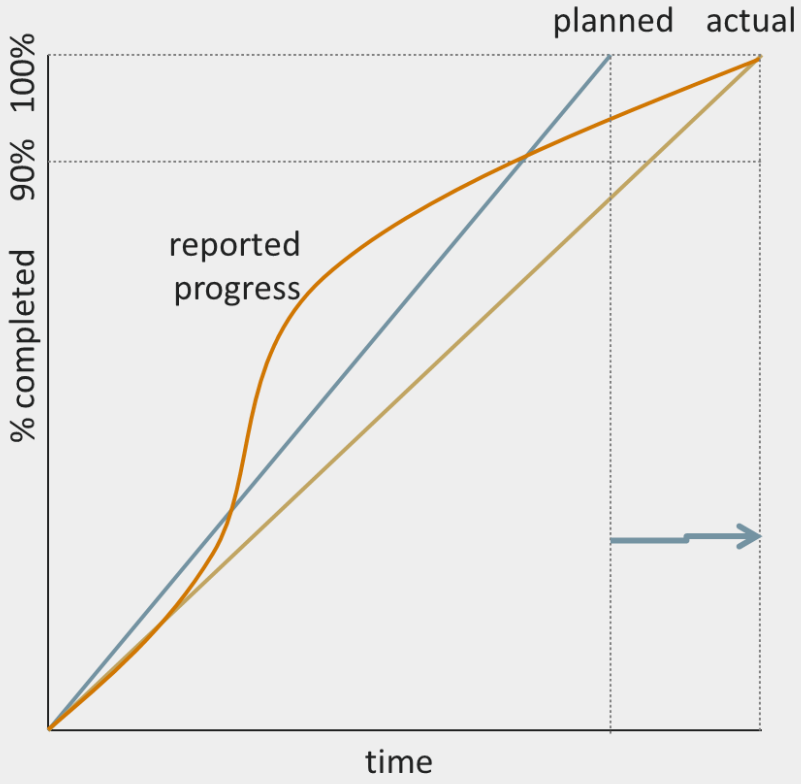


Gantt Chart


4/7
11/7
18/7
25/7
1/8
8/8
15/8
22/8
29/8
5/9
12/9
19/9
Start
T4
T1
T2
M1
T7
T3
M5
T8
M3
M2
T6
T5
M4
T9
M7
T10
M6
T11
M8
T12
Finish

Scheduling

- Inacurate predictions are normal → update
- The “almost done” problem: the last 10% of work takes 40% of the time
- Avoiding depending entirely on developer estimates



How does Microsoft solve this?

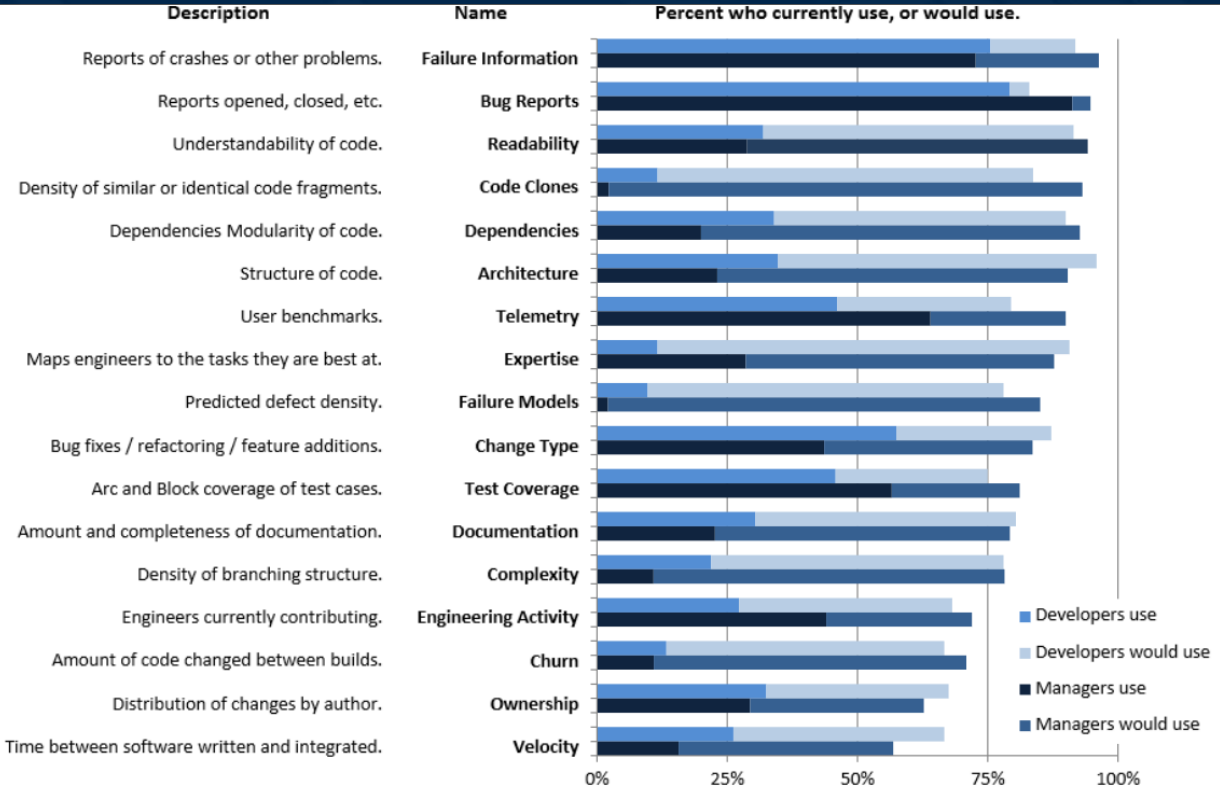


Fig. 5. Percent of managers and developers who reported that they either use or would use (if available) each of the given indicators in making decisions relevant to their engineering process.

The Story so far…

- Software processes can help, but to use them, we need project planning, which needs effort estimation, which is complicated by uncertainty, which stems from risk and a lack of data.
- So… we don’t know anything?
- Stay tuned next for **measurement**, a potential solution to our problems.
- Reminder: HW 0 due Wednesday!
- Other reading quizzes will be *surprise* pop quizzes