CSE 210 – Principles of Software Engineering

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Goals of the Course

- Work effectively in a team that uses an Agile development process
- Design and document software systems according to stakeholder needs
- Implement and debug complex software systems

- Bottom line: able to think in terms of **tradeoffs** and **risks**

Introductions

- Research in making software engineers more effective, mostly via better programming languages
- Recent work: smart contract languages; REST API design; Rust language
- Previously: Senior Software Engineer at Apple (eight years)

About Class

- Discussion is an integral part of class!
    - Past attempts have shown: Zoom is not as good
- BE HERE at 10 AM
- To promote open discussion, class will NOT be recorded
- Expect changes

Health

- Your health comes first
- Do not come to class sick
    - Instead, contact me for a Zoom link if you're up to it
- Masking is currently optional

Course Design

- Course design choice: learn **technologies** or **principles**?
- This class is optimized for learning **principles.**
- In assigning teams: we will assign according to the *tech stack* you want to learn and your schedule availability
- But we won't teach a specific technology
    - A quarter isn't enough anyway

Grading

- 40% project:
  - 22% your contribution:
    - Technical contributions
    - Teamwork
    - Independence/leadership
  - 18% team success (deliverables)
- 40% individual work
- 20% final exam

Individual assessment

- Reading responses
- Homework assignments

Teamwork

- Teamwork may be the hardest part of the class
- Team skills are a *learning goal*
- I and TAs are available to help!
- I will adapt content according to challenges you have
- Raise issues with each other and staff before they become serious, if possible
- Note: instructor and TAs are "responsible employees"
    - Please tell us about incidents of harassment, but know that we must report unlawful discrimination and harassment to OPHD

Course schedule

- This is a very tricky course to design!
- Some constraints:
    - Maximize time for project
        - recognizing that students add/drop for the first two weeks
    - Teach technical skills for security (Rust)
    - Rust assignment requires Rust lectures
- Result: Rust first

Giving you experience

- I want to give you as much experience as possible in just one quarter!
- Doing the work yourself is good but not enough
- Also: learn lessons from the past
- In business school: case studies
- Part of my approach: read "The Soul of a New Machine"

The Soul of a New Machine

- Pulitzer prize-winning book about the creation of a new computer in the early 80s
    - Written for a general audience
    - Themes: risk; management and people; design tradeoffs
- Available on Kindle ($10), Amazon ($20 new, maybe $10 used)
- You will submit a reading response on Gradescope (questions will be posted this week)
    - Due in three weeks

Questions about the course?

Why software engineering?

Building Great Software is Hard

2/3 of projects are *late* [Tata]

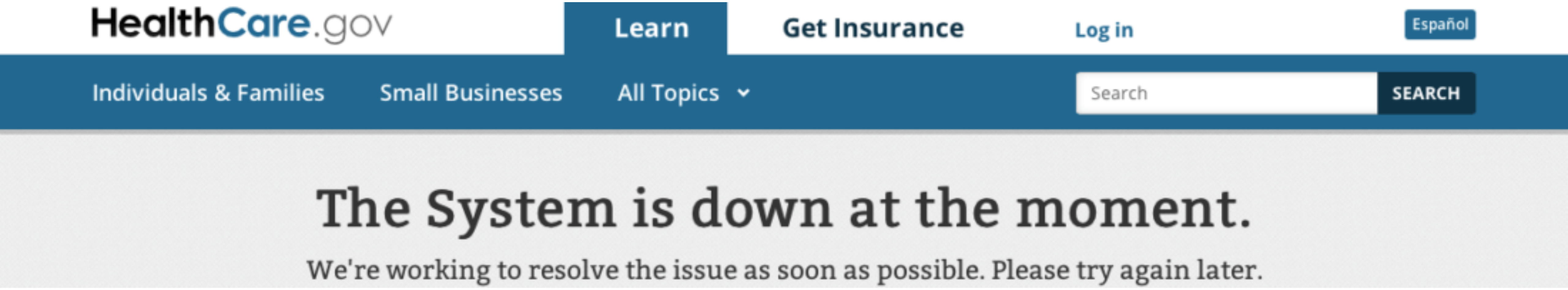
1/4 of all projects are *canceled* [Standish]

1/2 run *over budget* [Tata, SGR CACM]

Allstate insurance planned a 5-year, $8M project. Six years later they replanned for $100M.

http://www.galorath.com/wp/software-project-failure-costs-billions-better-estimation-planning-can-help.php

Healthcare.gov



The System is down at the moment.

We're working to resolve the issue as soon as possible. Please try again later.

- Demand (5x expected) took site down within 2 hrs. of launch
- Site incomplete (menus missing options, incomplete data transmitted to insurance companies)
- 6 users bought insurance the first day

https://d3.harvard.edu/platform-rctom/submission/the-failed-launch-of-www-healthcare-gov/

healthcare.gov failure causes

- HHS staff lacked experience launching technology products
- Failure to divide responsibilities appropriately
- Schedule pressure: launched before ready

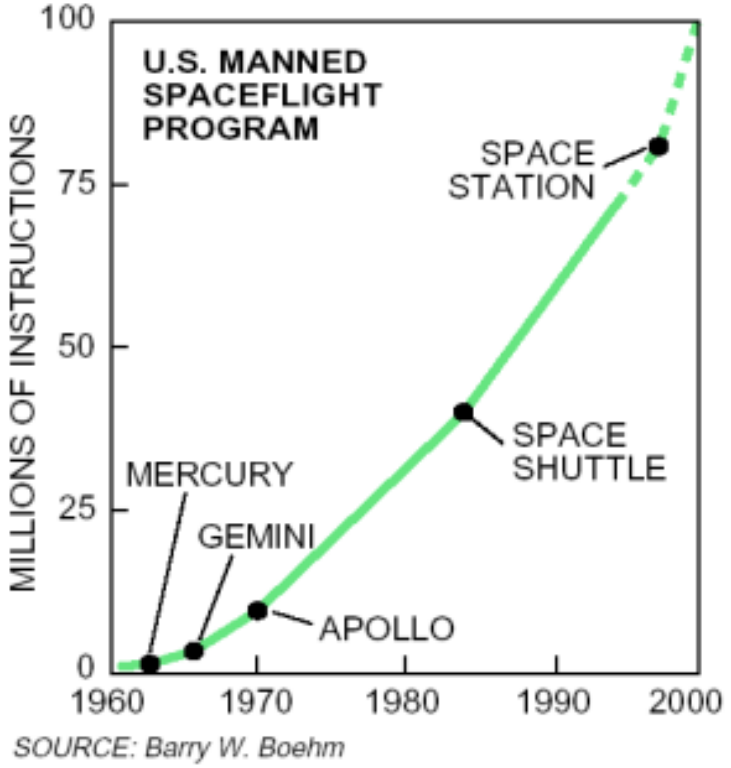
https://d3.harvard.edu/platform-rctom/submission/the-failed-launch-of-www-healthcare-gov/

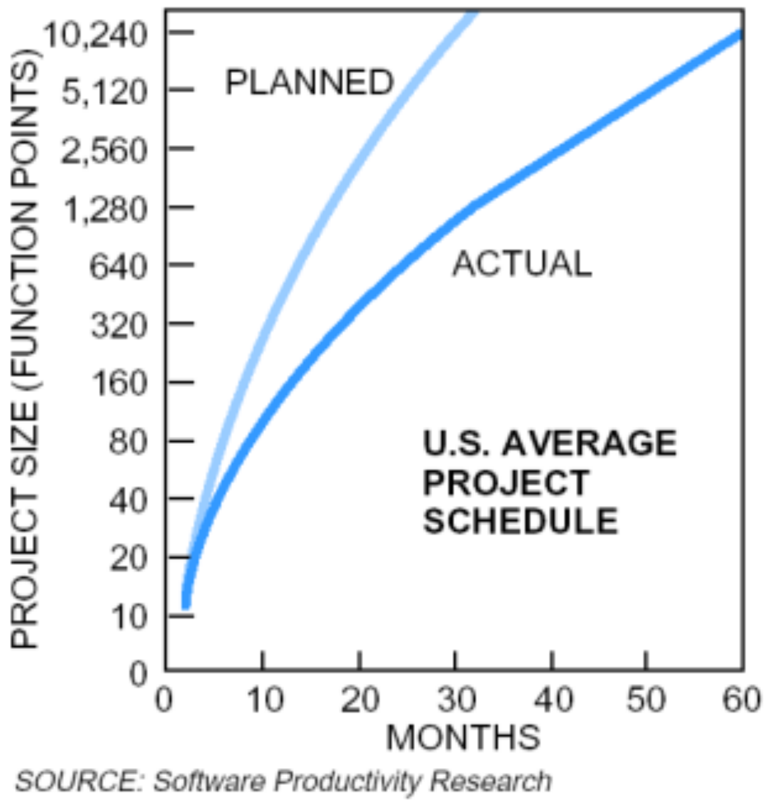
737 MAX

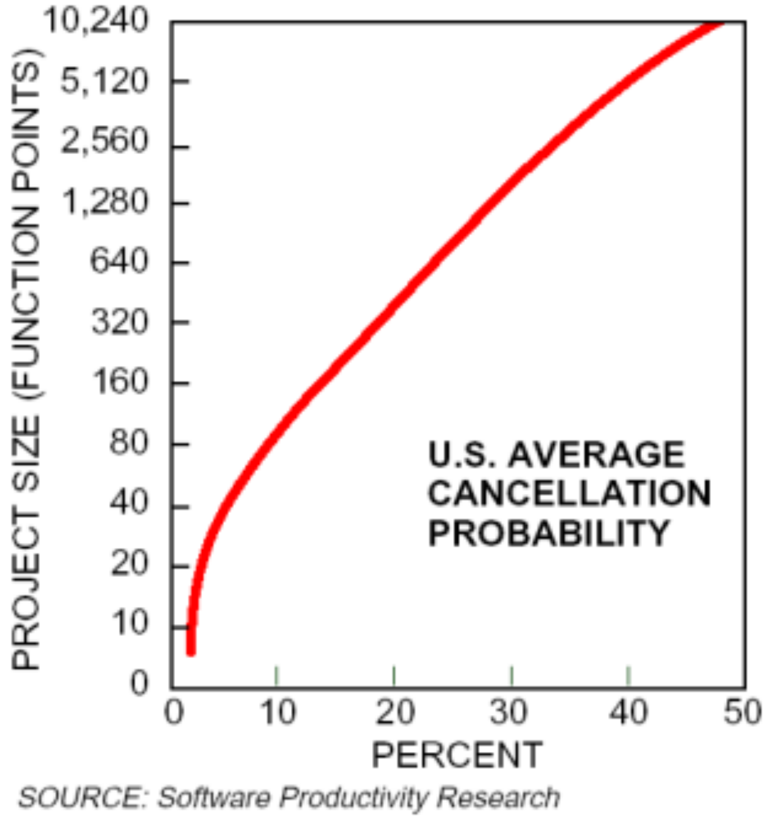
- To avoid cost of a major redesign, Boeing took shortcuts in aerodynamic design of 737 MAX
- Software was updated to compensate for side effects
- Software was not robust to angle of attack sensor failures (single point of failure)
- Pilots were insufficiently trained on failure modes
- Result: 346 deaths

https://spectrum.ieee.org/how-the-boeing-737-max-disaster-looks-to-a-software-developer

Why the disasters? Scale.

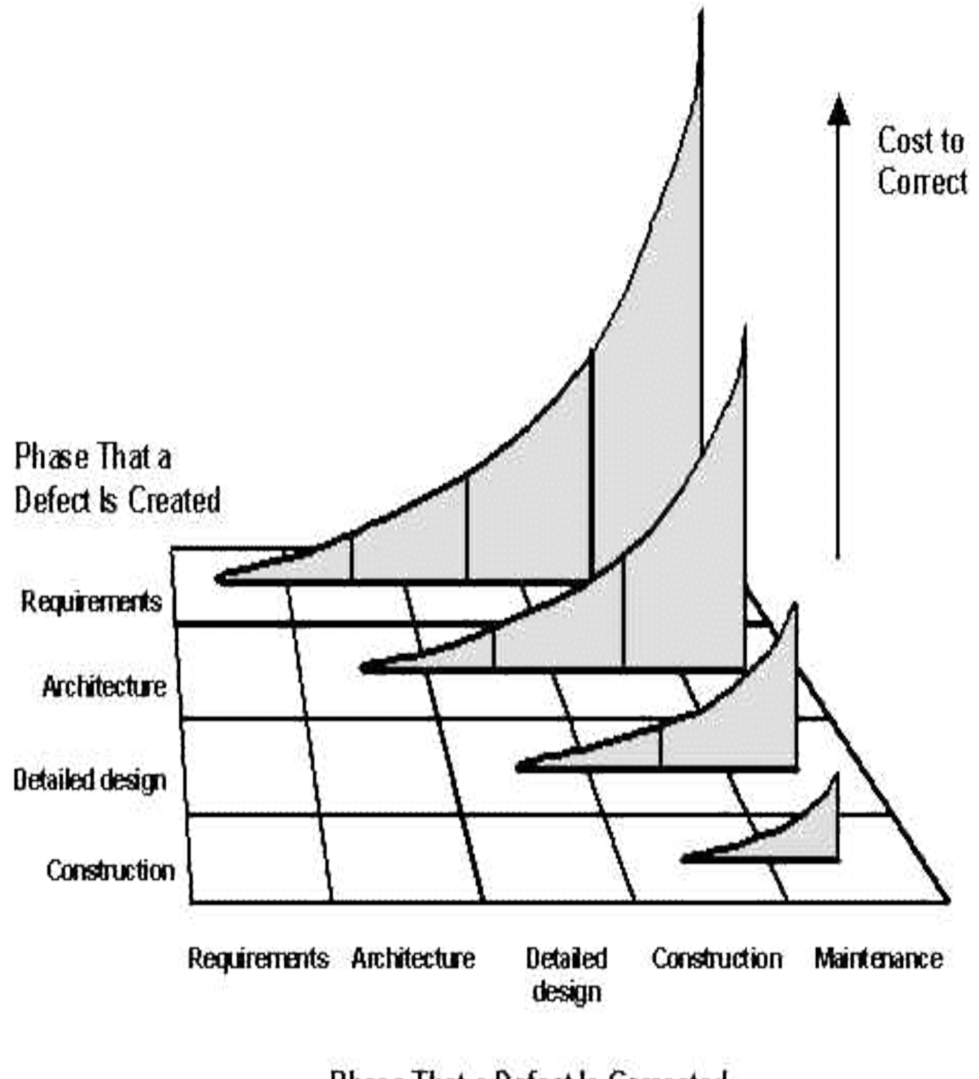






Users want more and more features

Why the disasters?
Misunderstood and changing requirements



"…reworking a software requirements problem once the software is in operation typically costs 50 to 200 times what it would take to rework the problem in the requirements stage… A 1-sentence requirement can expand into…500 lines of code…and a few dozen test cases."

Steve McConnell, Software Quality at Top Speed, *Software Development*, August 1996

Change/Evolution yields Complexity/Bugs

Figure 4 Serial and average growth trends of a particular attribute

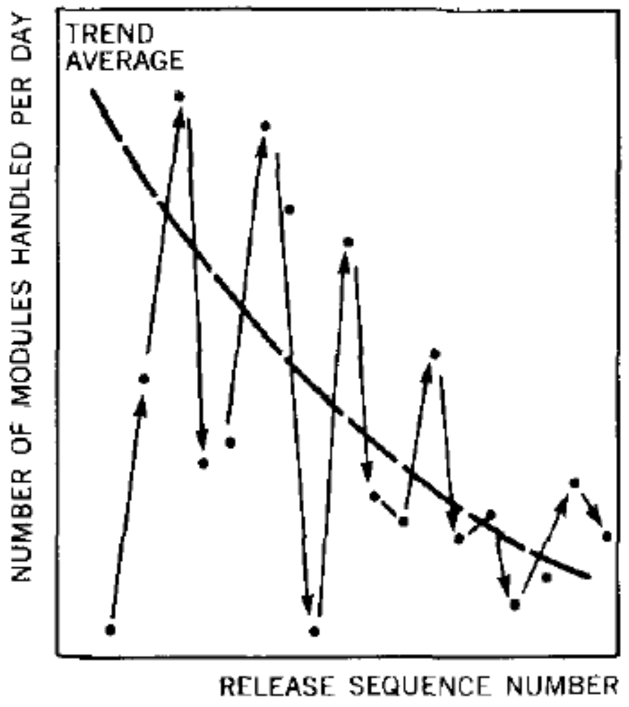
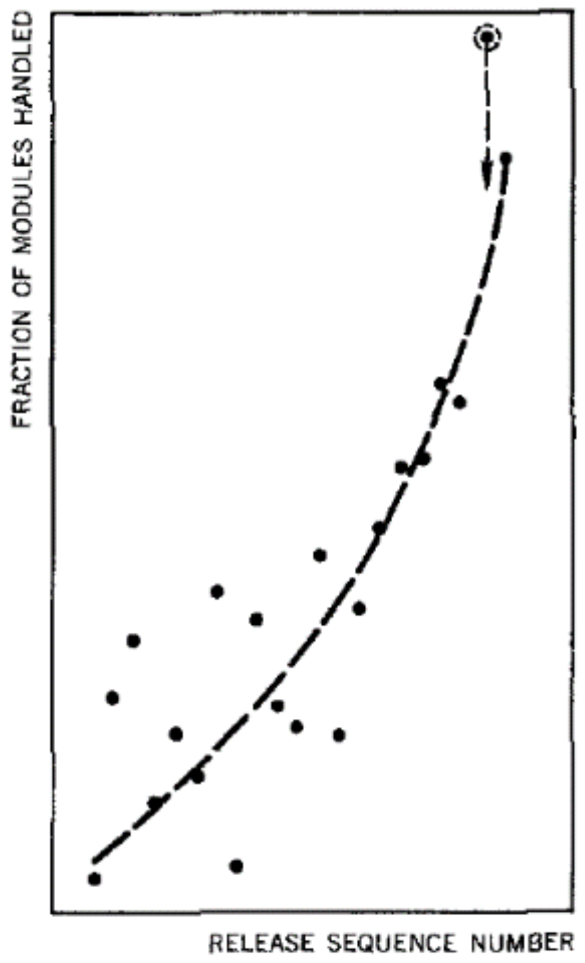


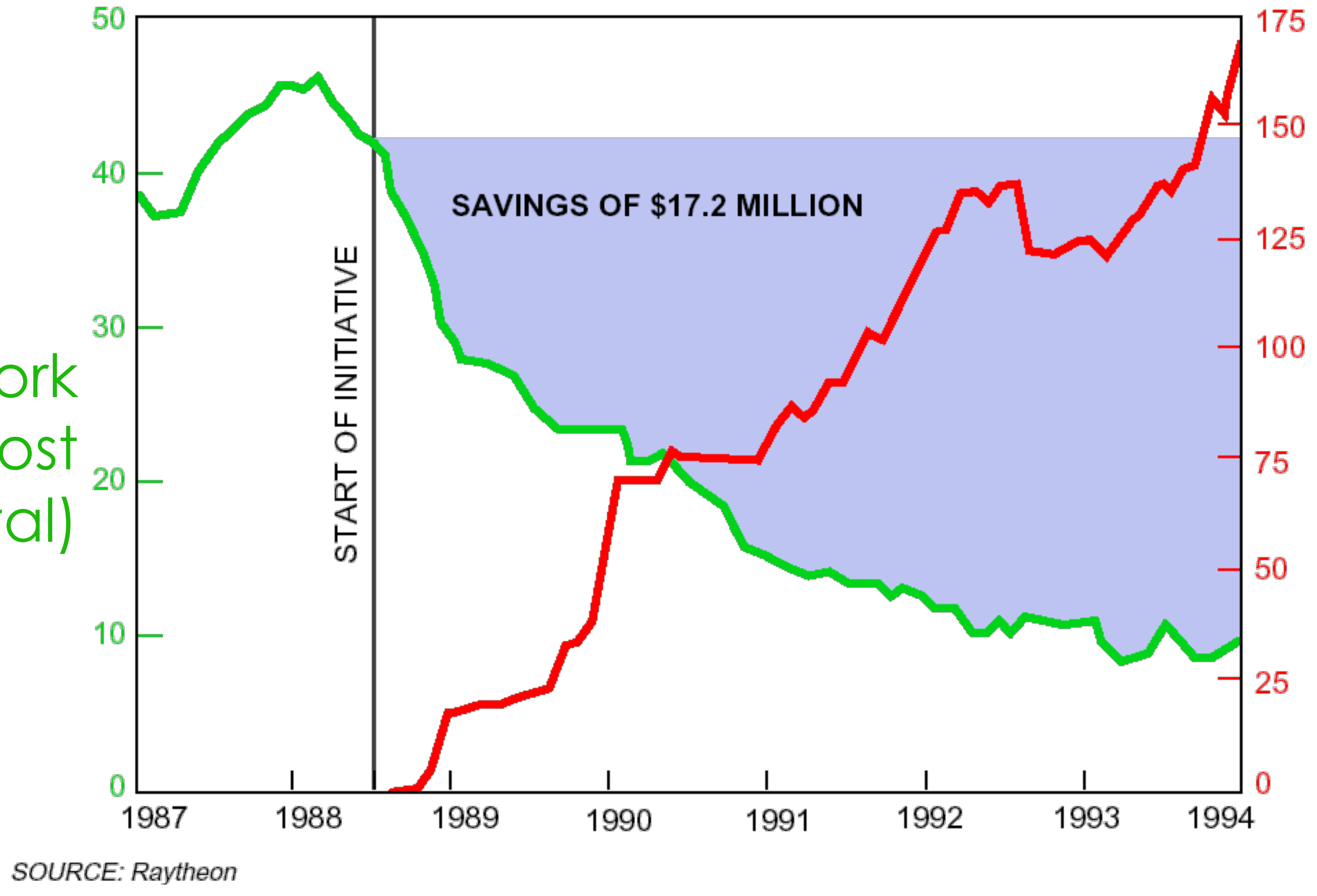
Figure 7 Complexity growth during the interval prior to each release



Belady & Lehman, A Model of Large Program Development, IBM Systems Journal, (15)3, 1976

S.E. Practices Like Agile Make a Difference

Rework Cost (% of total)



Productivity Increase (%)

SE practices are rooted in process-centric quality control

Results of Raytheon's use of best-practices.

SCIENTIFIC AMERICAN *September 1994* 91

Quality Control: A Short History

Quality control in early manufacturing was **Product-Centric** (“what”)

- Regularly test **product** outputs
- Make adjustments to factory as needed
- *But what to fix?*

mid-20th c., shift to **Process-Centric** (“how”)

- Still test **product** outputs
- Also measure **process** elements
  - *plans, people, tools, product-in-progress*
- Use **cause-and-effect model** to adjust factory as needed
- Statistics to precisely track variation
- Buzzword: *Statistical Process Control*

- **SE has inherited this legacy**
- ***SE methods are process-centric***

What's a Software Process?

It's the "how" that produces the "what" – quality software

- *What:* what customer wants, on time, under budget, free of flaws

A prescribed sequence of steps

Steps include:

- Planning
- Execution
- Measurement
    - Product, and process itself
    - Examples: *bugs, progress, time, feature acceptance by cust.*

A software process is a self-aware algorithm

- *Observes and adapts according to measurements*

Agile processes are adaptive to the "customer"

- Features, schedule, budget, priorities, markets, change
- Must measure these as well as internal elements (correctness)
- Easily extended to adapting to many other "problems"
    - …as long as they can be observed and measured

The Changing Face of Software

Applications

- Web 2.0, Mobile 2.0, …
- Ubiquitous computing
- Developing world
- Big data, AI, ….

Methodologies

- Open Source
- Agile (XP, Scrum)

Technologies

- Web services, JavaScript, AJAX, JQuery, …
- Programming environments
- Component-based, Model-driven software development

Do we rewrite the rules, or just reinterpret them?

Technical Themes of the Course

Scale

All of computer science, especially CS research, is about *managing scale*. So is SE.

Risk, Uncertainty

SE is all about *managing risk*. Doing something important requires taking risks. SE seeks to increase upside risk (great products), while decreasing downside risks (late, buggy, etc.)

Beyond Process

- Process is just the beginning
- Software engineering is about quality decision-making
    - Good architecture
    - Teamwork
    - Good design
    - Thorough quality assurance
- This course is about all of these things.

Project

- Everyone has some health and wellness concerns.
  - Exercise
  - Nutrition
- Some people have additional concerns.
  - Chronic conditions (diabetes, asthma, depression, etc.)
  - Acute illness (COVID, flu, etc.)
- Create something to help *some* people with health or wellness.
  - Any platform, any technology, any target audience for which you can find outside stakeholders (not yourselves)

Learning goals: first two weeks

1. Elevate your programming skill beyond *make it work* toward *professional* (maintainable, high-quality)

2. Learn practical skills for security (avoiding unsafe practices)

3. Learn re-usable design principles (ownership)

4. Learn and practice code review

What do you want to learn?