# Foundations of Software Engineering

Process: Linear to Iterative

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# Learning goals

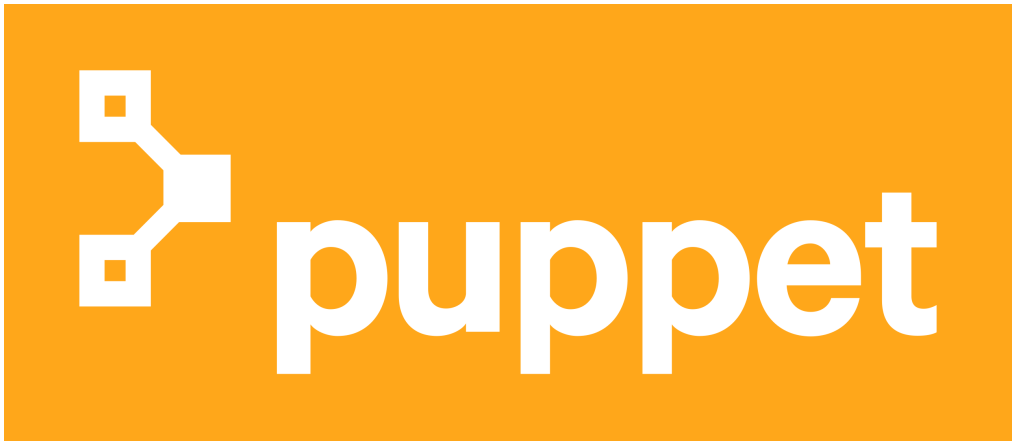
- Understand the need for process considerations
- Select a process suitable for a given project
- Address project and engineering risks through iteration
- Ensure process quality.

# Administrivia

- HW4 due today

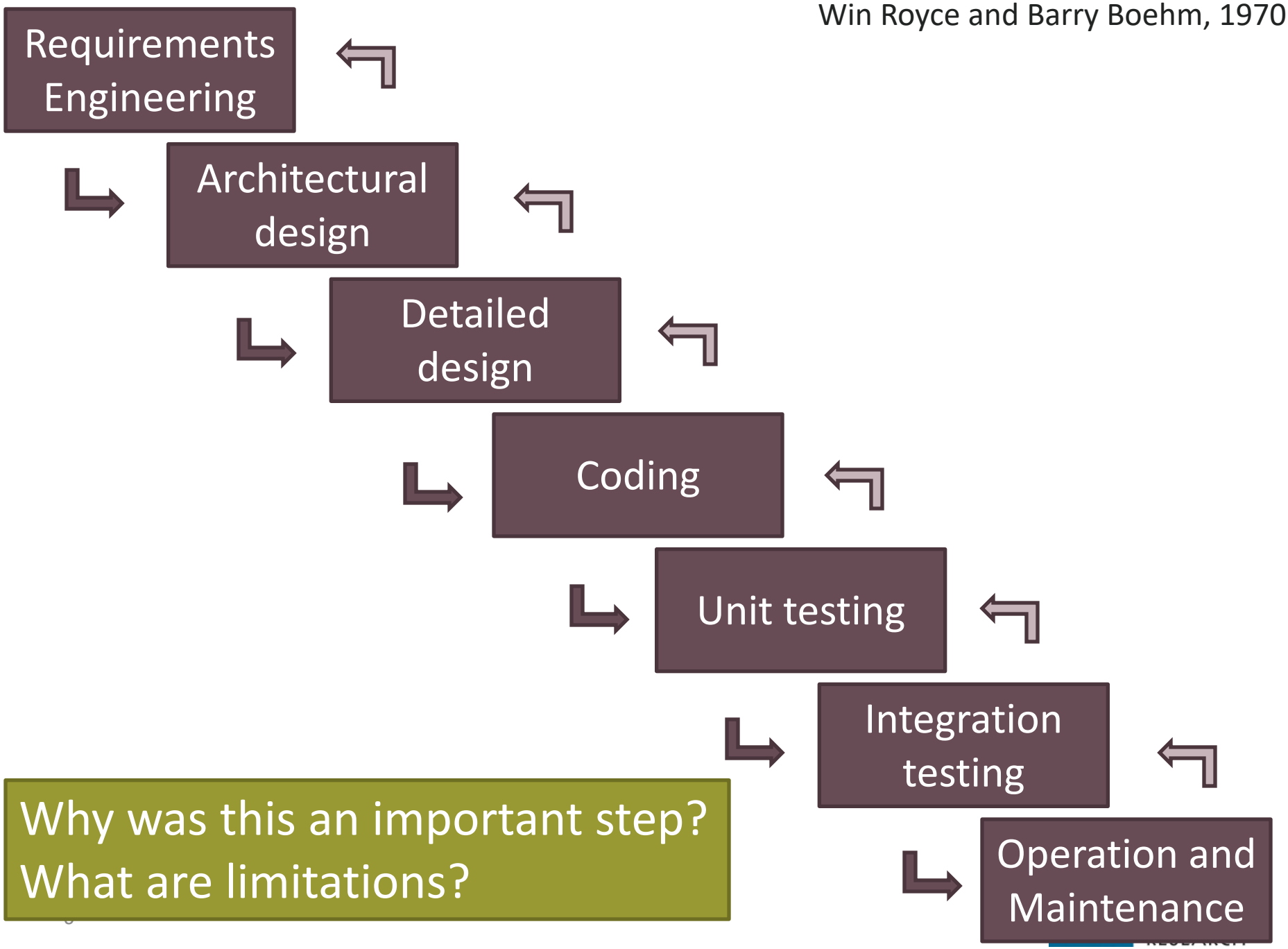
# Interview

- Sean McDonald



# The Waterfall Model

Win Royce and Barry Boehm, 1970



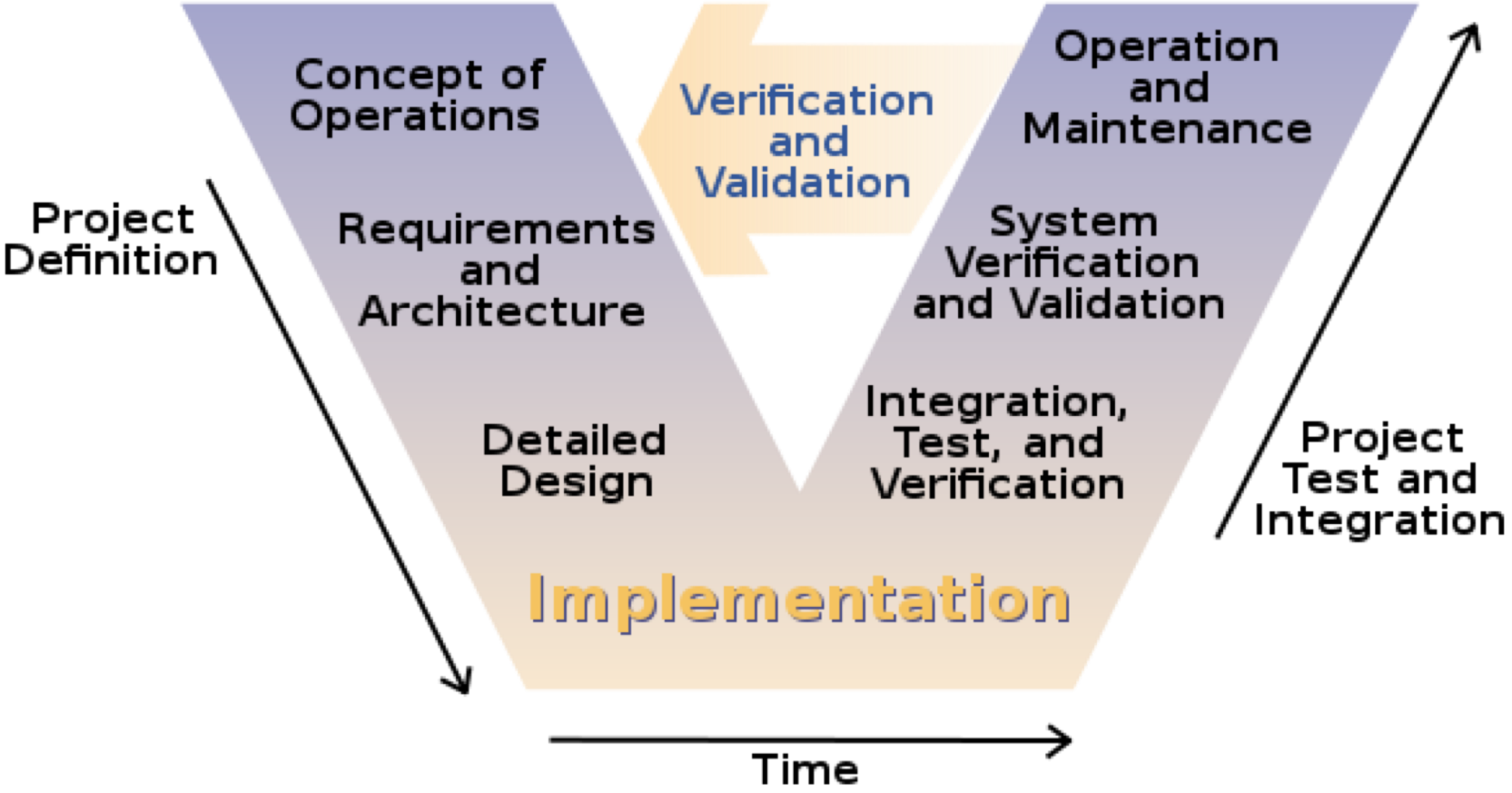

Why was this an important step?
What are limitations?

1:32pm
July 16th 1969

# Key challenge: Change

- Software seems changeable ("soft")
- Developers prone to changes and "extra features"
- Customers often do not understand what is easy to change and what is hard
- "Good enough" vs. "optimal"

# The "V" Model (80s, 90s)



# When is waterfall appropriate?

1. The requirements are known in advance.
2. The requirements have no unresolved, high-risk risks such as due to cost, schedule, performance, safety, security, user interfaces, organizational impacts, etc.
3. The nature of the requirements will not change very much.
4. The requirements are compatible with all the key system stakeholders' expectations.
5. The architecture for implementing the requirements is well understood.
6. There is enough time to proceed sequentially.

# Early improvement: sequencing

- Enforce earlier software considerations
- Waterfall instituted at TRW (Aerospace Govt Contractor) in 70s, with several additional recommendations for iterations (like prototypes).
- Modeled after traditional engineering
  - blueprints before construction
  - decide what to build, build it, test it, deploy
  - Reduce change
- Successful model for routine development
- Problematic at large scale
  - Requirements -> Delays -> Surprise!

# A natural engineering process?

- Decide what to build
- Build it
- Test it
- Deploy it

- Don't know what to build in advance
- Don't know all details how to build
- Struggling with testing and evaluation
- Deploy, evolve, redeploy

-> Early and frequent feedback

-> Support for constant adaptation

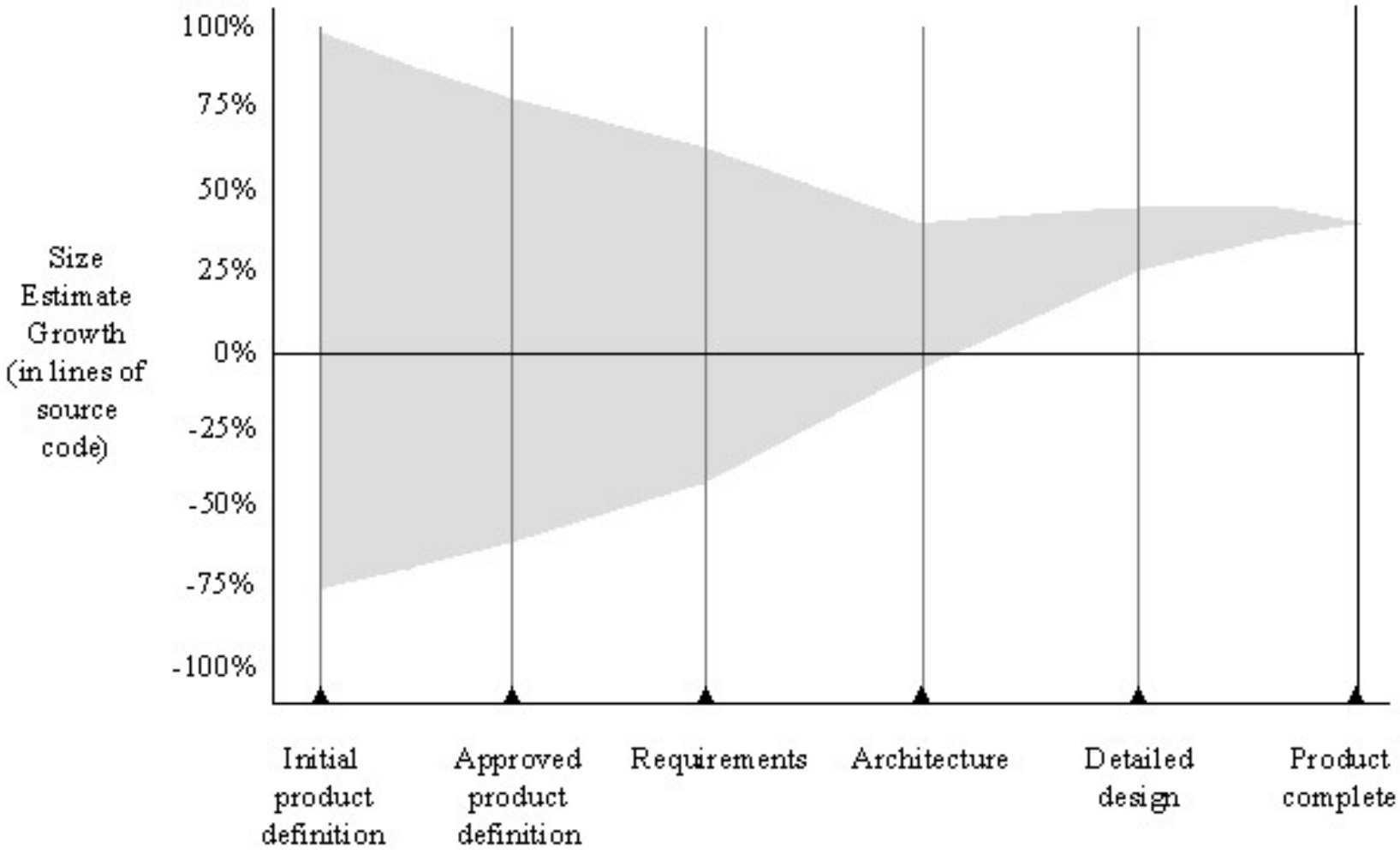
# Iteration!

-> Early and frequent feedback
-> Support for constant adaptation
-> Address risks first

# Software Engineering *Risks*

- Project risks
  - Projects late, buggy, cost overruns
- System risks
  - Security and safety issues
  - e.g. Toyota case
- Engineering risks
  - Unsuitable technology choices, validation issues, usability issues, scalability issues …

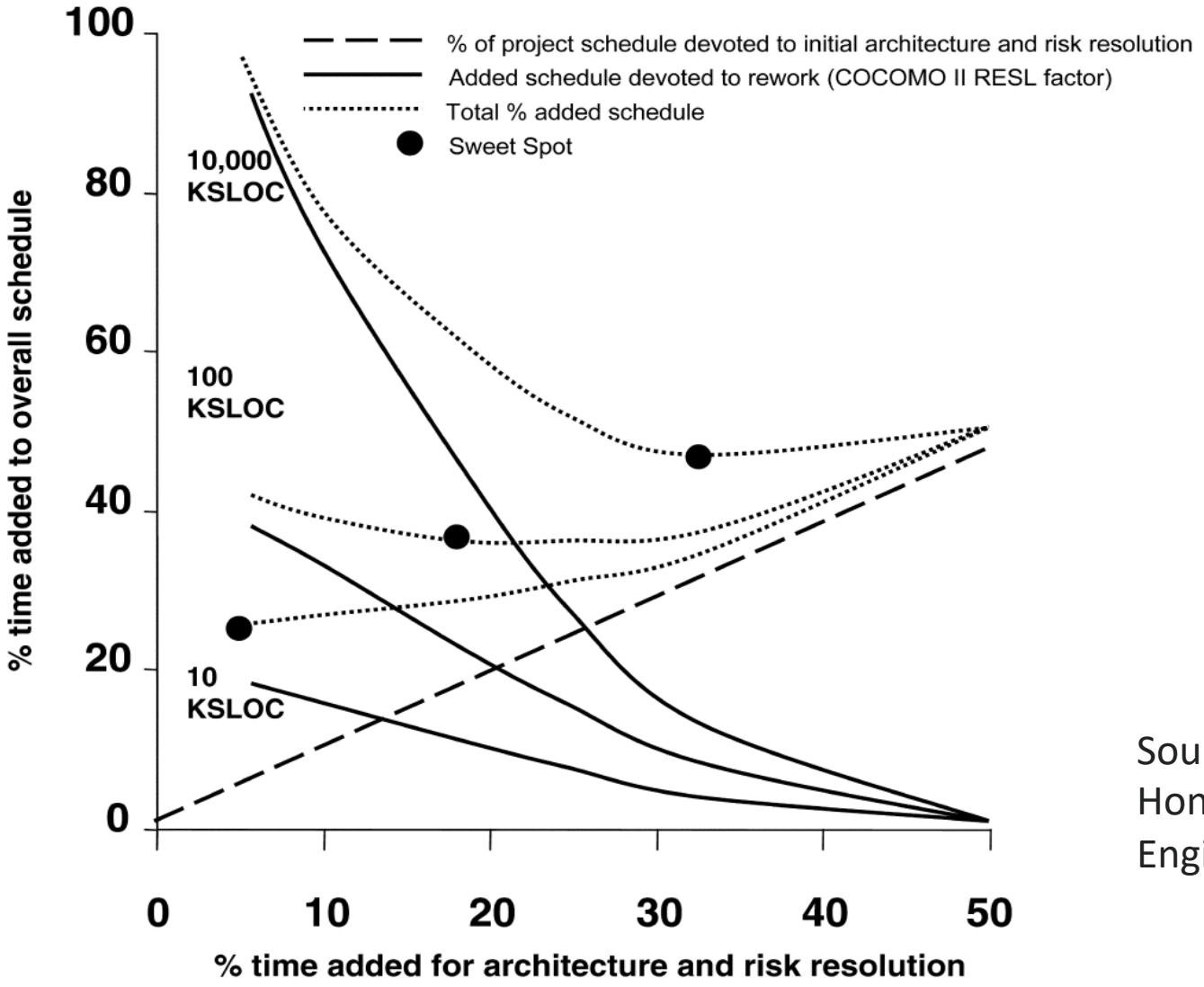
# Cone of Uncertainty



# Mitigation of risk through process interventions (examples)

- Risk-driven process
  - Prioritization and prototyping
- Architecture and design
  - Isolate/encapsulate risks
  - Follow industry standards
- Design for assurance
  - Preventive engineering
  - Codevelopment of system and evidence
- Functionality and usability
  - Prototypes , early usability labs

# The Role of Architecture

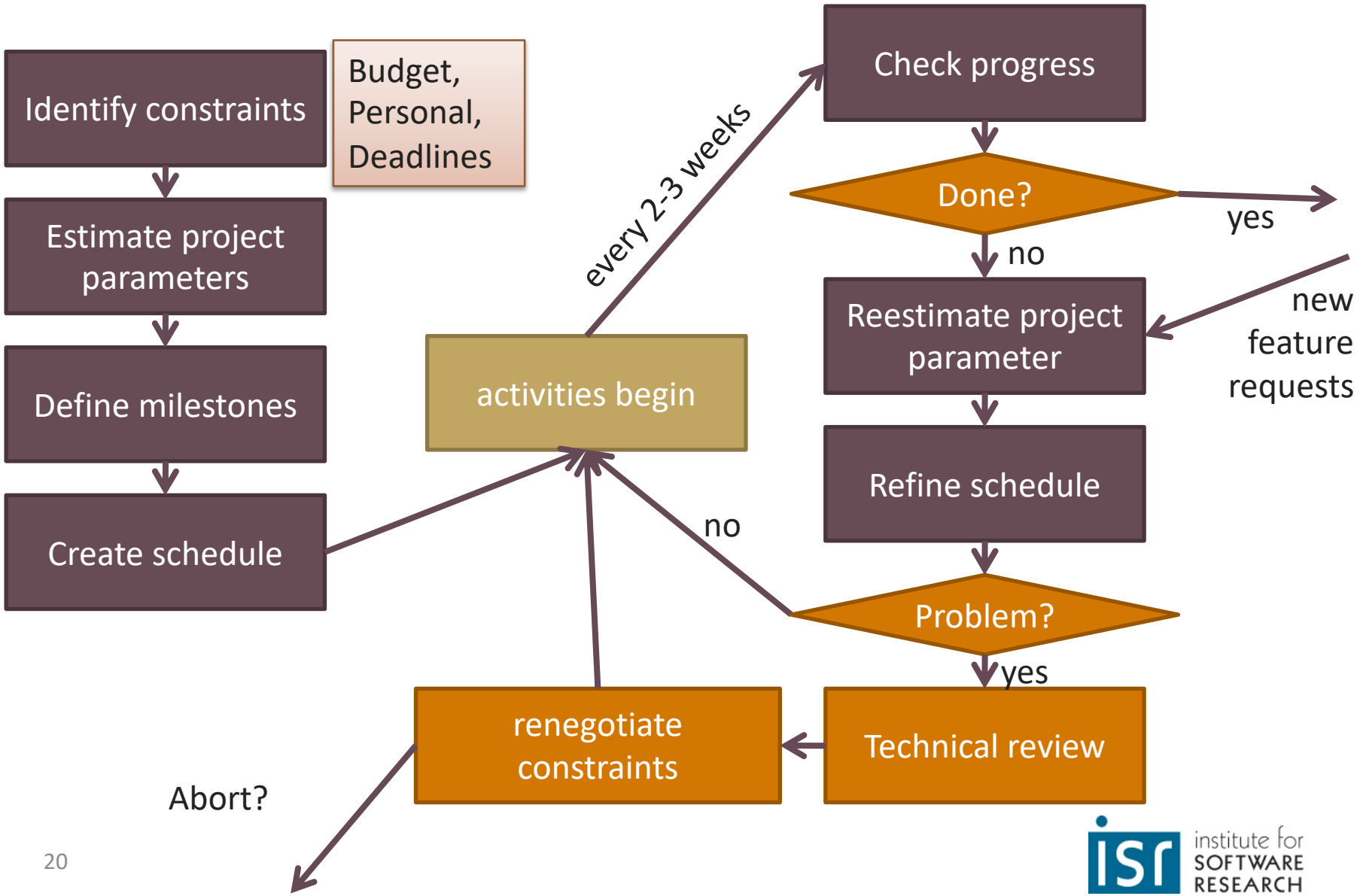



Source: Boehm, Valerdi, Honour, The ROI of Systems Engineering. 2008

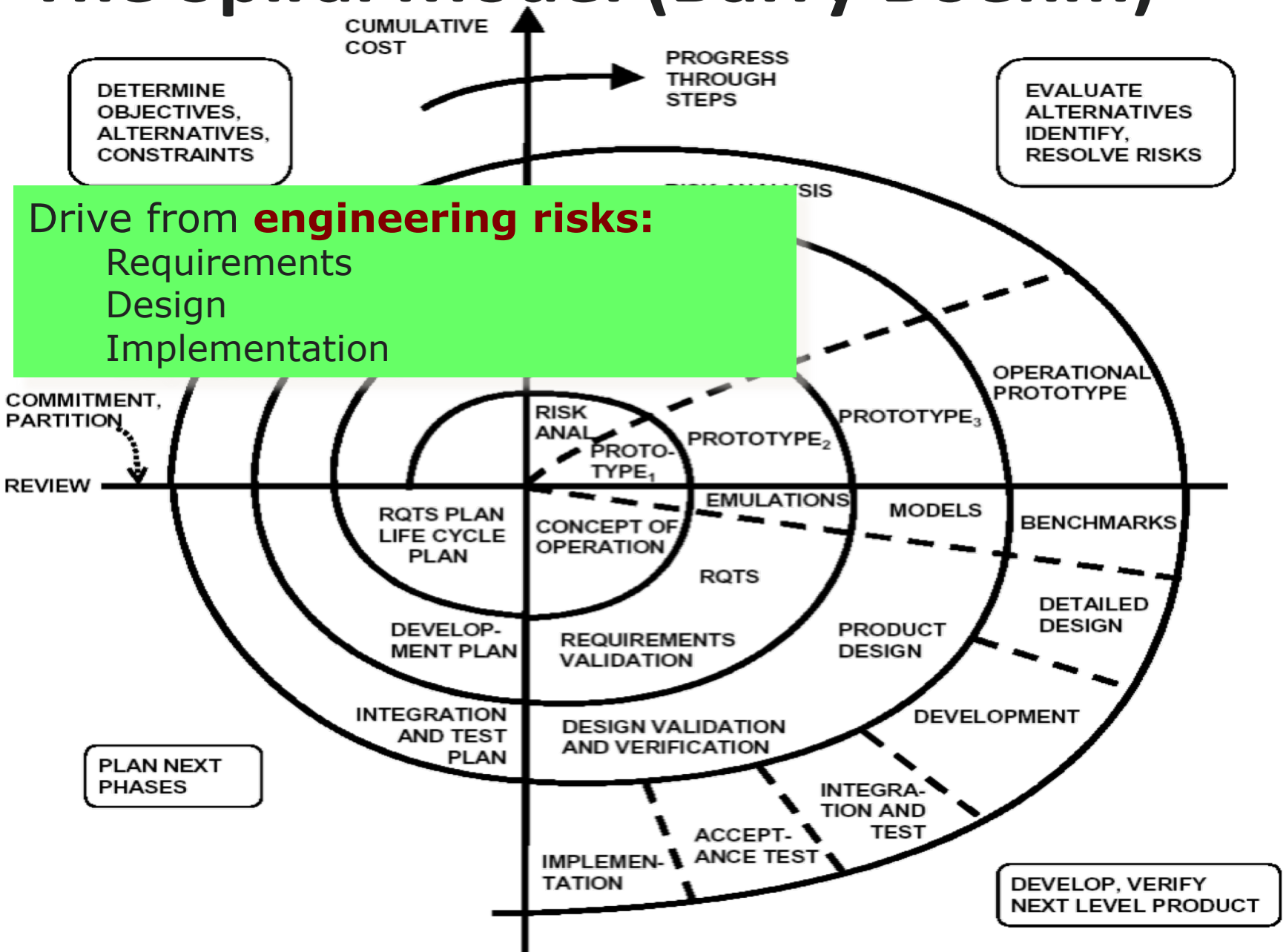
# Key: Iterative Processes

- Interleaving and repeating
  - Requirements engineering, Risk assessment
  - Architecture and design
  - Implementation
  - Quality assurance
  - Deployment
- But when, in which sequence, and how often?
- What measurements can ground decisions?

# Iteration in Project Management



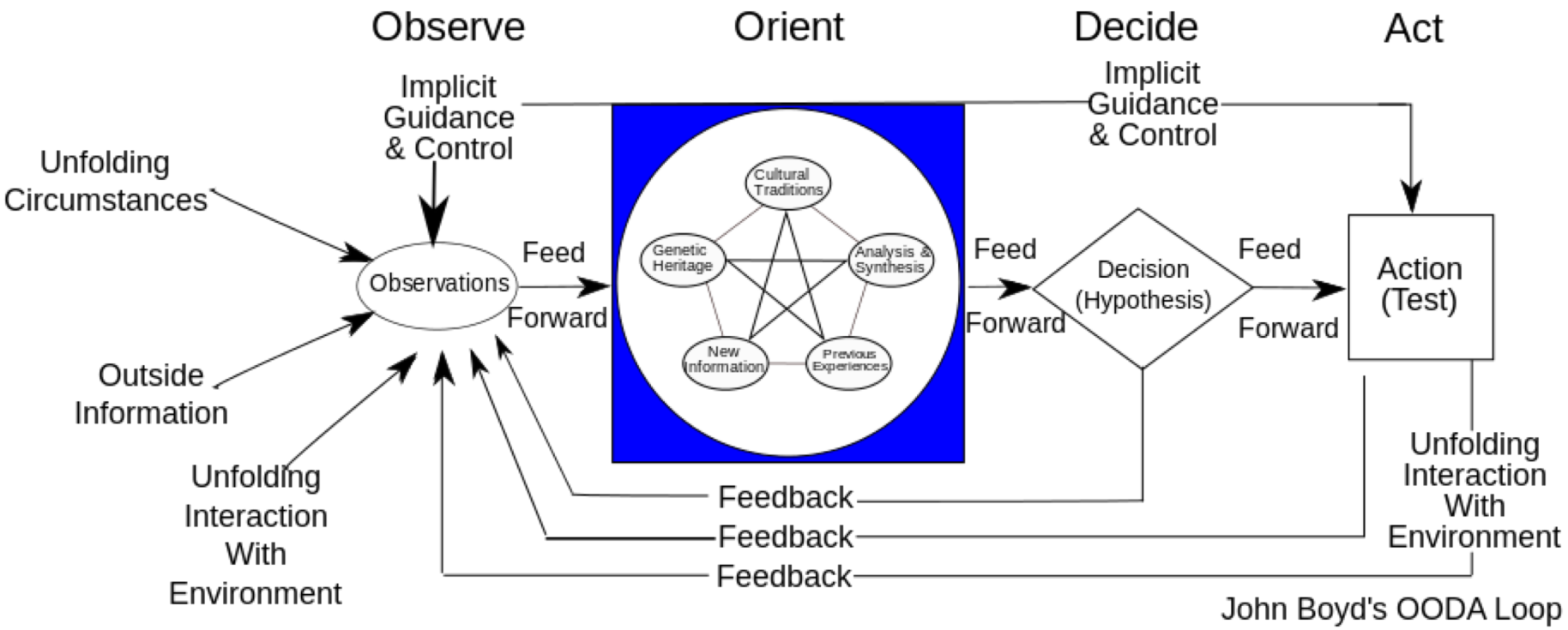
# The Spiral Model (Barry Boehm)




Drive from **engineering risks:**

- Requirements
- Design
- Implementation

# OODA Loop



# Iteration decision

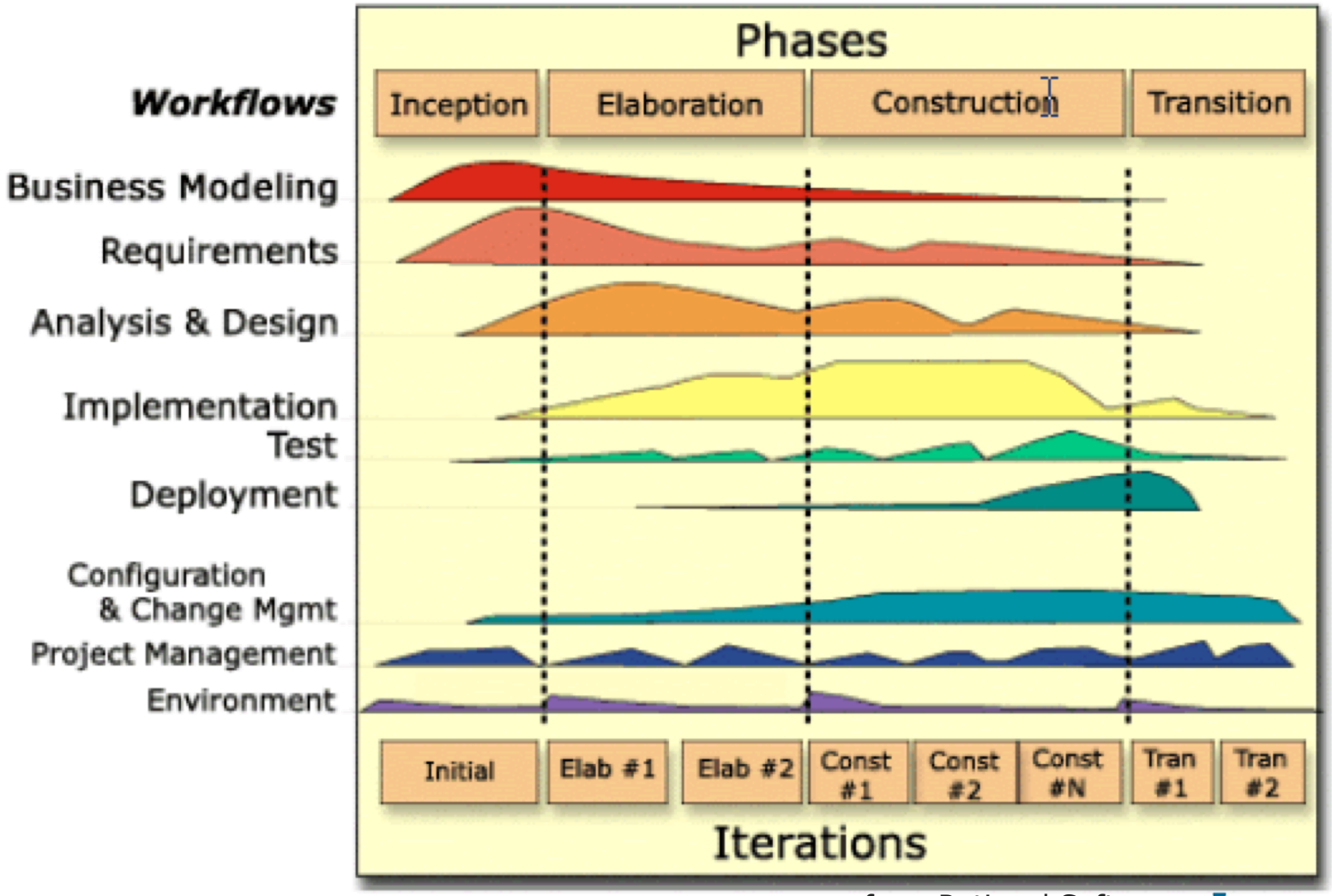
- Too slow?
- Too fast?

- -> Drive by risks and measurement data; per project decision
- Contracts?

# Iteration decision

- Too slow?
  - Late reaction, reduce predictability
- Too fast?
  - Overhead, reduce innovation
- "Death spiral"
  - deferred commitment, prototypes without conclusions, missing feedback loops
- -> Drive by risks and measurement data; per project decision
- Contracts?

# Rational Unified Process (UP)



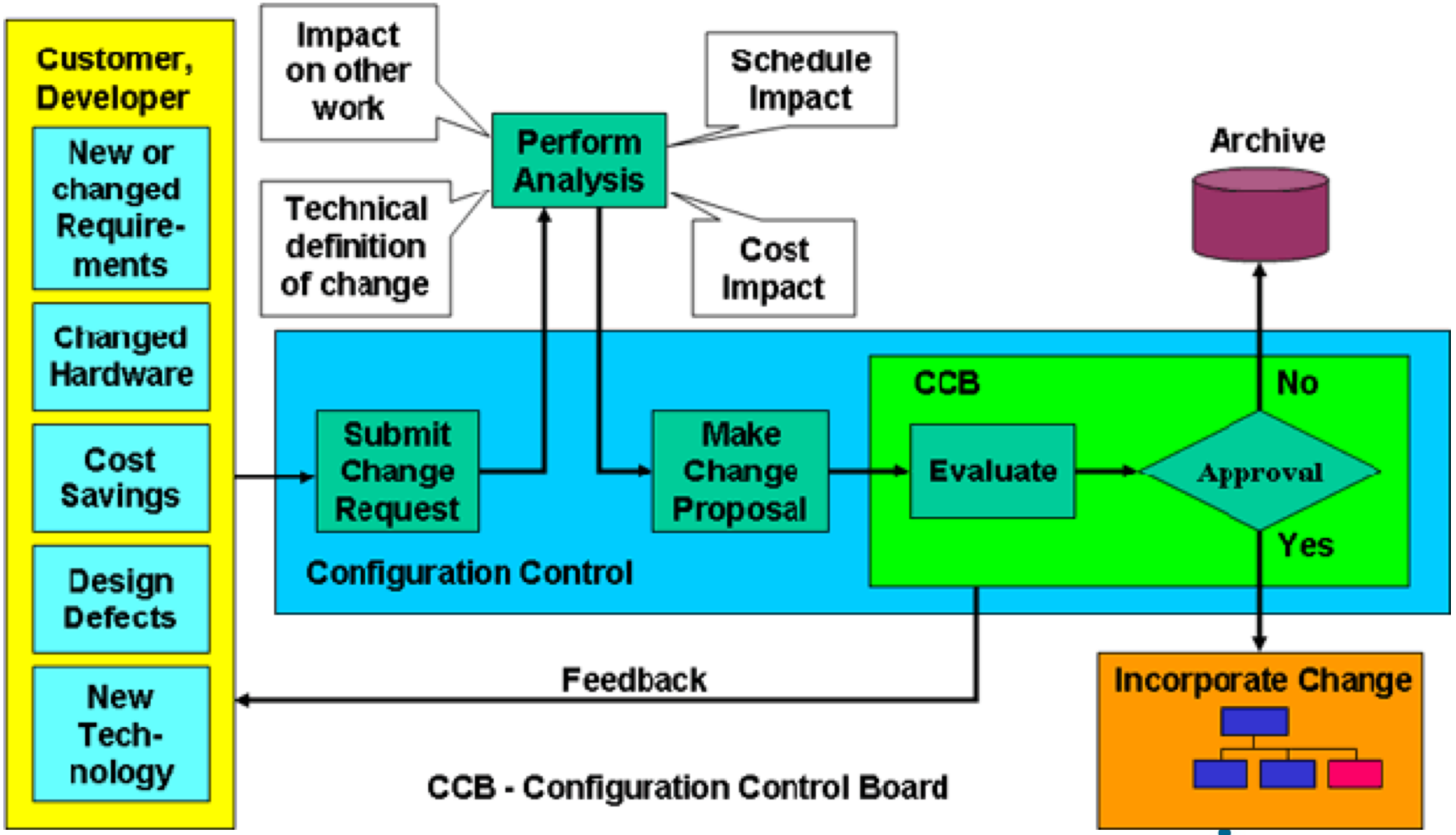

from Rational Software

**(more on Agile, XP, Scrum, Kanban in a later lecture...)**

# Iterative vs. Incremental?

# Change Control

# Change Control Board






www.chambers.com.au

## Change Request Form

**Project:** SICSA/AppProcessing **Number:** 23/02
**Change requester:** I. Sommerville **Date:** 20/01/09
**Requested change:** The status of applicants (rejected, accepted, etc.) should be shown visually in the displayed list of applicants.

**Change analyzer:** R. Looek **Analysis date:** 25/01/09
**Components affected:** ApplicantListDisplay, StatusUpdater

**Associated components:** StudentDatabase

**Change assessment:** Relatively simple to implement by changing the display color according to status. A table must be added to relate status to colors. No changes to associated components are required.

**Change priority:** Medium
**Change implementation:**
**Estimated effort:** 2 hours
**Date to SGA app. team:** 28/01/09 **CCB decision date:** 30/01/09
**Decision:** Accept change. Change to be implemented in Release 1.2
**Change implementor:** **Date of change:**
**Date submitted to QA:** **QA decision:**
**Date submitted to CM:**
**Comments:**

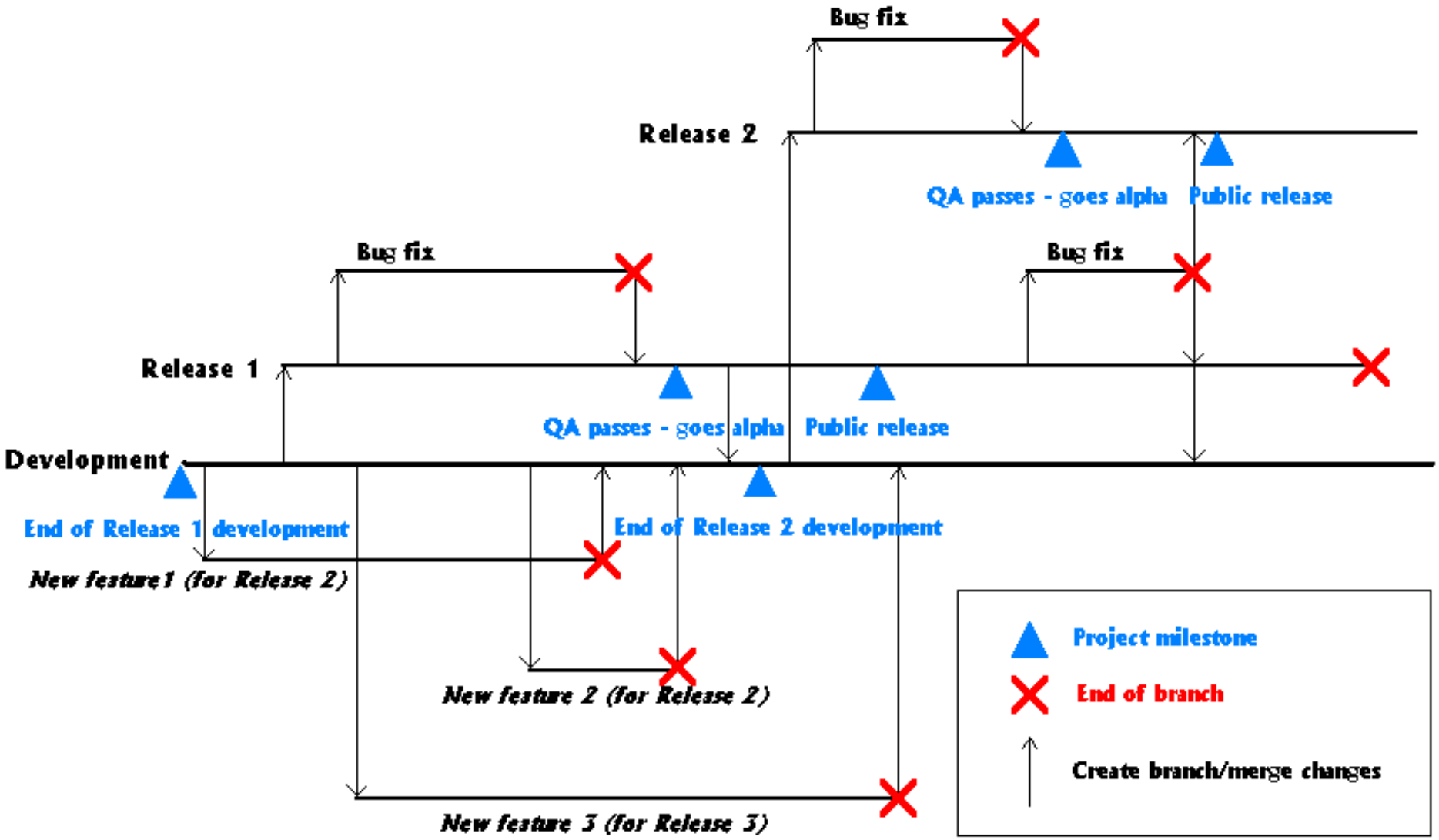
# Change Impact Analysis

- Estimate effort of a change
- Analyze requirements, architecture, and code dependencies
- Tractability very valuable if available
- Various tools exist, e.g., IDE call graphs

# Feature Freeze

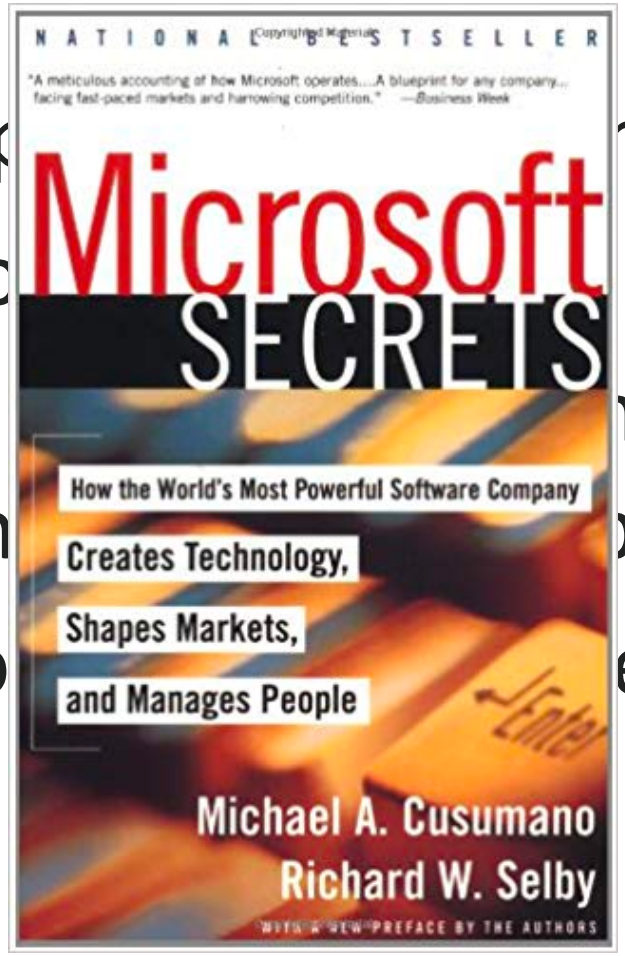
- Pre-release phase
- Do not allow any changes except bug fixes
- Avoid destabilization

# Release Planning with Branches



# Case Study: Microsoft

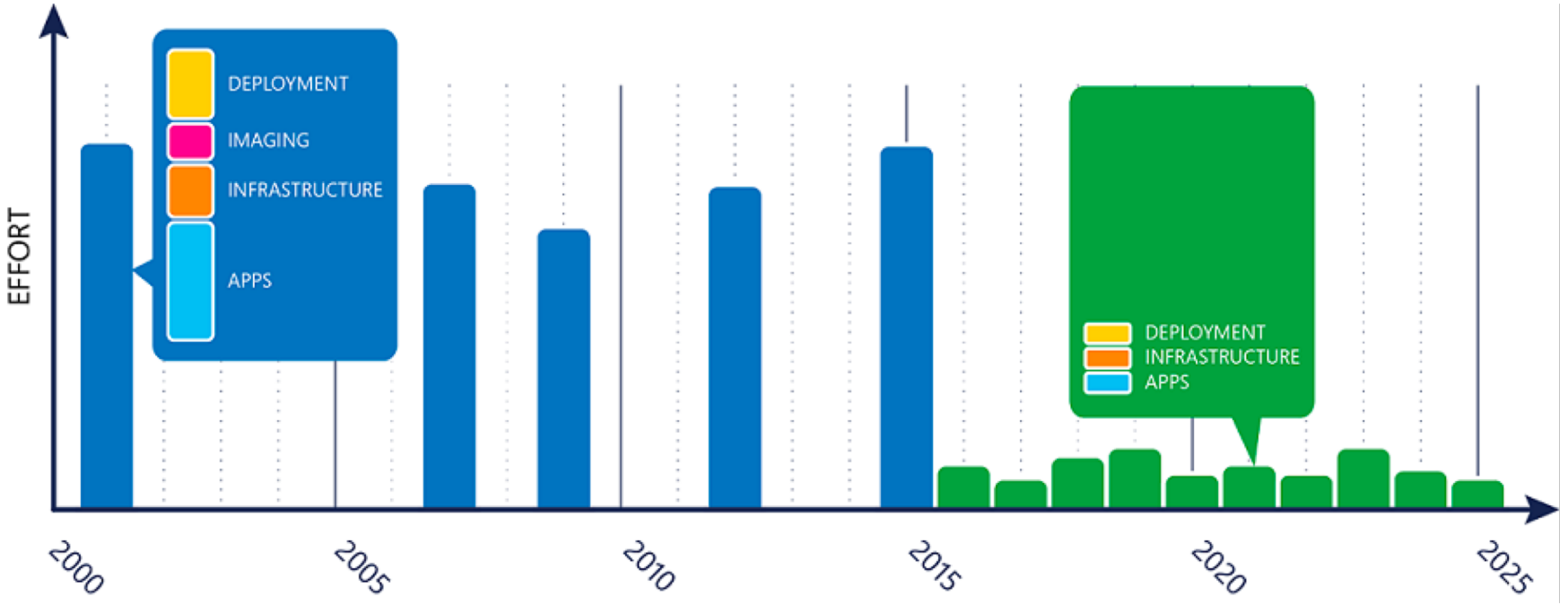
- Microsoft p h features
- 3-4 milesto
- After each nsider which features sh lemented
- Stabilizatio end of milestone




Cusumano and Selby. Microsoft Secrets.

# Prepare servicing strategy for Windows 10 updates

07/26/2017 • 6 minutes to read • Contributors



MICROSOFT | TECH | WINDOWS 10

# Microsoft slows down Windows 10 update pace for businesses following complaints

*Relief for IT admins*

By Tom Warren | @tomwarren | Sep 6, 2018, 11:00am EDT

# How much iteration? How much change control? (3 cases)


AK
Juneau
Olympia
Salem
OR
Boise
Helena
WA
MT
ND
Bismark
MN
SD
Pierre
WY
Cheyenne
NE
Lincoln
Sacramento
Carson City
NV
Salt Lake City
UT
Denver
CO
KS
Topeka
CA
AZ
Phoenix
Santa Fe
NM
OK
Oklahoma City
TX
Austin
Des Moines
IA
St. Paul
WI
Madison
MI
Lansing
IL
Indianapolis
Springfield
MO
Jefferson City
AR
Little Rock
LA
Baton Rouge
MS
Jackson
AL
Montgomery
GA
Atlanta
Tallahassee
FL
IN
KY
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Nashville
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Charleston
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Raleigh
SC
Columbia
NY
Albany
Montpelier, VT
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Concord
Boston, MA
Providence
Hartford, CT
Trenton, NJ
Dover, DE
Annapolis, MD
Richmond, VA
Honolulu
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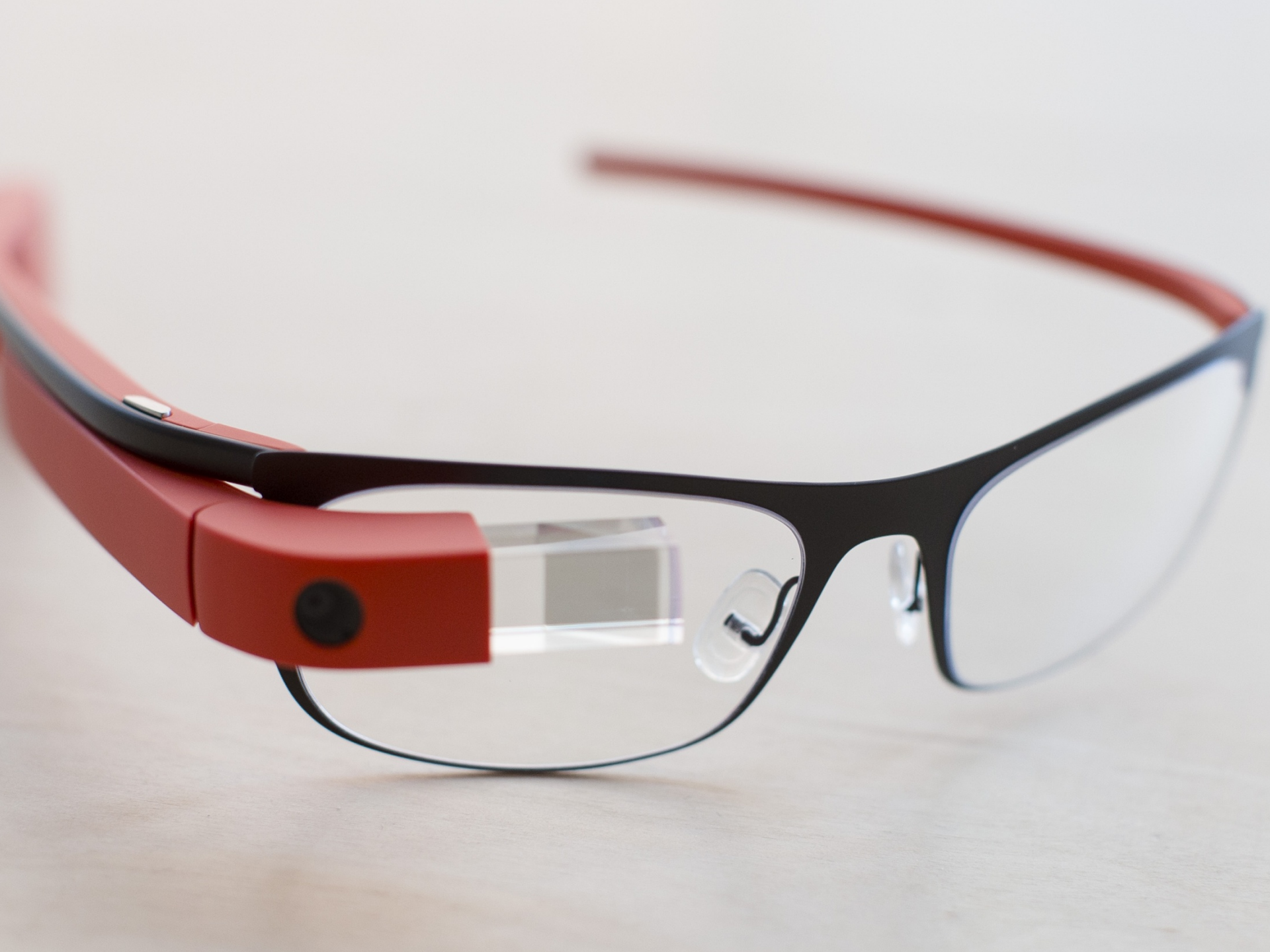
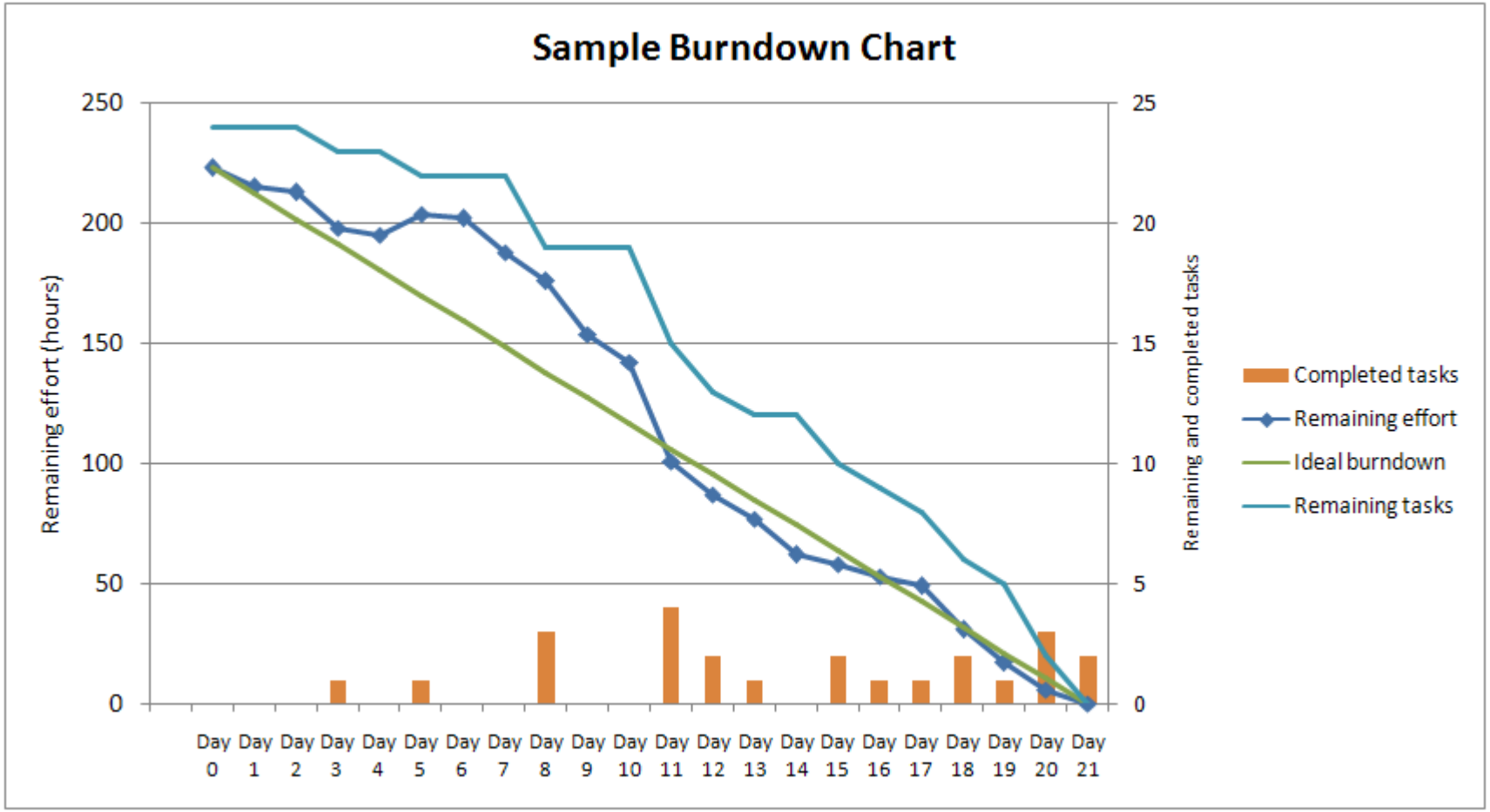
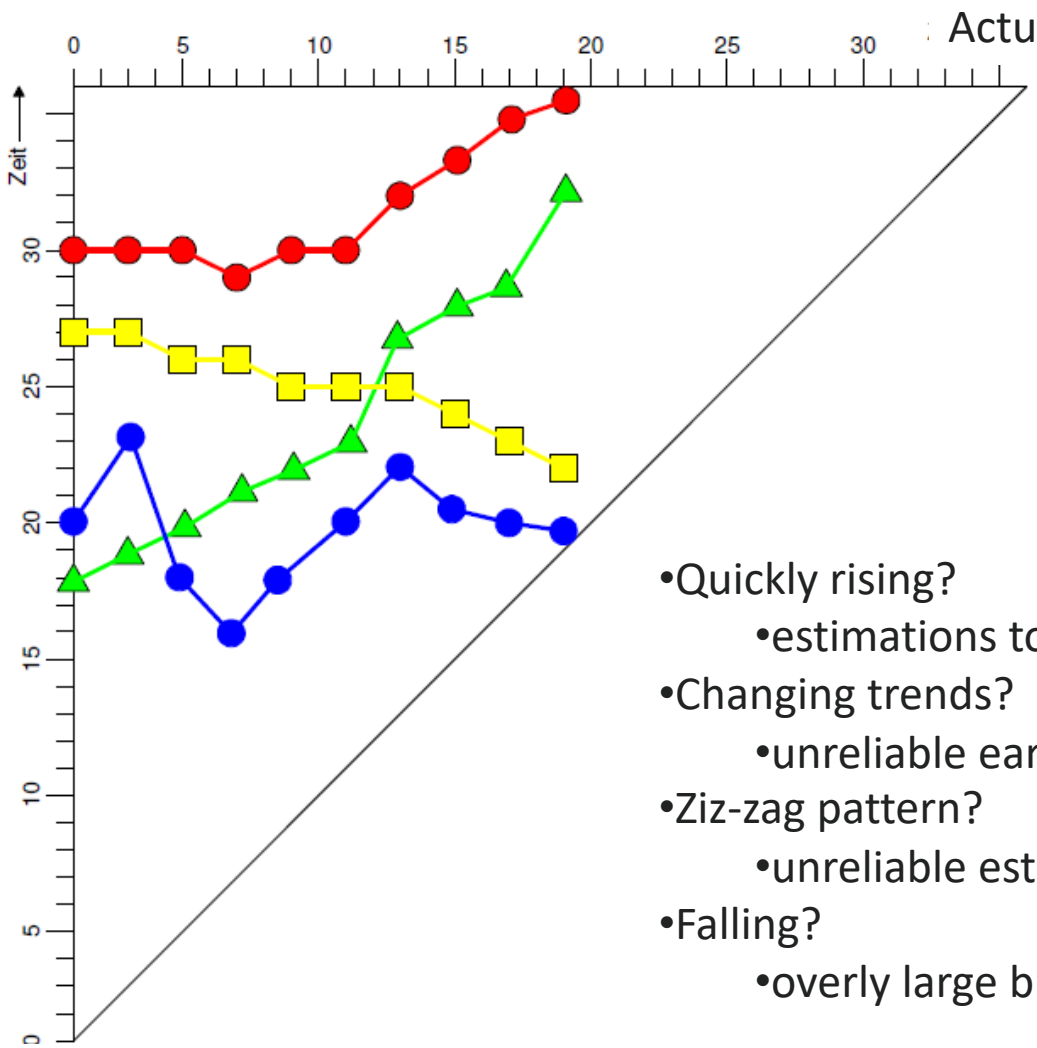


# Discussion: what is the purpose of tracking process?

# Burn Down Charts



# Milestone Trend Analysis




- Quickly rising?
  - estimations too optimistic
- Changing trends?
  - unreliable early estimations
- Ziz-zag pattern?
  - unreliable estimations
- Falling?
  - overly large buffers

# Process metrics: Quality

- Bugs reported?
- Bugs fixed?
- Evidence of completed QA activities
  - "Test coverage", inspection completed, usability study, …
- Performance analysis?

# Goodhart's law

"When a measure becomes a target, it ceases to be a good measure."

Process quality.

# Discussion: what makes a good process?

# Process evaluation

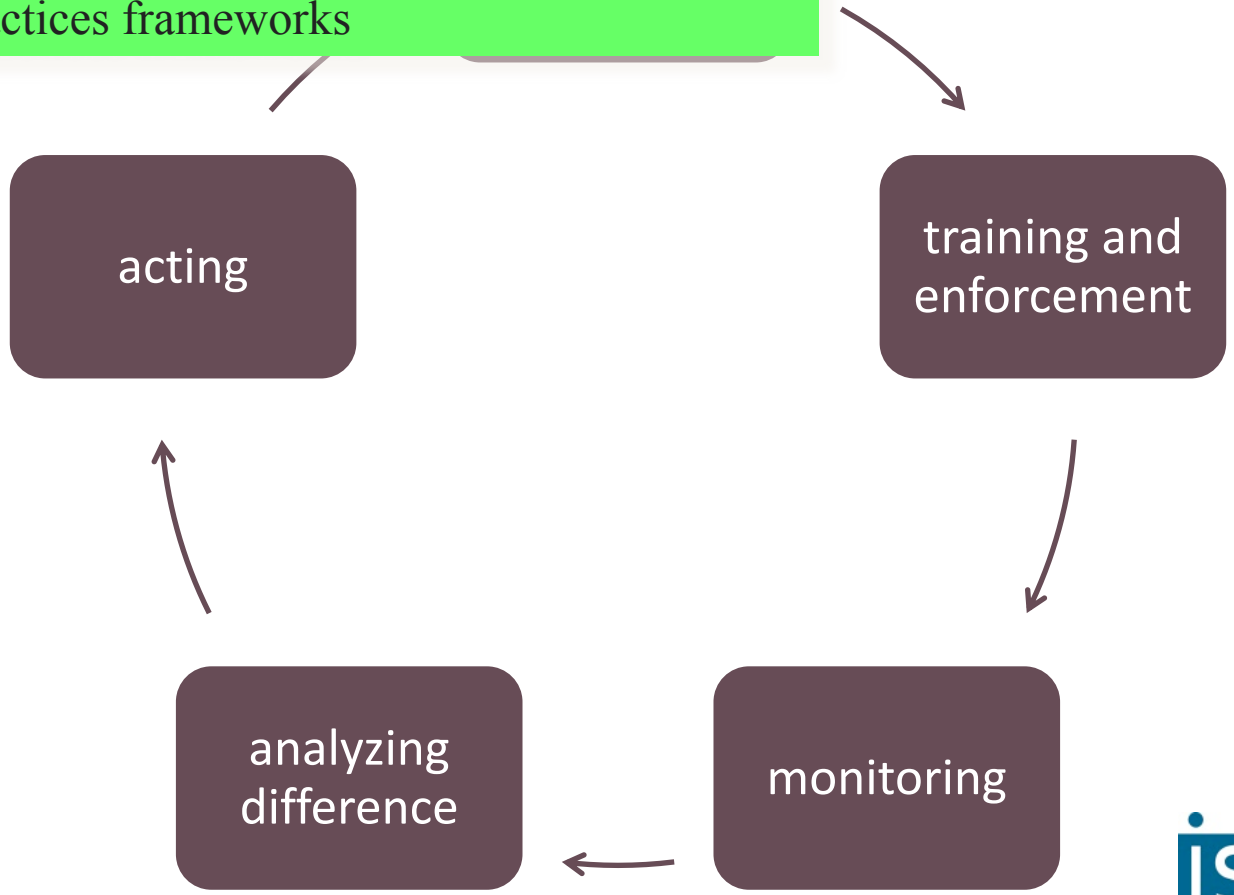
- How predictable are our projects?

- 33% of organizations collect productivity and efficiency data
- 8% collect quality data
- 60% do not monitor their processes

# Process improvement loop

High-level approaches:

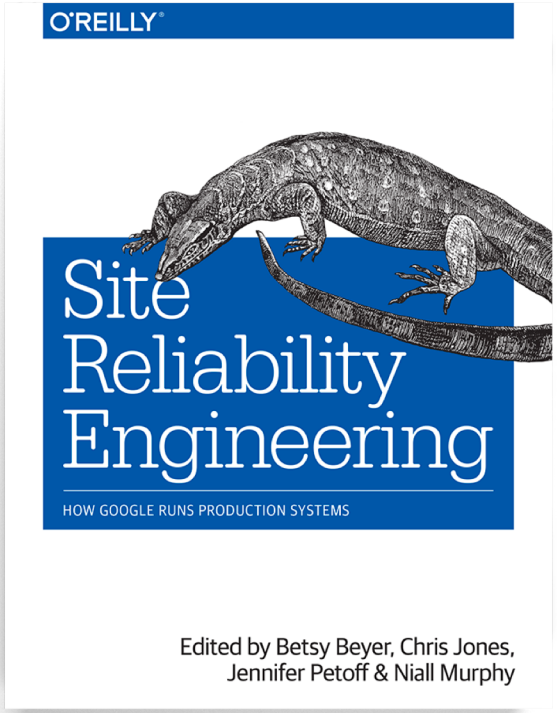
- Opportunistic, based on double-loop learning.
- Analytic, based on measurement + principles
- Best practices frameworks



# Defect Prevention Process, IBM 1985

- When a mishap occurs:
  1. Take corrective action
  2. Conduct root cause analysis (Root cause(s): Management, people, process, equipment, material, environment):
     - Why did the mishap occur? Why was it not detected earlier?
     - Is there a trend indicating a broader problem? Can we address it?
     - What went right during this last stage? What went wrong?
  3. Implement preventive actions within the team context
- Successful changes are percolate up to corporate level.

# Google SRE Process




- blame-free postmortem culture
- “Unless we have some formalized process of learning from these incidents in place, they may recur ad infinitum.”

https://landing.google.com/sre/sre-book/chapters/postmortem-culture/

# Six Sigma, Motorola 1985

“Six Sigma seeks to improve the quality of process outputs, reducing the defects to 3.4 per million, by identifying and removing their causes and minimizing variability. It is applicable to manufacturing and services. It uses statistical methods, and creates a special infrastructure of people within the organization ("Champions", "Black Belts", "Green Belts”) who are experts in them.”

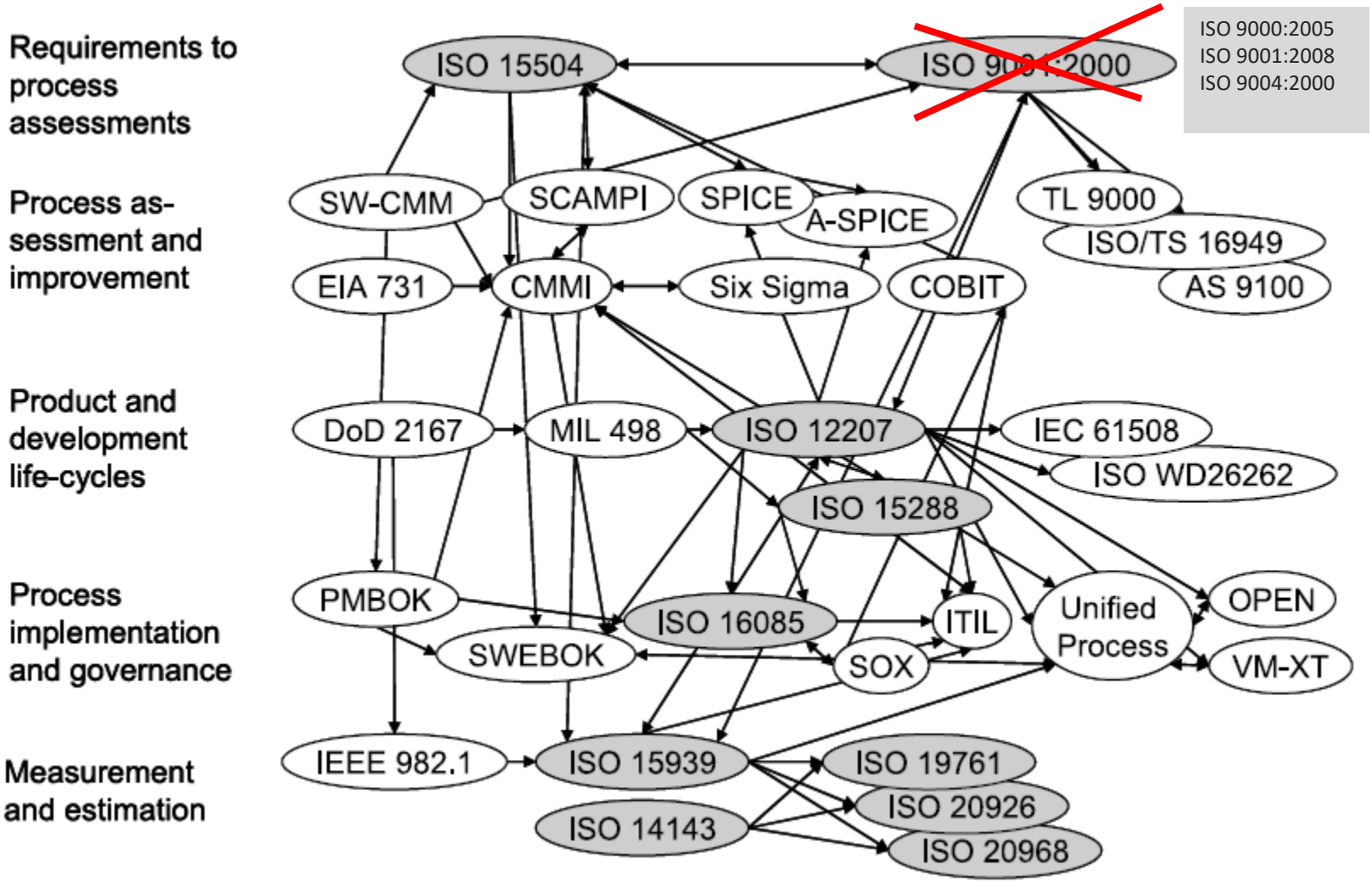
**DMAIC, Existing products and services**

- Define
- Measure
- Analyze
- Improve
- Control

**DMADV & DFSS, New or redesigned products and services**

- Define
- Measure
- Analyze
- Design
- Verify

# Process standards…

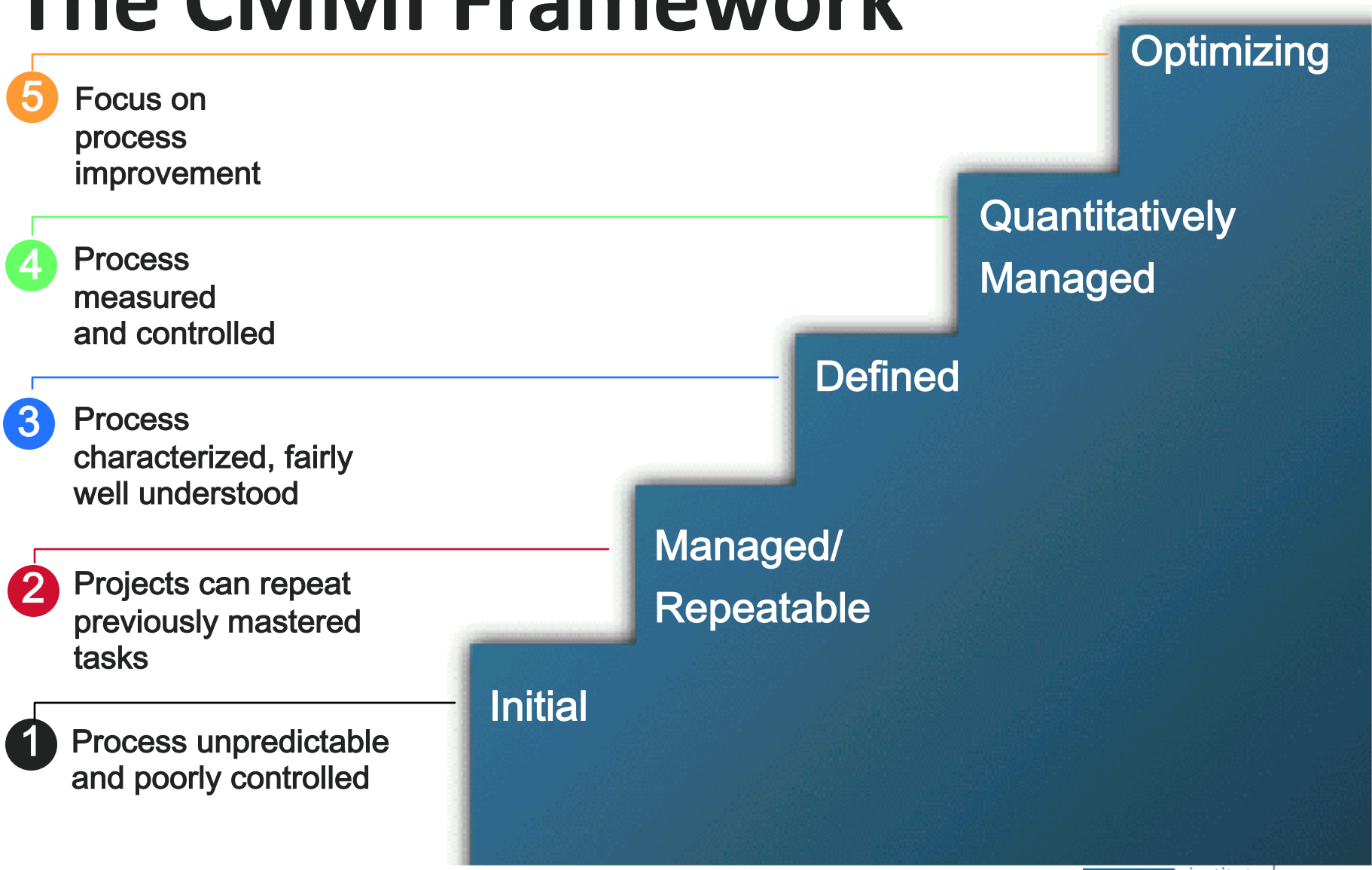



C. Ebert and R. Dumke, Software Measurement,: Establish – Extract – Evaluate – Execute, 2007

# SEI's Capability Maturity Model Integration

- Not a process, but a meta-process
  - Primarily used by the US government to control estimates from software vendors
  - Would prefer to accept a higher, more stable estimate.
- CMMI measures how well a company measures their own process

# The CMMI Framework



# Process Tradeoffs

- (Note: Success stories in many industrial settings, eg. automobile industry.)
- Process vs product quality. Process Quality influences Product Quality, but does not guarantee it
- Following "best practices" as legal defense strategy
  - "Check box compliance"?

# Scenario 1

- You work at an internet company on a large, existing code base.
- A bug manifests in a client-facing product, affecting profits.
- What do you do?

# Scenario 2

- You run a small software firm with a handful of really smart engineers.
- Your employees keep having great ideas and building awesome products!
- …but they're consistently beat to market by your competitors.
- What do you do?

# Scenario 3

- You're a large consulting firm that works on fixed cost engagements.
- A major client is threatening to cancel such a contract and cease contracting work to you in the future because you are late on several key milestones on two of your engagements with them.
- What do you do?

# Summary

- Sequential process models emphasized "think before coding"
- Often too rigid, with changing requirements and environments
- Iteration to address risks
- Change management to control change
- Measure process, continuously improve process