Catastrophe: CoCoMo and the Courtroom

USC CSCI 510
Guest Lecture by Warren S. Reid
October 28, 2015

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Failures:

- **Healthcare.gov** (mandated Go-Live date = untested, incomplete, missing functionality)
- **Kaiser Permanente** (scope changes - well over $1 billion overrun and several years late)
- **Boston’s Big Dig** (Cost overruns – 90%+; schedule delays – from 1998 – 2006+; construction shortcuts)
- **EMR UK** (Shut down after £2 billion project expanded to well over £6 billion)
- **US Air Force Procurement System** (failed: staff unwilling to alter existing business processes)
- **Disney Parks** (delayed/late openings; same rides must be specially altered for China)
- **Steven Hawking** (Estimated 2 years to live; still alive and kicking after 50 more years)
- **Planned Date of Birth** (with 7 billion data points still can’t accurately predict)
- **Flight to New York** (Factors: weather, planes landing, plane needs repairs, cancellations, etc.)
- **Drive to Office** (45 minutes to over 1 hr. depending...)
- **Microsoft Progress Bars** for Downloading ANYTHING (5min → 4 → 3 → 2 → 5 → 6 → 4...)
- And **Software Development Projects**...
**SYSTEMS FAIL: & Continue To Do So!**
Standish Group: Chaos Study Results 1994-2010

CHAOS 2004 *
*Survey Results*

Resolution of Projects

\[ \text{Challenged} = 53\% \]
\[ \text{Succeeded} = 29\% \]
\[ \text{Failed} = 18\% \]

**Results** similar to other surveys:
- Robbins-Gioia
- Conference Board
- KPMG Canada
- OASIG
- Panorama

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**CHALLENGED (Average Overruns):**
- Time: 184%
- $$: 56\%$$
- Rqts delivery: ~67%

**CHAOSS Summary 2009:**
+ success =34% (deliv’d on time, budget, target)
+ challenged =44% (late, over budget, < rqd F&F)
+ failed = 24% (cancel b4 complete/deliv/not used)

“… nos. show success rate downtick from 2007 study, big increase in # of failures… highest failure rates on over a decade.”
<table>
<thead>
<tr>
<th>User/Customer</th>
<th>Vendor/Integrator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>He Said...</strong></td>
<td><strong>...She Said</strong></td>
</tr>
<tr>
<td><strong>Planning</strong></td>
<td>No agreement on goals, roles, scope, QA, delivs. Shoddy project estimates</td>
</tr>
<tr>
<td><strong>Feasibility</strong></td>
<td>We contracted for &quot;Results NOT Resources&quot;; turnkey operational system</td>
</tr>
<tr>
<td><strong>Capability</strong></td>
<td>You delivered limited F&amp;F, quality, &quot;-abilities&quot; (i.e. reli-, usa-, maintain-, recov-, testa-, secur-, performance, etc.)</td>
</tr>
<tr>
<td><strong>Credibility</strong></td>
<td>You oversold services, capability, staff/industry experience/expertise</td>
</tr>
<tr>
<td><strong>Usability</strong></td>
<td>Can’t use system! Training poor; no usable sandboxes. No refresh training.</td>
</tr>
<tr>
<td><strong>Workability</strong></td>
<td>The system failed in the field when put into production!</td>
</tr>
<tr>
<td><strong>Stability/Reliability</strong></td>
<td>Your system is fundamentally flawed: bugs, bad data &amp; poor interfaces! Fixes unearth more defects! Will never work!</td>
</tr>
<tr>
<td><strong>Culpability</strong></td>
<td>You never told us we needed ____________! You gave us poor advice!</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>YOU failed as PM* &amp; SIPM* to ensure all components, resources &amp; business processes work together end-to-end.</td>
</tr>
<tr>
<td><strong>Risk</strong></td>
<td>YOU abandoned effective SDLC; project and cost estimation; PM standards; status/progress/issue reporting vs. milestones &amp; metrics.</td>
</tr>
</tbody>
</table>
Severe Cracks in the Nine Pillars of Software Success Will Bring Down This Project

1. Implement Proper Project Management
2. Create Attainable Estimates, Targets, Commitments & Plans
3. Assign Properly Qualified & Experienced Personnel
4. Gather, Understand & Manage Requirements
5. Follow Good Software Development Methodology
6. Perform Proper & Complete Testing
7. Execute Stellar Training & Learning
8. Communicate Fairly & Honestly
9. Deliver “Suitable” Production-Ready “SYSTEM” & Go-Live Support

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What is an Estimate? What is it NOT?

A. What is an estimate?
   - Part Art & Science. Industry working to make >> estimates up-front & throughout. Gets better over time with facts available.
   - Involves subjectivity, objectivity, experience, sense of impact, weighting of risks and variables. (“Not accurate or complete.”)

B. Dictionary Definition (form Dictionary.com – the Random House Unabridged Dictionary - and Merriam-Webster) [similar to other dictionaries]
   - An approximation; an approximate judgment or calculation, as of the value, amount, time, size, or weight of something.
   - To come near in position, character, amount, etc.; approximate; nearness/close approximation: a fair approach to accuracy.

C. Good estimates may even show a range of possibilities to avoid user’s focus on specific number or date. A single point estimate (done correctly) reflects the most likely outcome; with 50% probability the actual project schedule/effort/cost will be > estimate, and a 50% chance they are < estimate. The 3-point method (least likely, likely, most likely) is the most basic.

D. What is an estimate in terms of software development, engineering or construction?
   - In project management, estimates are basis of sound project planning & may be created using 1/+ of following practices:
     - Analogy based estimation
     - Delphi method
     - Educated assumptions
     - Examining historical data
     - Identifying dependencies
     - Parametric estimating
     - Structured planning
     - Risk assessment

E. Popular estimation processes/tools for software projects include:
   - CoCoMo II; CoSysMo; SEER-SEM; SLIM; Planning Poker; Program Evaluation and Review Technique
What are Estimates, Targets, Plans, & Commitments?

- **Estimate** is (American Heritage Dictionary, 2nd College Ed, 1985):
  - A tentative evaluation or rough calculation.
  - A preliminary calculation of the cost of a project.
  - A judgment based on one's impressions; opinion.

- **Target** is a desirable business objective such as:
  - I need Ver2.1 for May trade show
  - Stabilize release in time for holiday sales cycle.
  - Finish by July 1 so we comply w Federal regulations
  - Do it for $2mm - that's our budget

  **Targets may not be achievable**

- **Commitment**: promise to deliver defined functionality of specified quality by a certain date.
  - Commitment does not have to = estimate. Can be more aggressive or conservative.

- **Plans/Controls**:
  - Plans depend on ests & commits:
    - Creating a detailed schedule
    - Identifying a project's critical path
    - Creating a complete Work Breakdown Structure
    - Prioritizing functions for delivery
    - Breaking a project into iterations

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Project predictability and control are attainable only through active, skillful, and continuous efforts that force the cone to narrow. The cone represents the best-case; results can easily be worse. *

Estimates are possible anywhere in the cone, but organizational commitments tied to project completion should not be made until about here – and only if work has been done to narrow the cone.*

*Source: Construx, Bellevue, WA

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Risks Known **BEFORE** Project Starts!

**People/Resource Risks**
- **Turnover**, culture, x-comm.
- **Top Mgt Commit**: Proj Champ
- Partner; Ref. Checks/Ref’s Refs

**Requirements Risks**
- Poor Project Charter
- **Defined, Domain, Implied**
- Effective Elicitation, Management; Site Visits
- Stability, Complexity
- Incomplete, Misunderstood, Gallop
- I’faces, Integration, Data Conversion

**Technology**
- HW, SW, Net, D/B, Internet, Mobile
- Security; Privacy
  - C – Correctness
  - I – Integrity
  - A – Available
- Tool avail? mature? train? use?

**Project & Tech Mgmt Risks**
- Client, Depts, Users, IT, Vend, O/S consults, attys, custs, analyst, mkt “expectations”
- Unclear Leadership – SIPM
- Time to review/approve Deliverables w sign-off

**Process Risks**
- Project under- or mis-estimated
- SEI-CMMi level; ETC & EVM Stds
- Sched, $$, estimate recalibration, change control
- QC and QA
- Not enough time for testing
- Shortcuts to SDLC *on the fly*

**Product & Other Risks**
- Performance, testedness & Go-Live readiness
- -abilities (scale, use, test, port, maint)
- Competent T/O proc?
- Cutover support; Post Go-Live Support
- compet; economy; org; regulatory

If you know beforehand... **Plan, Contract for, Mitigate, Monitor, Manage Them!**

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Project Management of the Testing Phases of SDLC

Test Management:

1. Basic Build Tests
   - White Box; Black Box
   - Unit (w/ negative tests)
   - String; Initial Integrations Tests
   - Reused code
   - Component; Conversion
   - GUI; Navigation; Screens
   - Interface; Integration
   - Batch Testing
   - Regression Testing
   - Demos, Conference Room Pilot (CRP)
   - Stage Gates/Sign-off

2. Systems Tests Thru G-L Ready
   - Error Messages/Recovery
   - System Test
   - Unusual Sequences
   - Performance; Stress; Load
   - Backup, R&R, Disaster Recovery
   - UAT; Batch Testing; IV&V
   - Regression Testing
   - QA/QC; Stage-Gate signoff
   - Regulatory tests

3. Readiness Signoff/Cutover
   - Alpha, Beta tests
   - Org. Change Management (OCM) Testing
   - Training Walkthru, Test, Eval, Rollout
   - Blackout File Creation
   - Help-dekks/Expert Resources at sites
   - Contractual tests (FAT; OIT; Ops/KPI; etc.)
   - Pilot/Timed Rollout vs. Big Bang
   - Dev, Test, User, Ops, Tech, Mgt manuals
   - Hi-quality Maintenance turnover pack
   - Demos, CRP, Retraining, Sandbox

4. Settling Period
   - Approve/Sign-off
   - Put into Productive thru

5. Operations/Maintenance
   - Enhancements
   - Platform Upgrade
   - New Releases
   - Tune

A. 'ility
   - Usability
   - Maintainability
   - Reliability
   - Scalability
   - Reusability
   - Testability
   - Portability
   - Securability
   - Survivability

B. Static Analyses
   - Reviews; Inspections; Audits; Walkthroughs
   - Requirements
   - Design, Code, Tests
   - Documentation
   - Training
   - Standards Adherence
   - Go-Live Readiness

C. Ongoing Testing & Tools Use
   - Utilities
   - Code coverage
   - Code complexity
   - Auto Test Suite
   - Auto Regression Suite
   - Configuration Management
   - Library control & maintenance

D. Quality Control & Assurance
   - Internal & External Inspections
   - IV&V
   - Ready for Audit test
   - Periodic Reviews
   - Stage Gate Revs

THE TEST WHEEL
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THE SOFTWARE ECONOMICS OF LATE BUG FIXES:
Effort Multiples to Find/Fix Errors caught in Systems Test that should have been caught in earlier Software Development Phases

Additional multiples of Developer/Integrator effort are needed to isolate and fix errors found in System Testing that were not discovered earlier because of:
- Shortcuts taken
- Abandoning industry "best practice testing methods"
- Under-budgeted test resources & schedule
- Unskilled/untrained testers
- Poor test management
- Failure to use automated tools as appropriate, and
- Of course, poor requirements, design and, lower level testing.

From opposite perspective. (i.e., what costs 1 unit of effort to do right in Requirements, costs 5 units to find/fix in design, $20 in implementation [code/unit test], $50 in Testing/acceptance, etc.

- $1 Requirements
- $5 Design
- $20 Implementation
- $50 Verification
- $100 Maintenance

Relative cost factors to find and fix defects

Error Cost Escalation Through the project Life Cycle NASA Johnson Space Center and multiple peer-review publications.

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Child Support Enforcement System - Interfaces

High level child support business function areas are depicted as shaded rectangles and system interfaces as ovals or circles. Interfaces are deliberately drawn to overlap each business functional area that they support. For example, FCCMS is used in enforcement and case initiation, whereas the SESA interface is used only for locate activities.
Timeline of Bad Estimating Highlights Over Past 7 Years:

- **2007-02-23** – State signs contract w SI-1 for **36-mos project** [thru 2010-02-23] to spec, design, create, document, test, convert data, train, and implement integrated CSES and FCCMS systems.
- **2007-11-01** – SI-2 acquires SI-1
- **2008-12-20** – 22 mos post signing agreement, RON 3 extends schedule by 16 mos (*from 36 to 52 months*).
- **2009-05-00** – SI-3 acquires SI-2.
- **2010-02-23** – Original Go-Live date
- **2010-11-23** – 23 mos post RON 3, RON 5 extends schedule by 16 more mos (*to 68 mos.* (45 months in, they’re 36 months late.))
- **2011-09-02** – State files Contract Controversy bc SI-3 fails to complete Business Process Test (“BPT”) on time.
- **2012-03-06** – 15 mos post RON 5, RON 6 extends sched 5 mos to 73 mos (*60 months in, they’re 41 months late.*)
- **2012-06-29** – SI-3 starts System Test (ST), based on the schedule in RON 6
- **2012-09-14** – Mid-point of ST → SI-3 required to achieve **50% approval** of the test results. SI-3 only achieves approval of 477 test results (*16% of 2,943 test scripts, per Sept ‘12 Monthly Status Report (“MSR”). Per K, SI-3 provides State w new schedule extending ST fm **2012-11-30** to **2012-12-20**.
- **2012-09-24** – State issues Default Notice, bc SI-3 fails to produce reliable revised sched. ST extends to **2012-12-20** clearly unachievable given ST status.
- **2012-11-30** – Original promised ST 100% completion date per RON 6; but, SI-3 gets approval for 898 test results (*30% of total per Dec. 2012 MSR*)
- **2013-01-23** – In response to the State’s Demand for Cure, SI-3 submits a Corrective Action Plan (“CAP”). CAP projects ST w continue until March 2014 – for a total of 21 months, compared to the original RON 6 commitment of 5 months. Based on CAP, total time of project would >> to 83 mos. W/i 10 mos of signing RON 6, SI-3 asks for 10 mos. extension!
- **2013-06-11** – SI-3 attains **50% test script approval**, per CFS Project Director

At this pace, it will >> a year to complete ST. However, projection is unreliable/cannot be used to determine expected ST completion date and readiness for UAT. QA problems w system/software suggest it w/take much longer than estimate to conduct UAT/fix defects found in that test that s/h/b found/ixed before. CFS project schedule growth is in next graphic:
Timeline of Bad Estimating Highlights Over Past 7 Years:

- Proposed Schedule 36 months
- Original Contract 36 months
- SI-2 acquires SI-1
- RON 3 Amendment
- RON 3 Schedule 52 months
- SI-3 acquires SI-2
- BPT concept introduced
- RON 5 Amendment
- RON 5 Schedule 68 months
- SI-3 default (BPT)
- RON 6 Amendment
- RON 6 Schedule 73 months
- SI-3 default (System Test)
- SI-3 CAP 83 months
- SI-3 CAP proposed State-wide

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EXPERT OPINIONS

• Opinion 1:  *SI-3 did not meet the schedule of the contract as amended by CCO 6.*
  - Delay caused by SI’s failing to conduct “promised” (contracted for) work IN AND BEFORE ST (now manifesting in System Test)
  - At time of State termination, completion date lay well beyond CCO 6 statewide-GL date (2013-09-18)

• Opinion 2:  *Bc of SI’s failings, ST proceeds @ very slow pace revealing large # of basic design defects/functional gaps.*

• Opinion 3:  *Impossible to determine project’s true status @ termination, nor how long for SI to complete it*
  - Lo-Qual sw = E2E business process testing (in SFT & UAT) will be mired in significant defects, problems and delay.
  - $$, sched, effort to fix defects/functional gaps in SFT/UAT, w/o auto regression testing w/b OoM >> than if found when 1st entered

• Opinion 4:  *@ Term, SI unable to submit reliable CAP bc >failings in rqmts elic/analysis, mgmt, SDLC and testing.*
  - SI w/h/has to first acknowledge true causes of project’s low-QA software & delay  →  commit to signif advances in project performance
  - During 2013, SI d/NOT demo ability/willingness to do either  →  in no position to issue a credible or reliable Corrective Action Plan @ Term.

• Opinion 5:  *SI has not demonstrated ability or willingness to complete project in a reasonable amount of time.*
  - SI’s ad hoc, reactive project planning/execution had not/will not work to develop a suitable, maintainable system in foreseeable future
  - State had ample grounds to lose confidence in SI’s abil/willing to make improvements to complete project w suff quality in reasonable time.
  - Due to SI’s lack of abil/willingness to correct its performance it was not a viable or prudent option to continue the project with SI.

• Opinion 6:  *Some SI’s deliverables may be relied on going  →  w team able/willing to perform in workmanlike manner.*
  - Independent team must investigate SI deliverables in some detail to det an approp restart point, w which deliverables to carry forward.
  - Likely sw problems cannot be properly fixed w/o substantial work/rework requiring SDLC phase rollback to create dev/maint artifacts
The judge asks me as an expert in software development, project management and estimation:

“Well, Mr. Reid, please enlighten the court...
“What do you think it will take?
“The Systems Integrator thinks it will take another 18 months.”

“So, what do you think and why?
“Why do you know better?
“And you better be able to support it.
“No crazy science here.” (Daubert rule).
### What ARE the Estimating Factors?

(From Dr. Barry Boehm’s COCOMO Model)

<table>
<thead>
<tr>
<th>Scale Factors</th>
<th>Cost Drivers</th>
<th>Project</th>
<th>Platform</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precededness</td>
<td>Personnel</td>
<td>Use of Software Tools</td>
<td>Time Constraints</td>
<td>Required reliability</td>
</tr>
<tr>
<td>Development Flexibility</td>
<td>Analyst Capability (ACAP)</td>
<td>Multisite Development</td>
<td>Main Storage Constraints</td>
<td>Database Size</td>
</tr>
<tr>
<td>Architecture/Risk resolution</td>
<td>Analyst Experience (AEXP)</td>
<td>Development Schedule</td>
<td>Platform Volatility</td>
<td>Product Complexity</td>
</tr>
<tr>
<td>Team Cohesion</td>
<td>Programmer Capability</td>
<td></td>
<td></td>
<td>Required Reusibility</td>
</tr>
<tr>
<td>Process Maturity</td>
<td>Platform Experience (PEXP)</td>
<td></td>
<td></td>
<td>Documentation match to</td>
</tr>
<tr>
<td></td>
<td>Language and Tool Experience (LTEX)</td>
<td></td>
<td></td>
<td>lifecycle needs</td>
</tr>
<tr>
<td></td>
<td>Personnel Continuity (PCON)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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Proposed SI Estimate
$23,104/mo. (152hrs*$152/hr)
CMMi Level 3

SI Contract: 35.5 mos. $45 mm
SI Contract: 35.5mos. $45mm
All Nominal $10K/mo. CMMi Level 2

SI Sched.: 7.9 yrs. $153 mm
New Nominal Product changes
$10K/mo.
CMMi Level 2

Baseline: 9.2 yrs. $249 mm
## COCOMO II

### Sensitivity Analysis:

#### Part 1

<table>
<thead>
<tr>
<th>Estimate ID</th>
<th>All Average/Nominal</th>
<th>New Nominal/Real Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Cost (K$)</strong></td>
<td>$152,801</td>
<td>$248,847</td>
</tr>
<tr>
<td><strong>Total Duration Yrs</strong></td>
<td>7.9</td>
<td>9.2</td>
</tr>
<tr>
<td><strong>Average Staff Rate/mo</strong></td>
<td>$10k/mo</td>
<td>$10k/mo</td>
</tr>
<tr>
<td><strong>Estim. Summary (RQ to IT)</strong></td>
<td>CMMI Level 2</td>
<td>CMMI Level 2</td>
</tr>
<tr>
<td><strong>Brief Description/Impact</strong></td>
<td>Average Throughout</td>
<td>Avg Procs/Team; True Product Factors: more time/SS</td>
</tr>
<tr>
<td><strong>Developed Size</strong></td>
<td>2,250,000</td>
<td>2,250,000</td>
</tr>
<tr>
<td><strong>Tot Effort (Person-Mos)</strong></td>
<td>15,280</td>
<td>24,885</td>
</tr>
<tr>
<td><strong>Total Duration Mos</strong></td>
<td>94</td>
<td>110</td>
</tr>
<tr>
<td><strong>Productivity (Lines/PM)</strong></td>
<td>147.3</td>
<td>90.4</td>
</tr>
<tr>
<td><strong>Unit Cost ($/Line)</strong></td>
<td>$67.91</td>
<td>$110.06</td>
</tr>
</tbody>
</table>

### SCALE FACTORS

<table>
<thead>
<tr>
<th>Precededness</th>
<th>Somewhat Unprecedented</th>
<th>Somewhat Unprecedented</th>
<th>Sensitivity Check (change 1 at a time)</th>
<th>Dura- mos</th>
<th>Duratio- years</th>
<th>Incr Time - Yrs</th>
<th>New $$ Total (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.33</td>
<td></td>
<td></td>
<td>-&gt; Largely Unprecedented</td>
<td>116.6</td>
<td>9.7</td>
<td>0.5</td>
<td>$274</td>
</tr>
<tr>
<td>Development Flexibility</td>
<td>Some Relaxation</td>
<td>Some Relaxation</td>
<td>-&gt; Occasional Relax</td>
<td>115.4</td>
<td>9.6</td>
<td>0.4</td>
<td>$269</td>
</tr>
<tr>
<td>Architecture/ Risk Resolution</td>
<td>1.39</td>
<td>Often (60%)</td>
<td>Often (60%)</td>
<td>= Often (60%) [No Change]</td>
<td>110.3</td>
<td>9.2</td>
<td>$249</td>
</tr>
<tr>
<td>Team Cohesion</td>
<td>1.29</td>
<td>Basically Cooperative</td>
<td>Basically Cooperative</td>
<td>-&gt; Some Diff Interacts</td>
<td>115.8</td>
<td>9.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Process Maturity</td>
<td>1.43</td>
<td>SEI CMM Level 2</td>
<td>SEI CMM Level 2</td>
<td>-&gt; SEI CMM LL1</td>
<td>126.9</td>
<td>10.6</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Subtotal: all 5 above</strong></td>
<td>148.1</td>
<td>12.3</td>
<td>3.2</td>
<td>$410</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STEP-UP ANALYSIS & ESTIMATES: From Average Project (9.2 yrs, $249mm; 2,250KSLOCs) to continuing to use SI's SDLC Environment re planning, managing, staffing, coding, testing the system until Termination.
## COCOMO II Sensitivity Analysis: Part 2

<table>
<thead>
<tr>
<th>COST DRIVERS</th>
<th>Low</th>
<th>High</th>
<th>From this point on Cumulative Impact is shown (i.e., Changes build on one another)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Low</td>
<td></td>
</tr>
<tr>
<td>Personnel</td>
<td></td>
<td></td>
<td>&gt; Low</td>
<td></td>
</tr>
<tr>
<td>ACAP: Analyst Capability</td>
<td>1.42</td>
<td>0.71</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>APEX: Application Experience</td>
<td>1.22</td>
<td>0.81</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>PCAP: Programmer Capability</td>
<td>1.34</td>
<td>0.76</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>PLEX: Platform Experience</td>
<td>1.19</td>
<td>0.85</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>LTEX: Language/Tool Experience</td>
<td>1.2</td>
<td>0.84</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>PCON: Personnel Continuity</td>
<td>1.29</td>
<td>0.81</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
<td>&gt; Low</td>
<td></td>
</tr>
<tr>
<td>TOOL: Use of SW Tools</td>
<td>1.17</td>
<td>0.78</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>SITE: Multisite Developmt</td>
<td>1.22</td>
<td>0.80(XH)</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>SCED: Required Schedule</td>
<td>1.43</td>
<td>1.00</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>Platform</td>
<td></td>
<td></td>
<td>&gt; Low</td>
<td></td>
</tr>
<tr>
<td>TIME: Execution Time Constraint</td>
<td>1.00 (N)</td>
<td>1.63(XH)</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>STOR: Main Storage Constraint</td>
<td>1.00 (N)</td>
<td>1.46(XH)</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>PVOL: Platform Volitility</td>
<td>0.87 (L)</td>
<td>1.30</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td></td>
<td></td>
<td>&gt; Low</td>
<td></td>
</tr>
<tr>
<td>RELY: Required Reliability</td>
<td>0.82</td>
<td>1.26</td>
<td>Nominal High</td>
<td>$153</td>
</tr>
<tr>
<td>DATA: Test Database Size</td>
<td>0.90</td>
<td>1.28</td>
<td>Nominal High</td>
<td>$168</td>
</tr>
<tr>
<td>CPLX: Product Complexity</td>
<td>0.73</td>
<td>1.74(XH)</td>
<td>Nominal High</td>
<td>$192</td>
</tr>
<tr>
<td>RUSE: Develop for Reuse</td>
<td>0.95</td>
<td>1.24(XH)</td>
<td>Nominal High</td>
<td>$225</td>
</tr>
<tr>
<td>DOCU: Docs to meet Lifecycle Needs</td>
<td>0.82</td>
<td>1.23</td>
<td>Nominal High</td>
<td>$249</td>
</tr>
</tbody>
</table>

Cumulative Impact:
- RELY: Required Reliability: High (Baseline) 94.4 Mos., 7.9 Yrs., Change: $153
- DATA: Test Database Size: High (Baseline) 97.3 Mos., 8.1 Yrs., Change: $168
- CPLX: Product Complexity: High (Baseline) 101.5 Mos., 8.5 Yrs., Change: $192
- RUSE: Develop for Reuse: High (Baseline) 106.7 Mos., 8.9 Yrs., Change: $225
- DOCU: Docs to meet Lifecycle Needs: High (Baseline) 110.3 Mos., 9.2 Yrs., Change: $249

Cumulative Impact:
- Other Drivers Nominal:
  - Compression: 15% 151.2 Mos., 12.6 Yrs., Change: $814

Cumulative Impact:
- Total Est Yrs: 14.8

---

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New Nominal Product changes
Dev Flex: Occasional relaxation
$10K/mo.
CMMi Level 2

New: 9.6 yrs. $269 mm
Base.: 9.2 yrs. $249 mm
Delta: 0.4 yrs. $20 mm
New Nominal Product changes
Precedent: Largely Unprecedented
$10K/mo.
CMMi Level 2

New:  9.7 yrs.    $274 mm
Base.:  9.2 yrs.  $249 mm
Delta: 0.5 yrs.    $25 mm
New Nominal Product changes
Team Cohesion: Some Difficult Interactions
$10K/mo.
CMMi Level 2

New:  9.7 yrs.  $271 mm
Base.:  9.2 yrs.  $249 mm
Delta:  0.5 yrs.  $ 22 mm
New Nominal Product changes
Process Maturity: CMMi Level 1 (lower half)
$10K/mo.
CMMi Level 1 (lower half)

New: 10.6 yrs.  $317 mm
Base.: 9.2 yrs.  $249 mm
Delta: 1.4 yrs.  $68 mm
New Nominal
Product changes
Scale Factors: 3 decreased one notch, 1 decreased 2 notches
$10K/mo.
CMMi Level 1 (lower half)

New: 12.3 yrs.  $410 mm
Base.: 9.2 yrs.  $249 mm
Delta: 3.2 yrs.  $161 mm
New Nominal Product changes
Maintained scale factors below nominal
$10K/mo.
CMMi Level 1 (lower half)
ACAP: Low

New: 13.1 yrs.  $487 mm
Base:  9.2 yrs.  $249 mm
Delta: 3.9 yrs.  $238 mm
New Nominal Product changes
Maintained scale factors below nominal $10K/mo.
CMMi Level 1 (lower half)
ACAP: Low + APEX: Low

New: 13.5 yrs.  $536 mm
Base:  9.2 yrs.  $249 mm
Delta: 4.3 yrs.  $287 mm
New Nominal
Product changes
Maintained scale factors
below nominal
$10K/mo.
CMMi Level 1 (lower half)
ACAP: Low + APEX: Low +
LTEX: Low

New: 13.9 yrs. $585 mm
Base.: 9.2 yrs. $249 mm
Delta: 4.7 yrs. $336 mm
New Nominal Product changes
Maintained scale factors below nominal
$10K/mo.
CMMi Level 1 (lower half)
ACAP: Low + APEX: Low + LTEX: Low + PCON: Low

New: 14.4 yrs.  $655 mm
Base.: 9.2 yrs.  $249 mm
Delta: 5.2 yrs.  $406 mm
New Nominal Product changes
Maintained scale factors below nominal
$10K/mo.
CMMi Level 1 (lower half)
ACAP: Low + APEX: Low +
LTEX: Low + PCON: Low +
Project Tools Use: Low

New: 14.8 yrs.  $714 mm
Base.: 9.2 yrs.  $249 mm
Delta: 5.6 yrs.  $465 mm
New Nominal Product changes
Maintained scale factors below nominal
$10K/mo.
CMMi Level 1 (lower half)
ACAP: Low + APEX: Low +
LTEX: Low + PCON: Low +
Project Tools Use: Low
Schedule compressed 15%

New: 12.6 yrs.  $814 mm
Base.: 9.2 yrs.  $249 mm
Delta: 3.4 yrs.  $565 mm
# Summary of Selected Estimates

<table>
<thead>
<tr>
<th>Estimate Name</th>
<th>75% ERP match - Lvl 3</th>
<th>Baseline from scratch - Lvl 2</th>
<th>Actual To Complete - LL Lvl1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Name</td>
<td>COCOMO II 2000</td>
<td>COCOMO II 2000</td>
<td>COCOMO II 2000</td>
</tr>
<tr>
<td>Process Model</td>
<td>COCOMO II</td>
<td>COCOMO II</td>
<td>COCOMO II</td>
</tr>
<tr>
<td>Phases</td>
<td>Waterfall</td>
<td>Waterfall</td>
<td>Waterfall</td>
</tr>
<tr>
<td>Developed Size</td>
<td>562,500 (75% match)</td>
<td>2,250,000</td>
<td>2,250,000</td>
</tr>
<tr>
<td>Total Cost (K$)</td>
<td>$45,055</td>
<td>$249,066</td>
<td>$713,665</td>
</tr>
<tr>
<td>Total Effort (Person-Months)</td>
<td>1,950.10</td>
<td>24,906.60</td>
<td>71,366.50</td>
</tr>
<tr>
<td>Total Duration (Years)</td>
<td>3.0</td>
<td>9.2</td>
<td>14.8</td>
</tr>
<tr>
<td>Productivity (Lines/PM)</td>
<td>288.4</td>
<td>90.3</td>
<td>31.5</td>
</tr>
<tr>
<td>Unit Cost ($/Line)</td>
<td>$80.10</td>
<td>$110.70</td>
<td>$317.18</td>
</tr>
</tbody>
</table>

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Why Judge Selected my Estimates

- Used industry best practices & multiple estimation models to complete/redo system
- SI-3 had done estimation/PM wrong for 7 yrs (inc. use of SLIM)
- I used SI-3’s non-COCOMO II estimates for conversion, training, implementation, cutover, OCM, & Post GL assist w approp. rates
- Used 2,250,000 LOC for product size supplied by SI-3. Assumed 75% match.

- Calculated salvage value five logical ways incl. rules of thumb, experience, ST problem knowledge/poor QA system dev.
  - Reqmts – 33%
  - DSD – 10%
  - Code & Unit Test – 0%
  - Integration & Test – 10%
  - Total salvage – $19.8 - $25.6mm
Other SV estimations totaled
~$22.41mm
Confirming Estimate Consistency with Multiple Independent Models

I used several independent estimating models. They tended to converge to a duration range of **5 to 7 years** for the better disciplined teams and plans, and **7-9 yrs** for the average, but efficient nominal teams – thereby corroborating each other. Estimation models or activities included:

- COCOMO II models created for CFS (CMMi L3, CMMi L3 Compressed, Nominal) (estimated duration: **6.1 years, 5.2 years, 9.4 years** respectively) [corroborated by SEER-SEM]
- Comparison to other recent CFS type Projects (Michigan, Nevada, Texas) (actual and **estimated** durations: **16 years, 6-9 years, 8.5 years** respectively)
- Tried to do it with actual SI-3 history, metrics & productivity stats on CFS project for the past 5 years, but was not able to get access to those numbers, if SI-3 keeps them.
- **1st order estimation** (by Capers Jones – an industry heuristic) (estimated duration: **6.6 years** Best-in-Class; **8.2 years** average; **11.2 years** Worst-in-Class)
- Created a simple Rough Order of Magnitude (“ROM”) based upon my experience of: **5 to 7 years for a better than average, i.e., CMMi Level 3 team**

Best practices recommend using multiple estimating techniques to get project better estimate ranges.

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Lessons Learned: Estimating

• *Good engineers produce supportable estimates; GREAT engineers change them.* Warren S. Reid

• Hopfstadter's Law: “Everything takes longer than you think it will, even if you take Hopfstadter’s Law into account.”

• “It’s better to be approximately right than precisely wrong” Warren Buffet

• “A Good Plan today is better than a Perfect Plan tomorrow.” Gen. George H. Patton

• *Common definition of estimate: “most optimistic prediction with non-zero probability of coming true.”* Tom DeMarco

• “Managers need estimates of project cost/schedule to plan and manage software development. Such estimates are *approximate* due to imperfect knowledge of factors affecting these estimates. Project Managers need information on the biases/uncertainty in these estimates to gauge risk and make planning decisions.” R Stutske – Lead SEI/CMMI Author

• “IT estimating is the most thankless job in IT -- enormous responsibility for a grim/highly speculative job.” “Every estimate must have a contingency allowance – proportional to the risk.” Paul Coombs – European Estimation Thought Leader

• *Good Estimation requires a combination of personal experience, realistic analysis, and continual reassessment.* Cassie Oates

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AFTER YEARS OF EXPERIENCE:
THE GOLDEN ANSWER!

\[ d(y)^h : f(y)^p + \int (l) + \int (c) = P^2R \]
Warren S. Reid: Background

• 16 years as IT consultant ➔ Partner in Large IT Firms
• Designed/implemented/contracted myriad systems
• 1988, founded: WSR Consulting Group, LLC
  Consultants/Experts in Computers & Software

• Projects have included:
  • Helping launch FEO for Pres. Carter in 75 days
  • Oversaw acceptance of CA’s Lotto in 100 days
  • Helped resolve MESDAQ: day 1 failure.

• Extensive industry experience including:
  • Retail industry, grocery, fast food
  • POS systems of all kinds; E-business and e-commerce
  • Health care, hospital and HIPAA systems
  • Robotics and smart buildings, and more

• MS & MBA: Wharton Grad School Finance

• Developed seminal “IT Success Models”
  • Guest Lecturer at USC’s grad school programs
  • Lecturer in law school programs in IT Contracting
  • Many peer-reviewed articles/MCLE video for Attorneys
    “IT Litigation and Bad Contracts that Foster Failure” (3.5 hrs MCLE credit)

• Testifying expert/expert witness in matters re:
  • The root causes of system failure
  • ERP project/sw: development; implementation; estimating; scheduling; resourcing; project mgt
  • Systems Development Life Cycle (SDLC) issues
  • Definition of “World-Class” IT
  • Systems/software testing & acceptance
  • IT contract intention, meaning & interpretation
  • SW QA evaluation & fitness/usability purpose
  • Software requirements elicitation & control
  • Valuing IT assets, systems and companies

• Testimony: Mediations, Arbitrations; State/Fed Courts; Court of Fed Claims

• International Expert Witness in IT matters:
  • U.S. Dept of Justice & Pres. William Clinton
  • An Asian Stock Exchange; Pepsico; Harrahs Entertainment; B-to-C Internet companies
  • Her Royal Majesty, the Queen of England;
  • Compuserve; Fortune 500 retailers; Robotics manufacturing; Distribution companies; POS cases; Big -8 Consulting Firms
  • ERP software developers and systems integrators
  • International ticketing companies
  • Hospitals; US Dept of Defense; US Dept. of Justice & more.