Optimized Project Life Cycle Cost and Performance in an Era of Constrained Budgets

PSM Workshop

Tuesday

31 July 2012

Attendees

- Bob Epps
- Francie Bis
- Cari Pullen
- Cheryl Jones
- Bob Ferguson
- Bob McCann
- Bill Golaz
- JoAnn Lane

Jack McGarry
Joe Dean
Bob Chartte

Goals

- Discuss project optimization
- Add maintenance to total system optimization
  - Corrective actions
  - Enhancements
  - Technical Debt
- Establish methods to enhance parametric models to incorporate M&O for total system project optimzation

Workshop results

- Discussed Optimization as it relates to project management during SW project development
- Opened discussion concerning adding maintenance to consider total project optimization
  - Cost, Schedule, or risk
  - Product value and use
  - Capability and/or capicity
- Consideration for trade-offs versus constraints

Workshop Results (cont.)

- Potential considerations for Maintenance optimization
  - Defect density
  - Fixed versus variable cost for Maintenance
  - Number of change requests
  - Life Cycle Scope
- Consider the ability to incorporate Port Folio Management

Workshop Output

- Established that Port Folio Management consideration has wide range of objective considerations that are beyond current estimation methods.
- Established a limited maintenance parametric estimation aligned to the maintenance component of the WBS presented in Life Cycle Maintenance Cost Estimation Model and Drivers workshop
- Defined method to calibrate parametric model to estimate limited maintenance.

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Workshop Discussion Items

- Workshop discussion includes the following concepts and the software measures that will be required.
- Identify objectives as a requirement in making optimal project and design decisions
- Software Measures to support effective confidence based project plans.
  - Plans are consistent with the effort/schedule/risk estimates for the project
- Incorporation of performance based project management
  - Integration of the effort/schedule/risk estimation into project control
- Established methods to integrate project trade-offs into both planning and ongoing project control
  - Design decisions
  - Project decisions from architectural trade offs to low level decisions such as development standard applied versus additional functionality or coding standards versus shorter development cycle.
- Technical Debt
  - Define Technical Debt
  - What are effective measurement for Technical Debt in support of project planning and execution
  - Establish an objective Technical baseline of the system defining the structural quality and health index
  - System attributes and key indicators

Workshop Goals

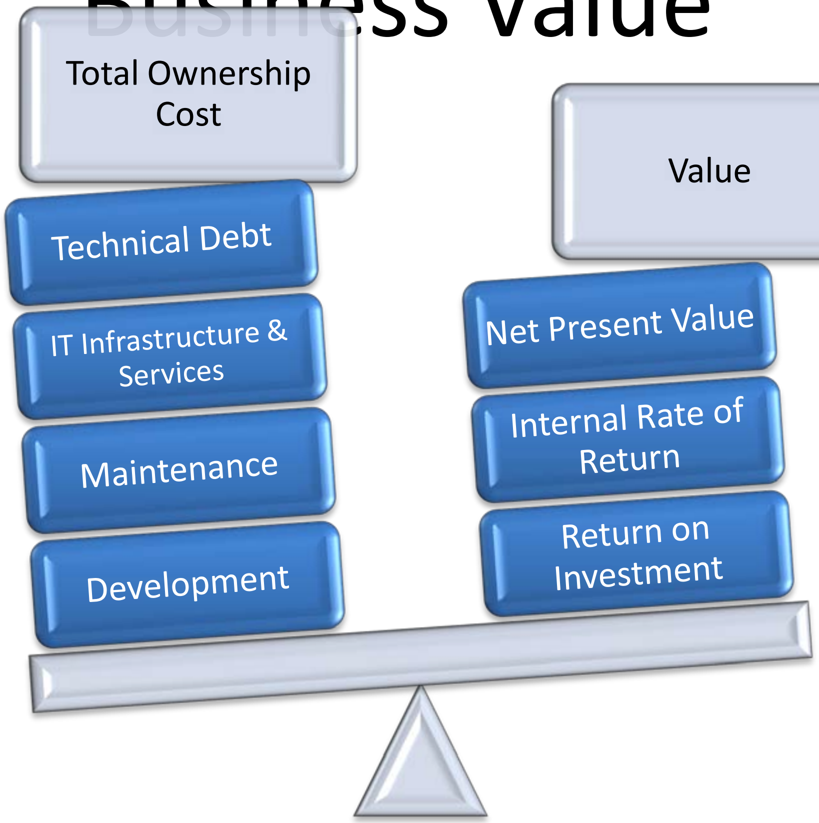
Developing measurements which provide the information required for Optimal project decisions

- **Performance based software project measurements**
- **Parameters that would support cost estimation models in the evaluation of total life cycle costs including development, maintenance, sustainment, and resolution of technical debt**
- **Software measurements to identify Technical Debt**
- **Identification of software measurements to support cost estimation of Technical Debt as component of total system costs.**

Optimization

- The maximizing or minimizing of a given function possibly subject to some type of constraints.
- (*systems engineering*) Broadly, the efforts and processes of making a decision, a design, or a system as perfect, effective, or functional as possible. Narrowly, the specific methodology, techniques, and procedures used to decide on the one specific solution in a defined set of possible alternatives that will best satisfy a selected criterion. Also known as system optimization.

Software & IT Systems Are About Business Value



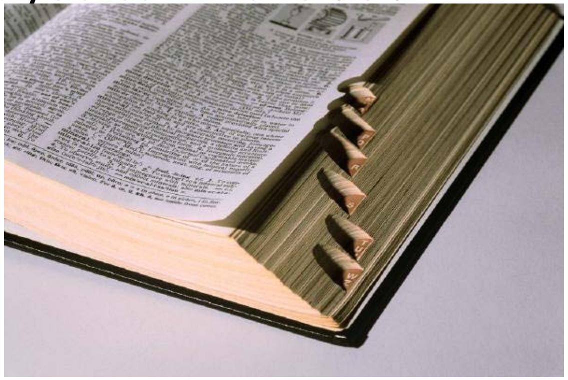
- Software economics should provide methods for analyzing the choices software projects must make." Leon Levy…
- Business economics should provide methods for analyzing choices in which projects to fund
- Project economics should provide methods for project trade-offs

Project Estimation

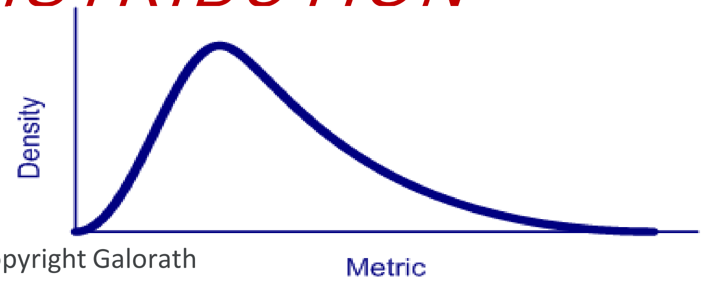
- Total systems level estimation
- Project initiation
- Project planning
- Project execution (Project Optimization)
- Technical Debt
- Maintenance and Sustainment

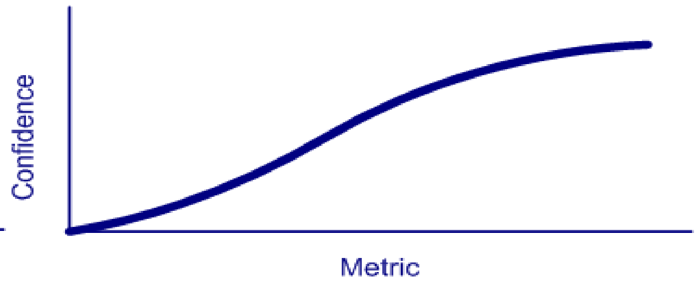
An Estimate Defined

- An ***estimate*** is the most knowledgeable statement you can make ***at a particular point in time*** regarding:
  - Effort / Cost
  - Schedule
  - Staffing
  - Risk
  - Reliability



- Estimates more precise with progress
- *A WELL FORMED ESTIMATE IS A DISTRIBUTION*





Control Theory – Project Management

- ***<u>Feedback control requires continual collection of measurements reflecting performance of “the system”</u>***
- Feedback control systems typically implement a model
  - Best possible math representation of the real world
  - Provides the basis to evaluate alternative control actions available
  - Typically control inputs are the result of analysis supported by a math model representing the “real world”
- Software Project Management control system can be implemented in the same fashion
  - The parametric models used to establish plan (effort, staffing, schedules) can provide basis for Project Management “feedback” control
  - Maintaining the models “after the estimate” allow the models to continually improve the fidelity of the information provided

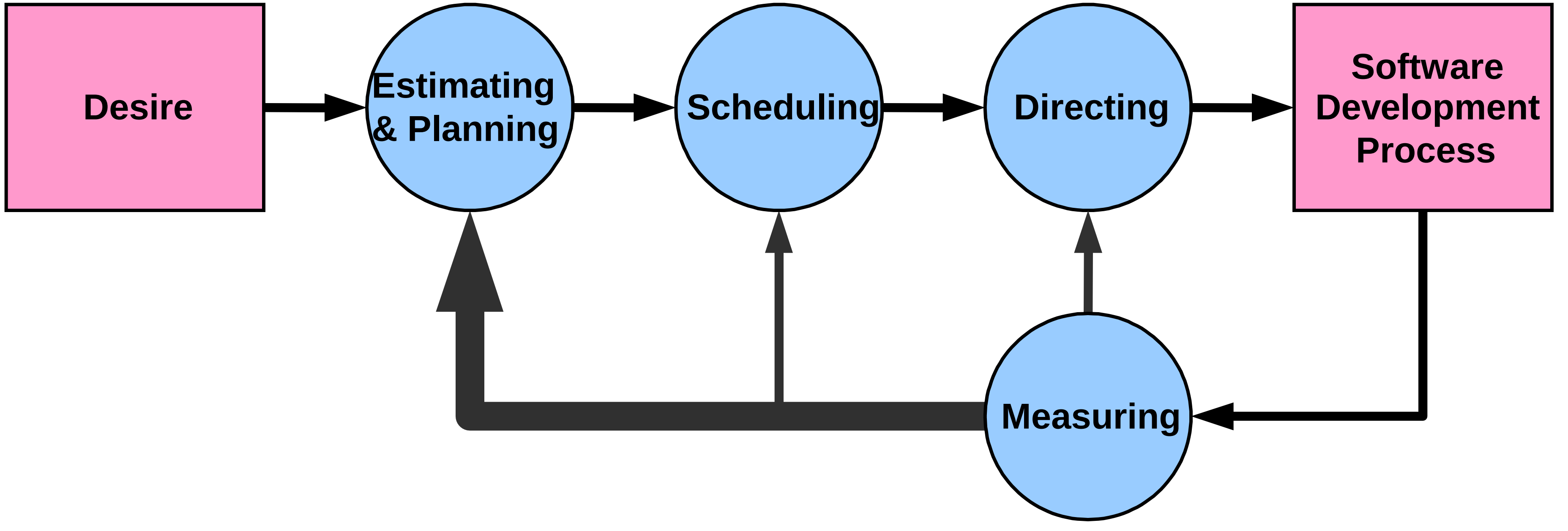
Software Project Management

- Software Project Management
  - Establish objectives
  - Apply resources
  - Obtain project measurements to reflect performance0
  - Analyze results--What are the metrics indicating about the project
  - Determine project issues
- Evaluate alternative actions to select control changes
  - Requires an evaluation of performance goal resulting from the metrics (EVM)
  - Apply a parametric modeling tool to provide the project expected results
- Implement corrections (Don’t stop measurements!!!)

Control Theory & Project Management

- Consider a project as a system process which:
  - Follows a detailed plan
  - Can be evaluated in process with process metrics
  - Includes feedback to project management
  - Should incorporate feedback response and control
  - Process control can be applied "during the process" to reduce the risk of not meeting project objectives
- Control systems theory provides a rigorous framework for analyzing complex feedback systems
- Control systems theory can readily incorporate the concepts of optimal control or choosing the best alternative actions to improve performance of the project placed under control

Software Project Management
Fully Managed Project

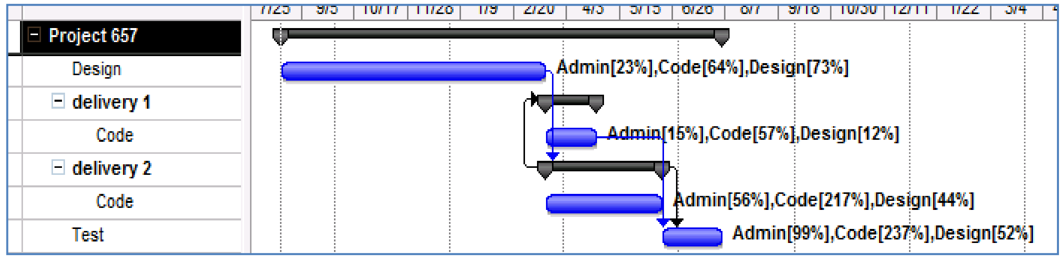


Project Control (Typical)

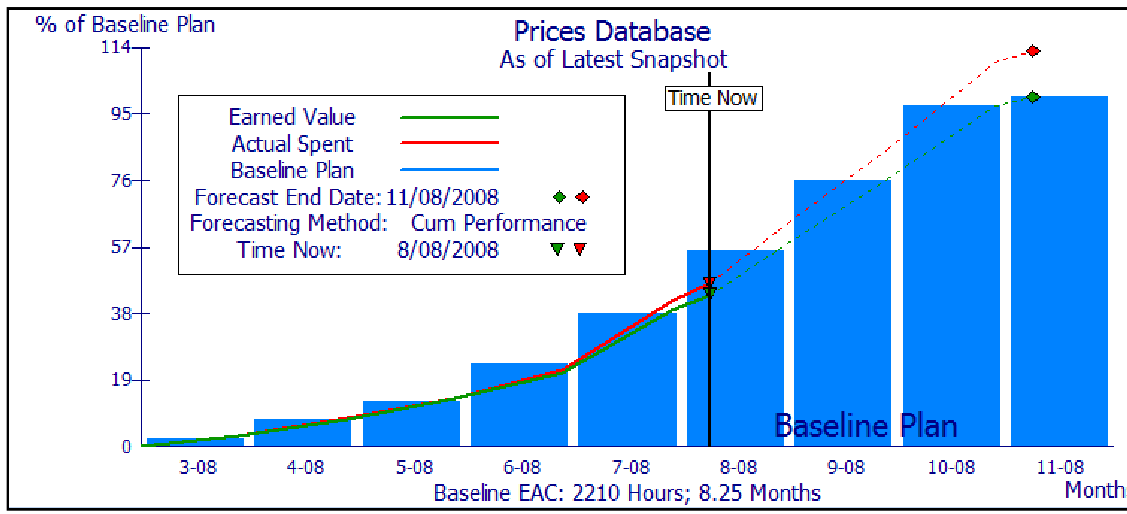
- Introduce and incorporate measurement process
- Next introduce tools that schedule tasks and allocate resources as some function of inter-task dependencies, resource availability, and priority
- Re-plan
  - Identify all remaining tasks
  - Replan redefined project to begin on the current date with a new best estimate of EAC and schedule to complete
- Problem: Does not consider what may have caused the project to be in trouble in the first place, i.e. size is much larger than expected and/or actual performance is not matching planned performance
- Potential solution: Control Theory incorporate established estimation methodology and algorithms as part of the project evaluation, prediction, and re-planning activities to provide the method to determine the corrective action.
- Performance Based Project Management is a result

Features That Inform and Improve Project Execution

Integration to Project planning tools



Performance Base EVM



Example to demonstrate EVM VS PMC

- Single software element – Mission Management and Control
- Ground based critical system with 498 Weapons Systems standard applied
- Parameters set to K base (expected industry nominal)
- Assumed start date 1-2-2011
- Assumed all new code in C++
- Initial estimate from SEER SEM:
  - 57,607 hours with over 28.76 schedule months
  - End date: 5/25/2013

Baseline Plan from SEER SEM

IMS is assumed to be aligned with SEM estimate

Program : 1.1: Mission planning and control

	Baseline Estimate

Development Schedule Months	28.76
Development Effort Hours	57,607
Defect Prediction	33
Defect Density	0.83/1000 SLOC
Total Lines Only	40,000
Effective Lines Only	40,000
SEI Equivalent Rating	3.09
Peak Staff	19
Effort Probability	50.00
Schedule Probability	50.00

SW Measurement with EVM and PMC Results

- System Req Done: Hrs 881 Size 40200 SLOC
  - EVM 57607hrs EAC 0% change 28.7 MO 0% Change
  - PMC 57978hrs EAC 1% change 28.4 MO 0% Change
- SW Req. Done : Hrs 3465 hrs Size 42000 SLOC
  - EVM 57607hrs EAC 0% change 28.7 MO 0% Change
  - PMC 60878hrs EAC 6% change 28.93 MO 0% change
- HLD Done: Hrs 12500 hrs Size 42000 SLOC
  - EVM 57607hrs EAC 0% Change28.7 MO 0% change
  - PCM 62474hrs EAC 8% change 30.81MO 7%growth
- DD Done: Hrs 25750 hrs Size 42500 SLOC
  - EVM 58825hrs EAC 2% change 30.06MO 5% growth
  - PMC 63088hrs EAC 10% change 32.13MO 12% growth

- NOTE: EVM has no indication of impact of requirements growth impact on EAC until added staff during DD as a result of seeing size growth.

Definitions

TECHNICAL DEBT: Effort required to fix violations of good architectural and coding practices that remain in the code when an application is relesed.

Violations: Structure in the source code that is inconsistent with good architectural or coding practices and has proven to cause problems that affect either the cost or risk profile of an application.

Technical Debt (the future cost of defects remaining in code at release, a component of the cost of ownership.

- Principal – **Cost of fixing problems remaining in the code after release that must be remediated CRITICAL DEFECTS IN SEER.. Some subset of the structural analysis**

- Interest - C**ontinuing IT costs attributable to the violations causing technical debt, including higher maintenance costs, greater resource usage, etc. PERFECTIVE IN SEER**

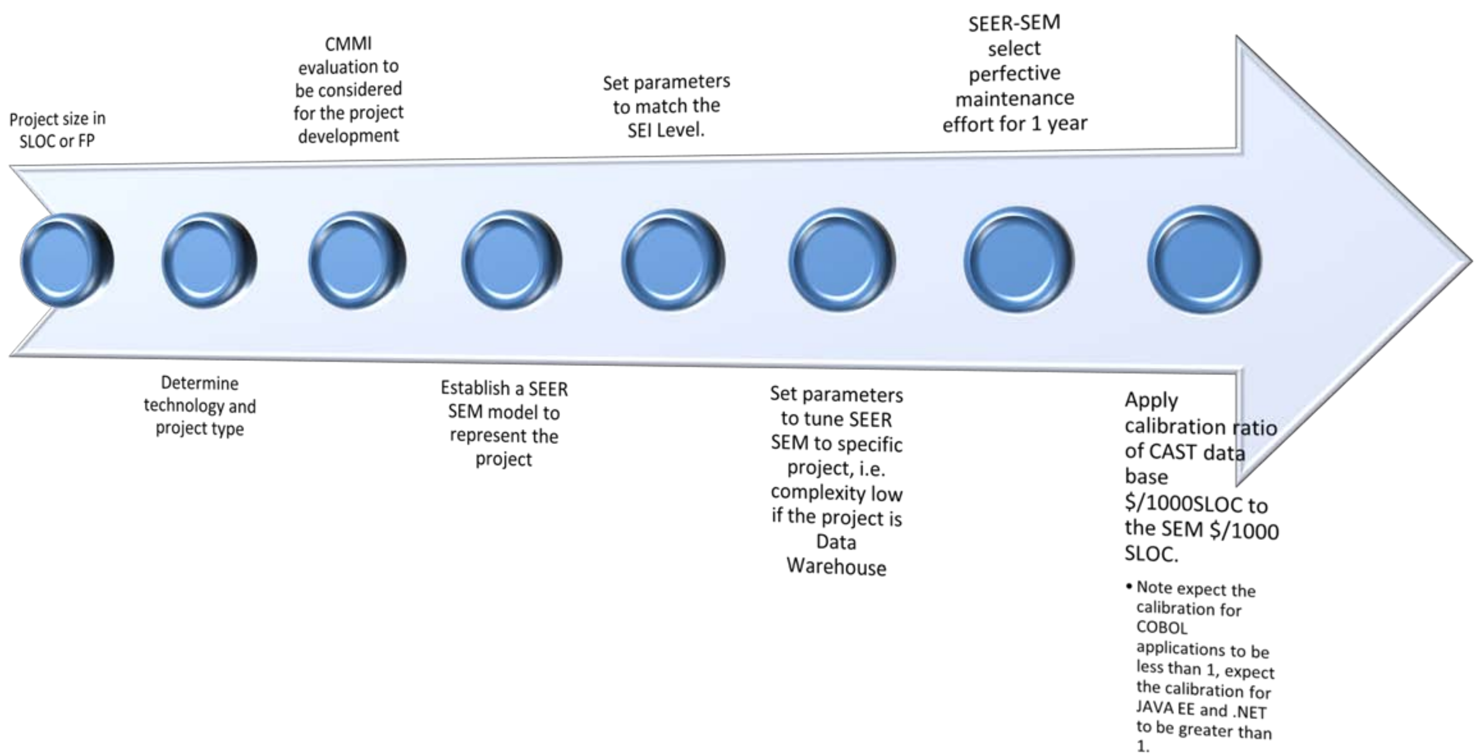
- Liability**—business costs related to outages, breaches, corrupted data, etc. MANUAL COST CALCULATION O BUSINESS LOSSES.. Mean time to defect??? MTTR? Based on amount of tech debt.. Calc bus cust by hour**

- Opportunity cost**—benefits that could have been achieved had resources been put on new capability rather than retiring technical debt…. By doing it right the first time I can save X …. CAN I USE SPEC, TEST, QUAL, MODP.. Experience impacts defects …. Input the defects from cast (use a calibration kbase)**

CAST Study on Technical Debt concentrates on 5 Structural Quality Characteristics.

- *Robustness:* The stability of an application and the likelihood of introducing defects when modifying it.
- *Performance:* The efficiency of the software layer of the application.
- *Security:* An application's ability to prevent unauthorized intrusions.
- *Transferability:* The ease with which a new team can understand the application and quickly become productive working on it.
- *Changeability:* An application's ability to be easily and quickly modified.

Process To Estimate Cost of Clearing Violations (Perfective Maintenance)



CAST /SEER Preliminary Example

- Analysis to define a ratio of CAST projected $/KSLOC to SEM projected $/KSLOC
- Ratio developed calibration to perfective maintenance projection
- Validates applying SEER-SEM to provide estimated cost of clearing technical debt

SEER / CAST Sample Projects

- Internal Application project
  - CMMI Level 4
  - Size 3,150KLOC COBOL
  - Critical violations per KSLOC 0.44
  - **Estimate of SEM vs CAST $ per KLOC $1070 vs $1006 (6%)**
- Data Warehouse project
  - CMMI Level 4
  - Size 106KLOC JAVA
  - **Estimate of SEM vs CAST $ Per KLOC $828 vs $833 (0.6%)**
- Customer Facing WEB application
  - Size 1152 KLOC
  - CMMI Level 3
  - Language JAVA
  - **Estimate SEM vs CAST in $/KLOC**
    - **$4614/$4083 (13%)**

Looking At Maintenance and Technical Debt

Reports

Quick Estimate | Basic Estimate | **Maintenance Effort by Year**

Base Year: 2010
Fiscal Year Start Month: 1

Base: High Rigor, No Technical Debt

Fiscal Year	Average Staff Level	Correct	Adapt	Perfect	Enhance	Total	Cumulative	Base Year Cost	Base Year Cumulative
		Effort Months							
2013	0.9	1.8	2.5	2.9	3.4	10.5	10.5	185,034	185,034
2014	0.9	1.8	2.5	3.0	3.5	10.8	21.3	189,709	374,743
2015	0.9	1.8	2.5	3.0	3.5	10.8	32.1	189,709	564,452
2016	0.9	1.8	2.5	3.0	3.5	10.8	42.9	189,709	754,160
2017	0.9	1.8	2.5	3.0	3.5	10.8	53.6	189,709	943,869
2018	0.9	1.8	2.5	3.0	3.5	10.8	64.4	189,709	1,133,578
2019	0.9	1.8	2.5	3.0	3.5	10.8	75.2	189,709	1,323,286
2020	0.9	1.8	2.5	3.0	3.5	10.8	86.0	189,709	1,512,995
2021	0.9	1.8	2.5	3.0	3.5	10.8	96.7	189,709	1,702,704
2022	0.9	1.8	2.5	3.0	3.5	10.8	107.5	189,709	1,892,412
2023	0.9	0.0	0.1	0.1	0.1	0.3	107.8	4,675	1,897,087
TOTALS		18.0	25.5	29.6	34.7	107.8			

Maintenance Effort by Year

Low Maint.Rigor, Lower Cost, Increased Technical Debt

Year	Average Staff Level	Correct	Adapt	Perfect	Enhance	Total	Cumulative	Base Year Cost	Base Year Cumulative
		Effort Months							
2013	0.6	3.7	0.4	2.8	0.3	7.2	7.2	125,899	125,899
	0.6	2.9	0.8	2.3	0.9	6.9	14.1	121,720	247,619
	0.5	1.1	1.5	1.7	2.0	6.3	20.3	110,434	358,053
	0.5	1.0	1.5	1.7	2.0	6.3	26.6	110,153	468,207
	0.5	1.0	1.5	1.7	2.0	6.3	32.9	110,153	578,360
	0.5	1.0	1.5	1.7	2.0	6.3	39.1	110,153	688,514
	0.5	1.0	1.5	1.7	2.0	6.3	45.4	110,153	798,667
	0.5	1.0	1.5	1.7	2.0	6.3	51.6	110,153	908,820
	0.5	1.0	1.5	1.7	2.0	6.3	57.9	110,153	1,018,974
	0.5	1.0	1.5	1.7	2.0	6.3	64.2	110,153	1,129,127
	0.5	0.0	0.0	0.0	0.0	0.2	64.3	2,714	1,131,842
		15.0	13.0	18.9	17.4	64.3			

Reports

Quick Estimate | Basic Estimate | **Maintenance Effort by Year**

Base Year: 2010
Fiscal Year Start Month: 1

High Actual Cyclomatic Complexity, Low Rigor

Fiscal Year	Average Staff Level	Correct	Adapt	Perfect	Enhance	Total	Cumulative	Base Year Cost	Base Year Cumulative
		Effort Months							
2013	18.5	213.5	0.4	2.8	0.3	217.0	217.0	3,818,928	3,818,928
2014	14.4	169.3	0.8	2.3	0.9	173.3	390.3	3,050,642	6,869,570
2015	5.7	63.3	1.5	1.7	2.0	68.5	458.8	1,205,187	8,074,757
2016	5.5	60.6	1.5	1.7	2.0	65.9	524.7	1,159,117	9,233,874
2017	5.5	60.6	1.5	1.7	2.0	65.9	590.5	1,159,117	10,392,992
2018	5.5	60.6	1.5	1.7	2.0	65.9	656.4	1,159,117	11,552,109
2019	5.5	60.6	1.5	1.7	2.0	65.9	722.2	1,159,117	12,711,226
2020	5.5	60.6	1.5	1.7	2.0	65.9	788.1	1,159,117	13,870,344
2021	5.5	60.6	1.5	1.7	2.0	65.9	853.9	1,159,117	15,029,461
2022	5.5	60.6	1.5	1.7	2.0	65.9	919.8	1,159,117	16,188,579
2023	5.5	1.5	0.0	0.0	0.0	1.6	921.4	28,561	16,217,140
TOTALS		872.1	13.0	18.9	17.4	921.4			

Example consideration of Level of Documentation

	Dev. MO	Maint MO	Defect Pred
Low	545	53	64
Nom	567	49	60
Hi	595	46	51
Vhi	607	44	43

Low-Min doc. easy recovery from loss

Nom- Mod. loss; Recovery without extreme cost

High- full mil spec with IV&V, Remote Financial tran.

Example consideration of Level of Development Process

	Dev MO	Maint MO	Defect Pred
Low	567	49	60
Nom	517	36	53
Hi	472	25	44
Vhi	432	17	36

Low- Min use of SW development best practices

Nom- reasonable use of some practices

VHI – Routine use of complete SW dev process (CMMI Level 3 or above)

Best Practices Regarding Technical Debt

1. Measure structural quality
2. Establish strategy for retiring technical debt (each or alternate iterations/releases)
3. Prioritize violations for remediation
4. Set thresholds for debt to be retired in each iteration
5. Plan actions in each iteration for retiring technical debt
6. Eliminate causes of technical debt (checklists, training, etc.)

Future Developments in Technical Debt

Multiple Component Defects (MCDs)

- **Defects that require changes to multiple components**
- **Require 20X more changes to remediate**
- **MCDs account for over 50% of remediation effort**

Architectural Hotspots

- **8%-10% of defects are MCDs**
- **20% of components with MCDs contain 80% of MCDs**
- **These hotspots account for ≈ 40% remediation effort**
- **Single greatest opportunity to reduce technical debt**

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