
How Much Does Software Maintenance Cost?



**Deputy Assistant Secretary of the Army for Cost and Economics
ICEAA Workshop 2015**

9 June 2015

U.S. Army Software Maintenance Cost Estimation Initiative

Provide the Department of the Army with the ability to accurately estimate, budget, allocate, and justify the software maintenance resources required to meet evolving mission and service affordability requirements across the system life-cycle

Critical Software Maintenance Questions

1. How much funding does each Army system need to maintain its required capability?
2. How many dollars were allocated to a given system from all sources to upgrade and maintain the capability embedded in the software?
3. How were those dollars executed? - What did the Army actually buy?
4. What was the mission impact of this investment?
5. How much will the Army need in the future to sustain the capabilities implemented in software?

Software System Size Growth



107 - AH-64As



1620 - AH-64Ds

Apache Software Growth
300 KSLOC to Over 1.4 Million SLOC
Since 1984

Software System Configuration Complexity



4,300 - M1A1 & variants
580 - M1A2 & variants
580 - M1A2 SEP & variants

- Complex system interfaces
- Multiple software change drivers
 - End user requirements
 - Mission evolution
 - System interoperability
 - Change mandates
 - Security requirements
 - Technology updates
 - Technical debt

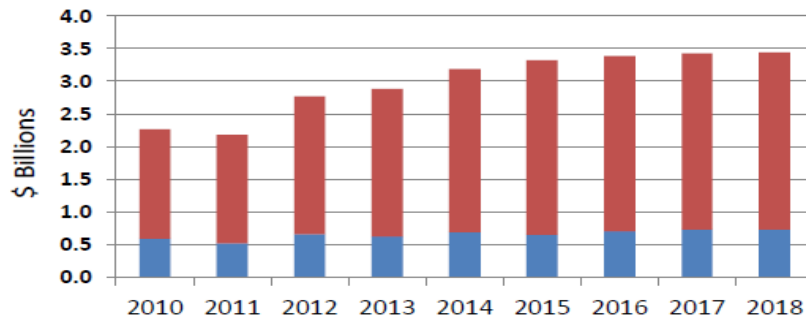
Army Software Engineering Center Requirements Growth

	STARTING DATA POINT		ENDING DATA POINT		WORKLOAD
	YR	#	YR	#	
Number of Systems/Programs	1983	37	2011	400	+1081% over 28 years
Software Releases	1997	64	2011	378	+591% over 14 years
Software Licenses	2004	34,205	2011	131,037	+383% over 7 years
System Size/Complexity	1970	Small	2011	Med-Large	500+%
PPSS Requirements	2003	\$126M	2011	\$569.5M	+452% over 8 years
Customer Requirements	2001	\$179M	2011	\$841.5M	+470% over 11 years

Source: http://www.sae.org/events/dod/presentations/2012/dod_maintenance_symposium.pdf

DOD SW Maintenance Funding (Estimates)

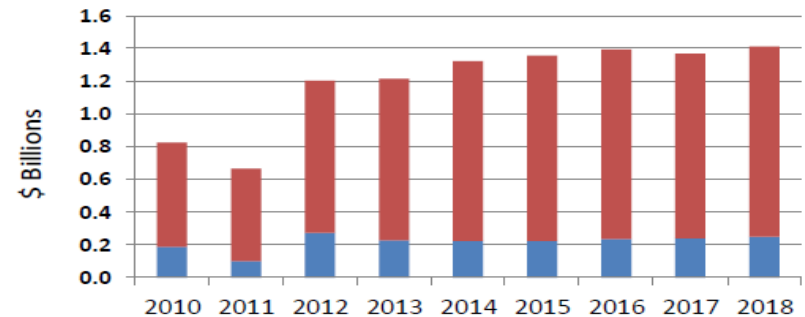
DoD Software Maintenance (\$B)



Source: POM 2014 PB-45 SNaP Data

■ Organic ■ Contract

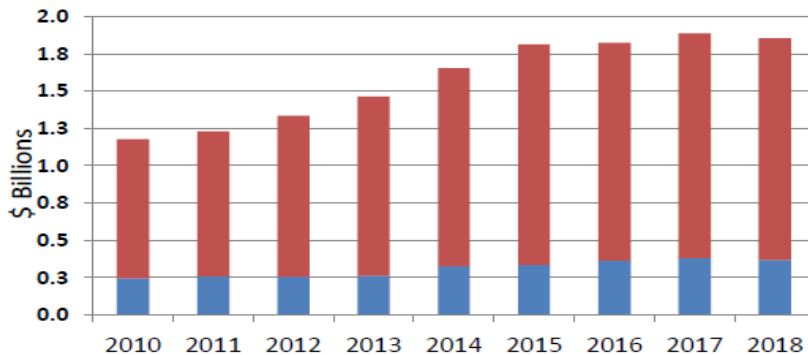
Army Software Maintenance (\$B)



Source: POM 2014 PB-45 SNaP Data

■ Organic ■ Contract

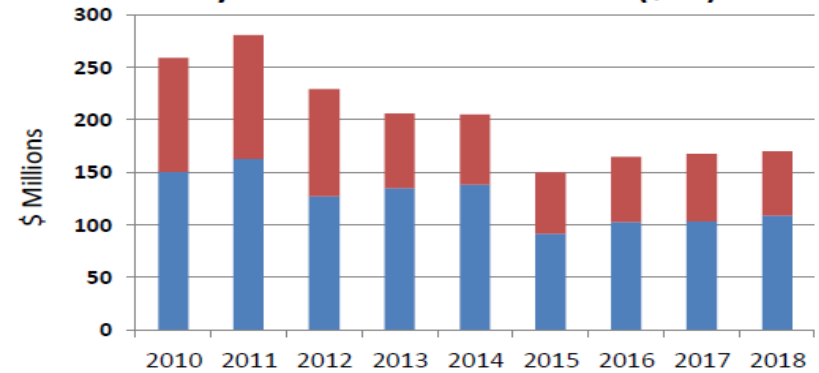
Air Force Software Maintenance (\$M)



Source: POM 2014 PB-45 SNaP Data

■ Organic ■ Contract

Navy Software Maintenance (\$M)



Source: POM 2014 PB-45 SNaP Data

■ Organic ■ Contract

Do More, Without More



Frank Kendall
Under Secretary of Defense for AT&L

- Achieve Affordable Programs
- Achieve Dominant Capabilities While Controlling Life Cycle Costs
- Incentivize Productivity in Industry and Government

Cause and Effects

**Significant Overseas Contingency Operations (OCO)
dollars available to fund Army SWM efforts
for the past 10-15 years**

**SWM cost efforts focused on high-level planning
numbers for requesting funding**

**Lack of software maintenance
actual cost tied to execution output visibility**

**Inability to effectively estimate software
maintenance costs**

Key Cost Related Issues

1. Discordant SWM maintenance definitions and cost accounting accrual structures (system, functional, organizational, etc.)
2. Non-aligned cost, resource, and software technical SWM information / systems
3. Volatile change requirements - execution priorities
4. Multiple funding streams (separately managed)
5. Minimal reported contractor performance data (cost/schedule/product output)
6. LOE management structures - LOE resourcing
7. Minimal enterprise level SWM governance/policy (DOD, Army, etc.) - low level cost management autonomy

Software Maintenance Integrated Cost Estimation Methodology

Approach

- All major Army software maintenance organizations were visited to understand what people do and when they do it
- Cost and technical data was collected from a sample set of programs
- An initial estimation model/methodology was developed and validated based on this data
- Supporting constructs included a tailorable SWM WBS, a relevant set of software functional domains, and a refined set of data requirements
- This model was successfully applied on a set of Army and Air Force pilots, in parallel with the current estimation methodology

Software Maintenance

Software Maintenance

- All activities associated with modifying a software product/system after delivery

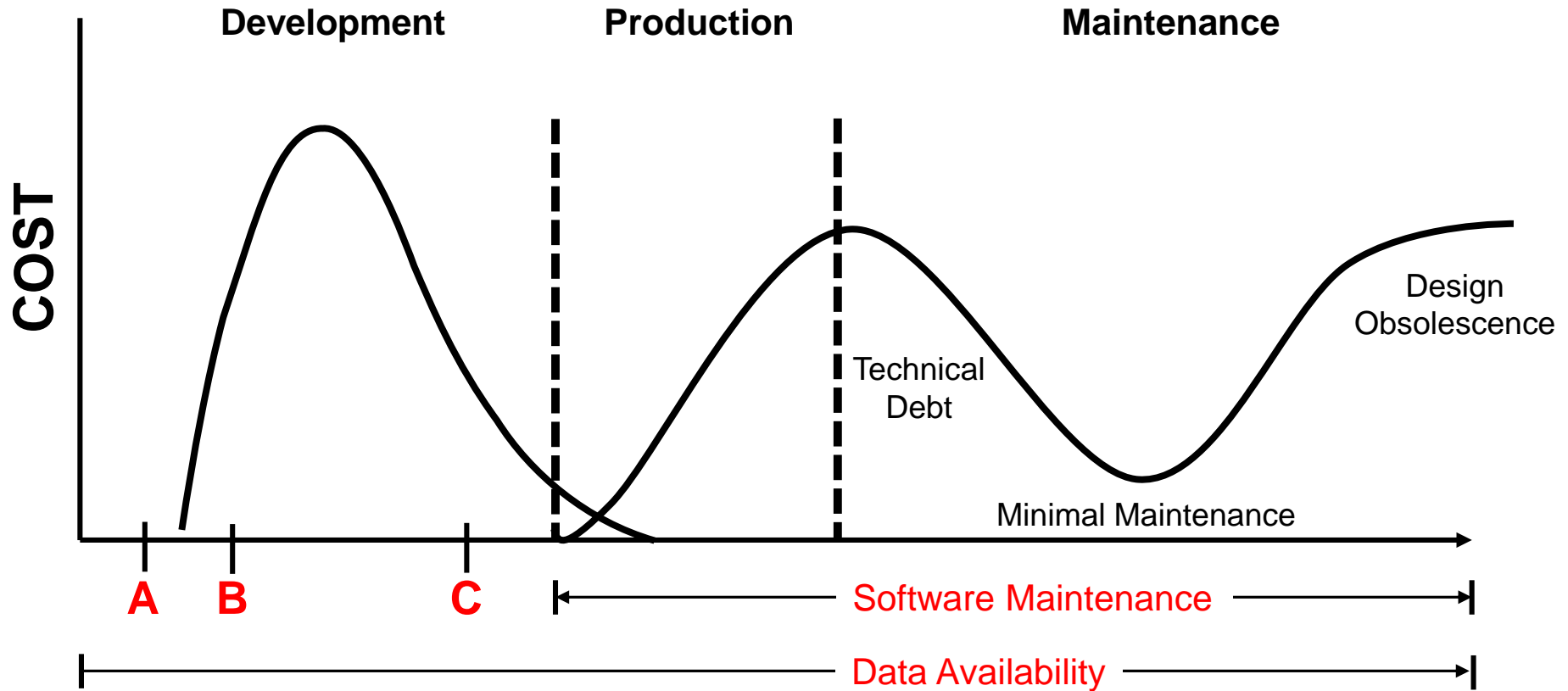
Software Maintenance Costs

- May be directly allocated to a single system or treated as “shared” organizational costs
- Costs are aggregates of outputs/activities executed under multiple funding sources
- Includes software enhancements (RDTE, OCO, Production) and software corrections/adaptations/etc. (PPSS, OMA)
- Costs not aligned with software maintenance output products/activities

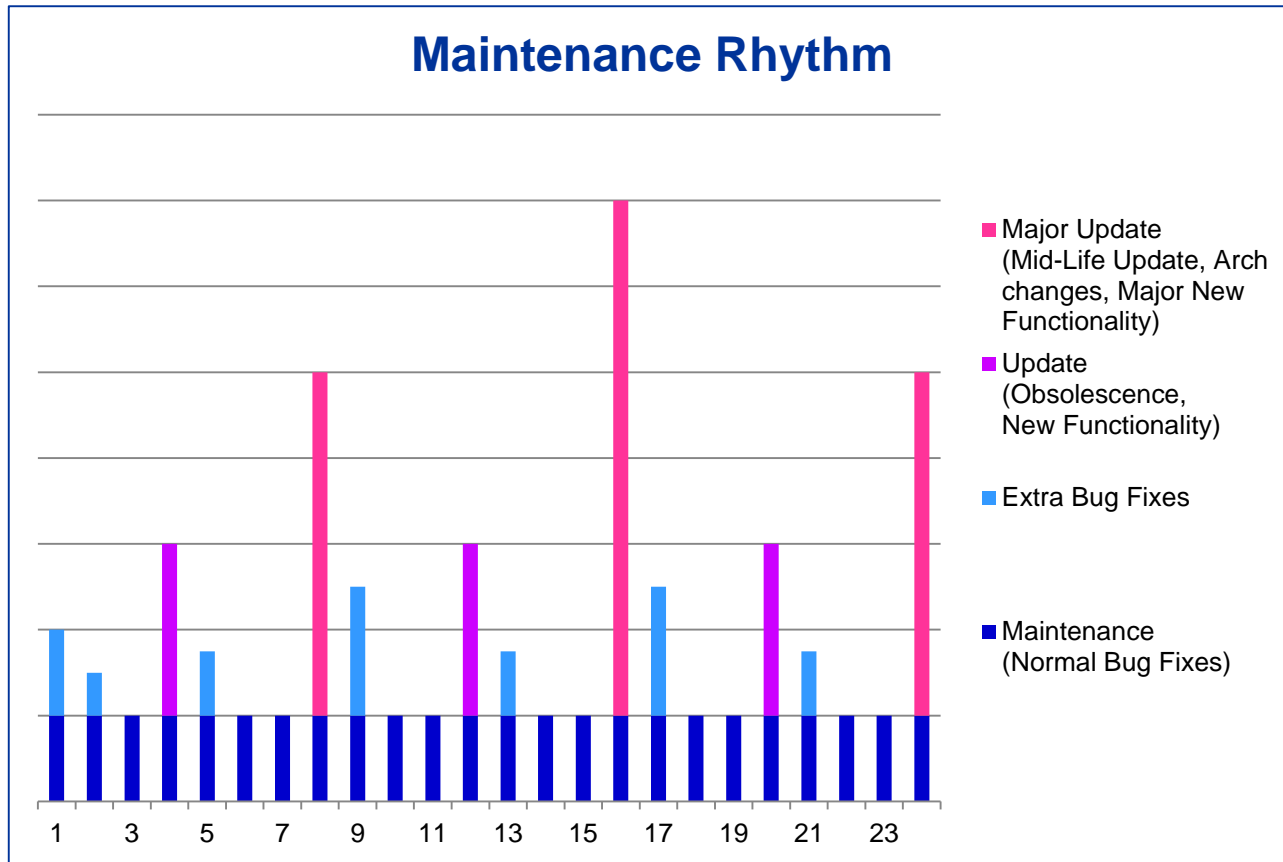
Software Maintenance Cost Estimation Requirements

- Need to effectively estimate and justify software maintenance costs across the system lifecycle
- Estimates required at all phases of a program: beginning before milestone A and continuing through O&M
- Current methods are inadequate and do not provide the information needed by decision makers
- SWM costs are currently estimated as a percentage of the development costs

Notional Software Maintenance Life-Cycle Cost Model

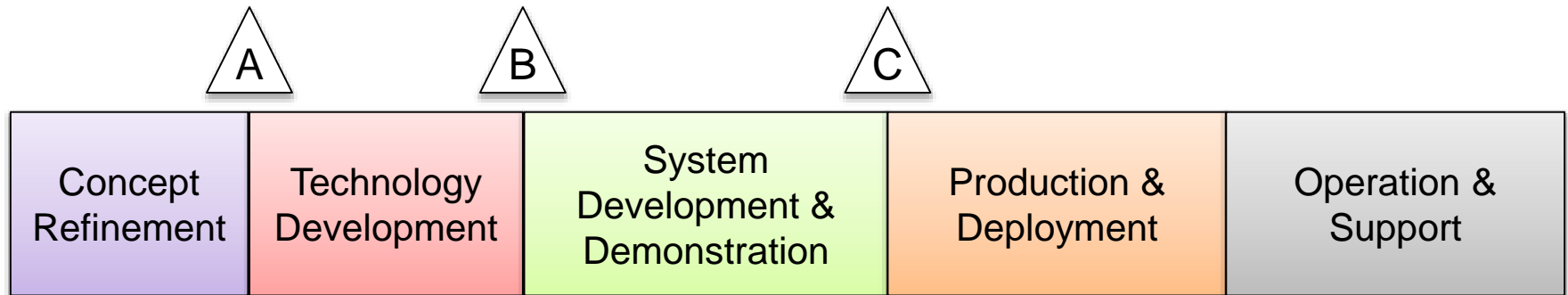


Software Maintenance Release Profile



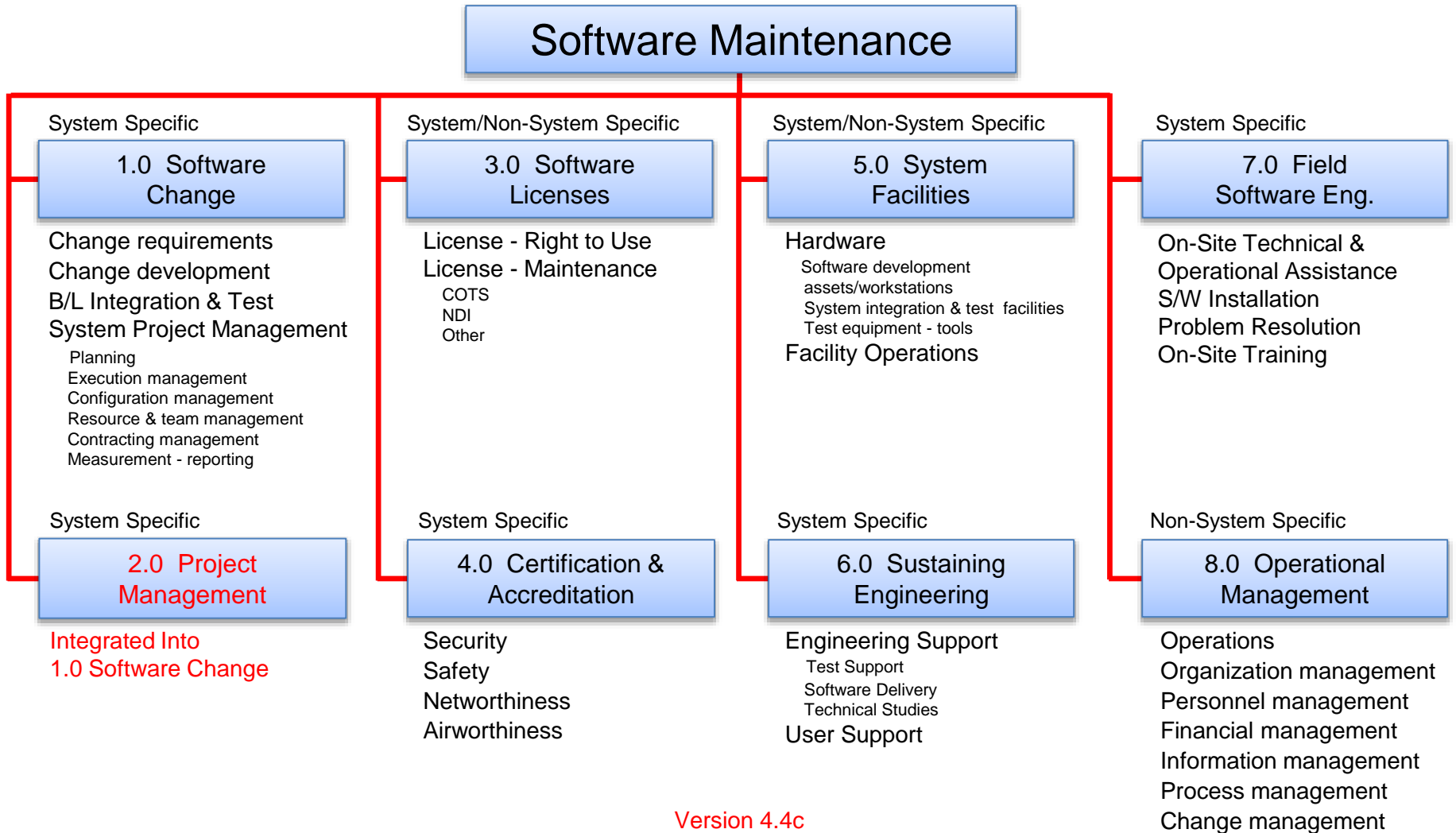
Cycles are different for different programs
User needs drive release content

DOD Acquisition Lifecycle Model



- Programs may be in any lifecycle phase
- Estimates are required at the major milestones and periodically after milestone C
- Estimation considerations:
 - Availability and quality of program data
 - Different CERs at different estimation points and for different system characteristics (e.g. domains)
 - Different types of CERs: parametric, ratios, trends

Software Maintenance WBS



Version 4.4c

Software Maintenance WBS

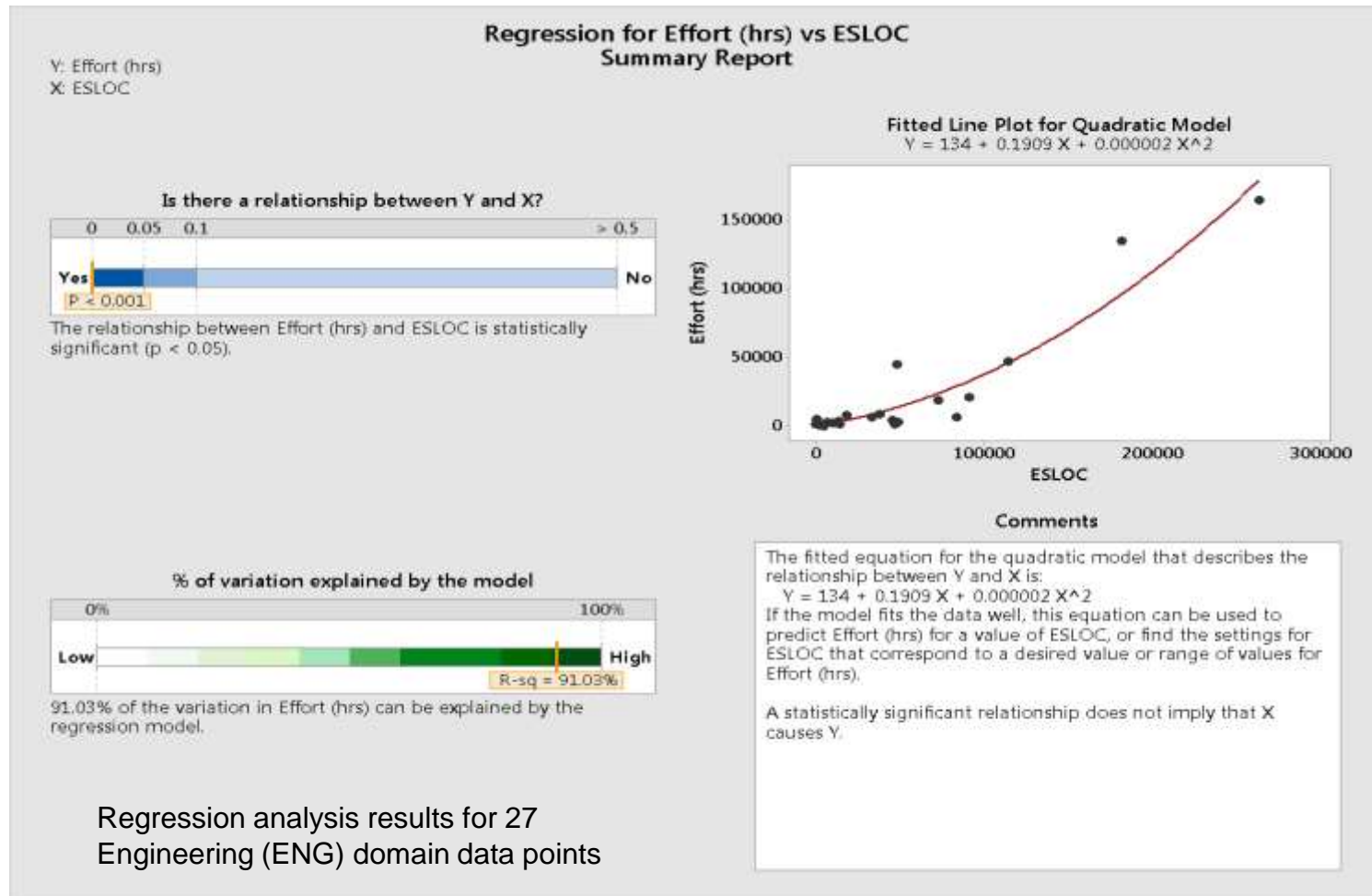
- Common structure that includes all potential software maintenance products and activities - “what’s in” - “what’s out”
- Defines the superset of program software maintenance cost elements
- Foundation for common software maintenance definitions and terminology
- Basis for identifying the specific SWM cost elements attributable to a given system and/or organization software maintenance effort
- Product based - system and organizational cost elements identified as those required to make changes to an operational software baseline(s)
- Cost elements represent both system allocated and non-system specific products and activities
- Flexible structure - designed to be adapted to unique system contexts and existing data structures
- The SWM-WBS is equally applicable to:
 - software maintenance estimation and planning
 - tracking software maintenance execution

Acquisition Milestone CER/SER Matrix

WBS Element #	MS A	MS B	MS C	Production/PPSS
1, 2 & 6 - Software Change Produce, Project Management	Analogy for cost based on system domain	Analogy for size Historical data derived proxy tables for size-based effort and cost with system domain	Development (baseline) size and build information (Program data derived formulas for effort, schedule, and cost)	MS C information plus actual maintenance data from completed releases (locally derived formulas for effort, schedule, and cost)
3 - Software Licenses (Cost of)	Analogy based on type of system and anticipated maintenance depot	Information by system type – used in analogy Post-MS B, quoted costs from vendor(s)	List of actual products with costs – license quoted costs	List of actual products with costs – license quoted costs (changes for obsolescence)
4 – Certifications & Accreditations	Analogy for cost by system domain	Analogy for cost by system domain and anticipated maintenance depot	List of actual C&As with costs (by release or annual)	List of actual C&As with costs (by release or annual)
5 – Software Maintenance Facilities	Analogy for cost by maintenance depot	Analogy for cost by maintenance depot	Budget cost (%) by depot plus extras	Actual cost (%) by depot plus extras
7 - Field Software Engineering	Analogy for cost by system domain	Analogy for cost by system domain	Analogy for cost by system domain	Analogy for cost by system domain
8 – Support Infrastructure	Analogy for cost by maintenance depot	Analogy for cost by maintenance depot	Budget cost (%) by maintenance depot plus extras	Actual cost (%) by maintenance depot plus extras

Effort CER

Engineering Super-Domain



CER - Project Data

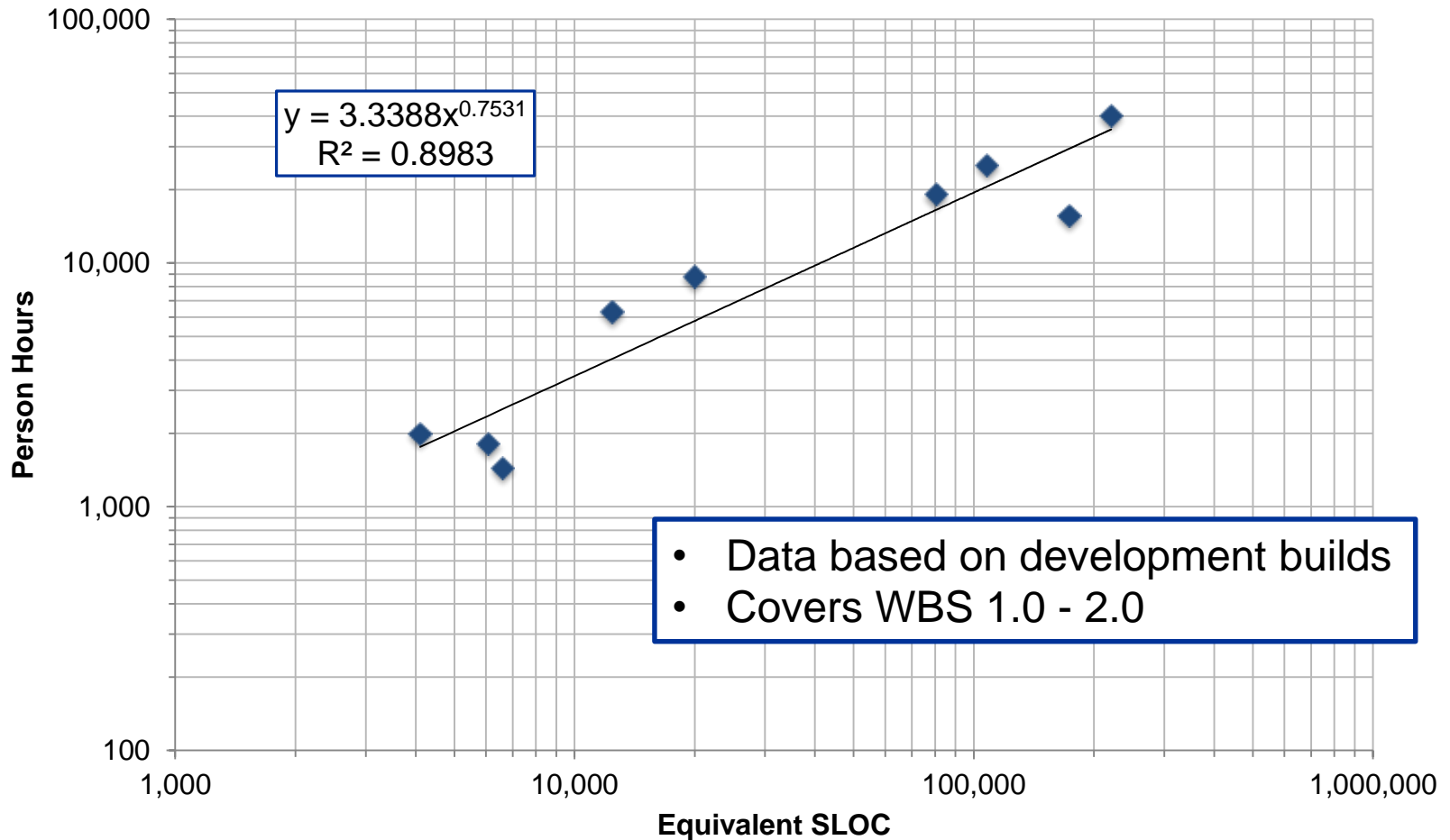
Build	Equivalent SLOC	Hours	Start Date	End Date	Months Duration
1	173,447	15,648	01/01/08	07/10/09	18.0
1a	6,085	1,806	07/01/09	09/15/09	2.0
1b	6,609	1,441	09/10/09	11/03/09	1.0
2	108,081	25,153	06/01/09	12/15/10	18.0
2a	12,436	6,305	12/01/10	05/05/11	5.0
2b	4,106	1,994	04/01/11	10/15/11	6.0
3	220,788	40,104	08/20/11	01/09/13	16.0
3a	19,969	8,785	12/01/12	03/30/13	3.0
3b	80,575	19,105	02/01/13	09/05/13	7.0

CER Data

Rhythm Data

CER Derivation

Historical Data

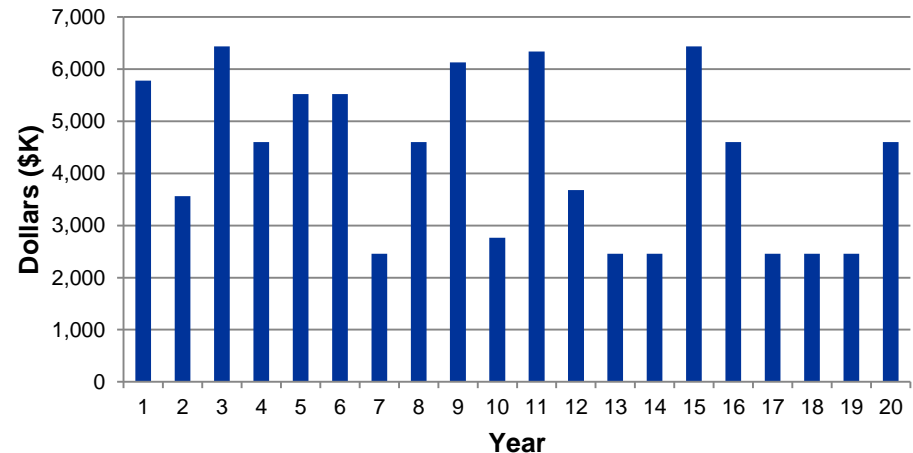


Cost Projection - WBS 1.0 and 2.0

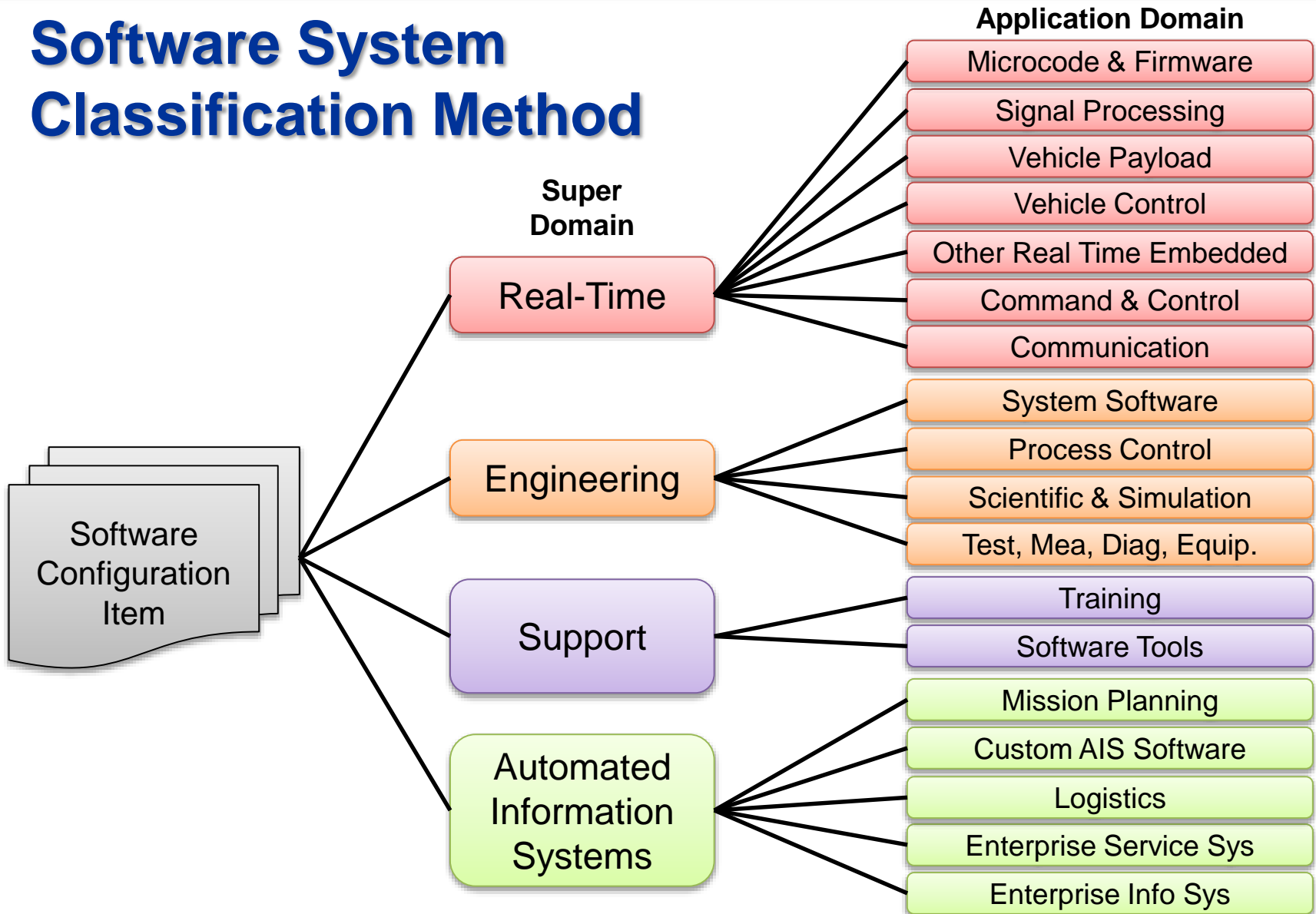
Release	SLOC	Effort (staff hours)	Cost (@ \$90/hour)	Duration (months)	Monthly Burn Rate
4	175,000	87,936	\$7,914,281	16	\$481,707
4.1	25,000	14,678	\$1,321,056	6	\$204,616
4.2	25,000	14,678	\$1,321,056	6	\$204,616
5	200,000	99,431	\$8,948,784	18	\$510,857
5.1	25,000	14,678	\$1,321,056	6	\$204,616
5.2	25,000	14,678	\$1,321,056	6	\$204,616
6	200,000	99,431	\$8,948,784	18	\$510,857
6.1	25,000	14,678	\$1,321,056	6	\$204,616
6.2	25,000	14,678	\$1,321,056	6	\$204,616
6.3	25,000	14,678	\$1,321,056	6	\$204,616
6.4	25,000	14,678	\$1,321,056	6	\$204,616
(cont.)					

Estimate by Release

Cost Estimate by Year



Software System Classification Method



Operating Environment

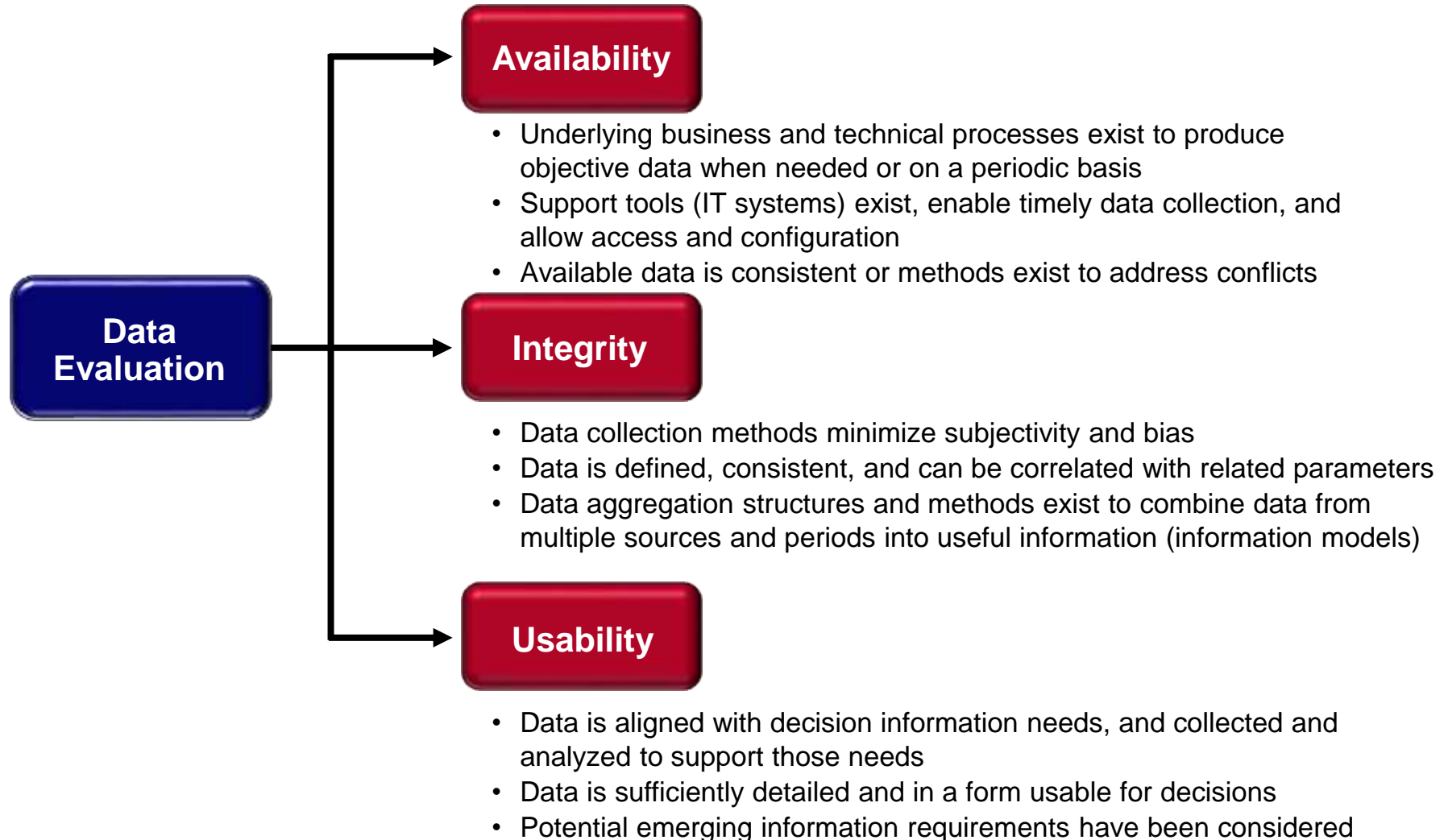
- Operating Environment: In which the maintained software system operates:
 - Surface Fixed - in a system at a fixed site
 - Surface Mobile - in a system that is moved & setup
 - Surface Portable - in a handheld or portable device
 - Surface Vehicle - as part of a moving vehicle
 - Air Vehicle - as part of an aircraft
 - Sea Systems - as part of a surface or underwater boat/ship
 - Ordnance Systems - as part of a missile or rocket
 - Space Systems - as part of a spacecraft
- Manned vs. Unmanned: For the operating environment above, indicate if it is a manned or unmanned environment.

Army Software Maintenance Data - To Date

Data Evaluation

- System processes and data aligned closely with the SWM-WBS
- Data sets evaluated for availability, integrity, and usability
- Large variance in data evaluation results across programs - multiple factors
- Most data focused on the budgeting process - funding requests - dollars - OPS-29 OMA accounts
- Minimal execution data provided
- Inconsistent business, technical, project management processes across systems
- Correlation of cost and technical data in general was problematic
- Cost data not generally mapped to activity and product outputs

Data Assessment



SWM Data Assessment

Organization	Program	Data Availability					Data Integrity				
		Profile Data	Size	Effort/Cost	Schedule	Overall	Size	Licenses	C&A	FSE	Overall
Org 1	Pgm 1	0.41				0.10		0.80	0.15		0.24
Org 1	Pgm 4	0.34				0.09					
Org 1	Pgm 5	0.98		0.98	0.90	0.72		0.20	0.15	0.15	0.13
Org 1	Pgm 6	0.34				0.09			0.33		0.08
Org 1	Pgm 7	0.27				0.07			0.33		0.08
Org 1	Pgm 8	0.41	0.80	0.61	0.90	0.68	1.00	0.85	0.75	0.15	0.69
Org 1	Pgm 29	0.20	0.20		0.65	0.26	0.85	0.20	0.15		0.30
Org 1	Pgm 30					0.00					
Org 1	Pgm 31	0.98	0.60	0.79		0.59	1.00	0.20	0.15		0.34
Org 1	Pgm 32	0.27				0.07					
Org 1	Pgm 35	0.20				0.05					
Org 1	Pgm 38	0.20	0.20	0.20		0.15	0.85				0.21
Org 1	Pgm 40	0.27	0.20			0.12	0.50				0.13
Org 1	Pgm 41	0.20	0.20			0.10	0.50				0.13
Org 1	Pgm 43	0.34	0.30	0.32	0.90	0.47	1.00	0.20			0.30
Org 2	Pgm 33	0.27	0.65	0.46	0.70	0.52	0.93				0.23
Org 2	Pgm 34	0.20	0.20	0.20	0.90	0.38	0.10				0.03
Org 2	Pgm 37	0.20	0.45	0.33	0.70	0.42	0.65				0.16
Org 2	Pgm 42	0.20	0.75	0.48	0.80	0.56	0.95				0.24
Org 3	Pgm 11	0.41				0.10		0.65	0.33	0.40	0.35
Org 3	Pgm 12	0.20				0.05		0.65	0.33	0.40	0.35
Org 3	Pgm 13	0.34				0.09		0.65	0.33	0.33	0.33
Org 3	Pgm 14	0.27				0.07		0.65	0.33	0.33	0.33
Org 3	Pgm 15	0.41				0.10		0.65	0.33	0.40	0.35
Org 4	Pgm 2	0.13				0.03					
Org 4	Pgm 3	0.49		0.49	0.40	0.35		0.60	0.33	0.40	0.33
Org 4	Pgm 9	0.13	0.85	0.49		0.37	0.65	0.20			0.21
Org 4	Pgm 10	0.49	0.20	0.35	0.30	0.33	0.50	0.60	0.33		0.36
Org 4	Pgm 16	0.13	0.95	0.54		0.41	0.73	0.20			0.23
Org 4	Pgm 17	0.49	0.20	0.35	0.30	0.33	0.50	0.65	0.33	0.40	0.47
Org 4	Pgm 18	0.13			0.10	0.06					
Org 4	Pgm 19	0.49				0.12			0.33		0.08
Org 4	Pgm 20	0.13	0.90	0.52		0.39	0.73	0.20			0.23
Org 4	Pgm 21	0.49	0.20	0.35	0.30	0.33	0.10	0.65	0.33	0.40	0.37
Org 4	Pgm 22	0.49		0.49	0.30	0.32			0.33		0.08
Org 4	Pgm 23	0.13	0.75	0.44		0.33	0.63	0.20			0.21
Org 4	Pgm 24	0.49	0.20			0.17	0.50	0.70	0.33		0.38
Org 4	Pgm 25					0.00		0.20	0.33		0.13
Org 4	Pgm 26	0.49	0.20	0.35	0.30	0.33	0.50	0.60	0.33	0.40	0.46
Org 4	Pgm 27	0.13	0.85	0.49		0.37	0.65	0.20			0.21
Org 4	Pgm 28	0.49		0.49	0.40	0.35			0.33		0.08
Org 4	Pgm 36	0.49		0.49	0.40	0.35					
Org 4	Pgm 39	0.49		0.49	0.40	0.35			0.33		0.08
Org 5	Pgm 44	0.27				0.07					

Next Steps - Collecting Army Data

- Collect and assess SWM execution data from a wide base of Army systems - data call 22 May 2015
 - Phase 1 (3 months) - data from 5 programs from each PEO/SEC
 - Phase 2 (9 months) - data from remaining Army programs
- Data questionnaire includes:
 - Program level data
 - Context data
 - Annual data on effort and cost for Software licenses, certification and accreditations, software facilities, etc.
 - Release data on release effort and cost, size (requirements, SLOC, change requests, etc.), schedule
 - Details on COTS licenses

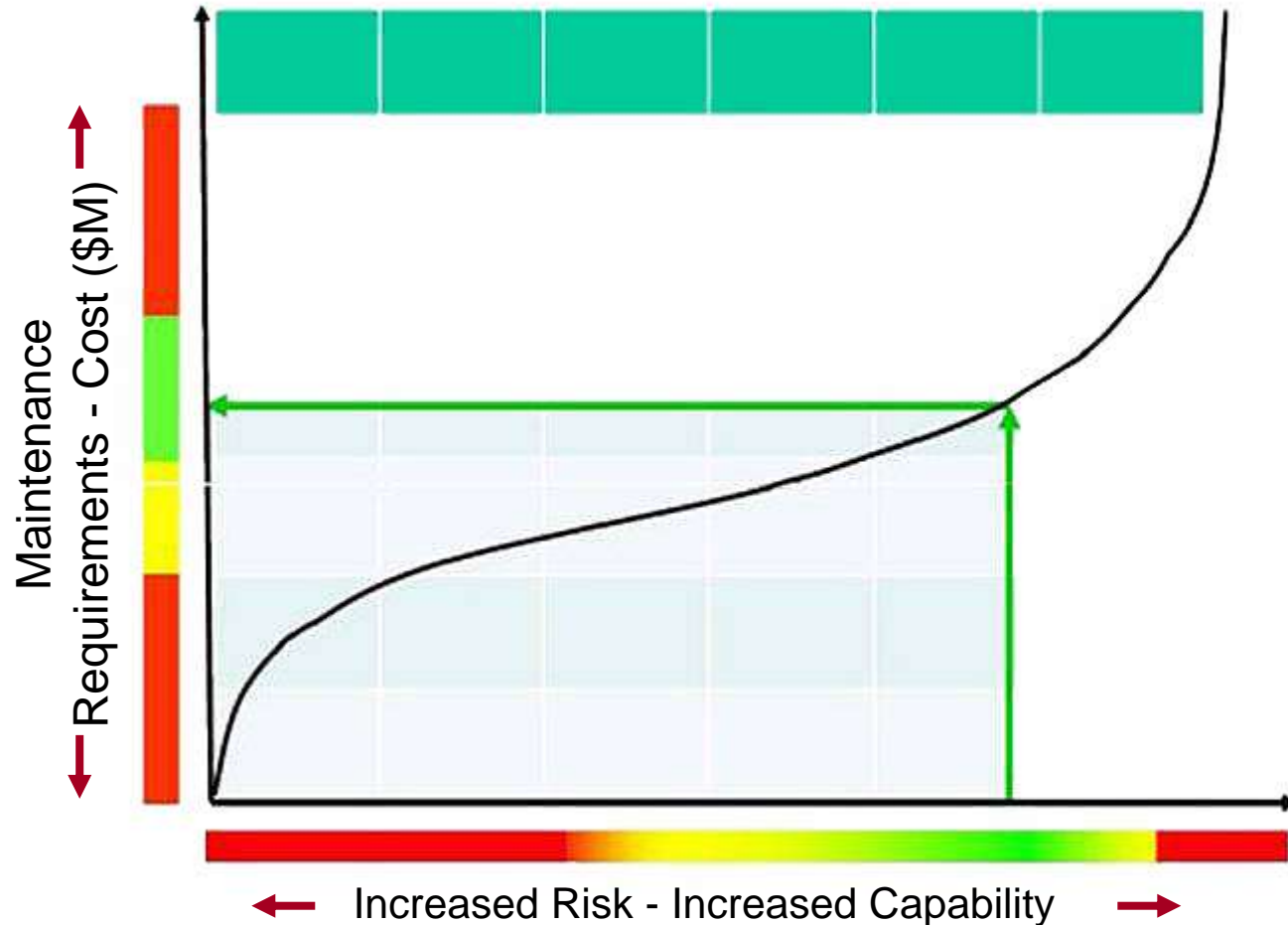
Next Steps - Refinement of CERs

- Refine the underlying SWM CERs - calibrate to application domains and operating environments
- Update the estimation models/methodology with respect to structure and application
- Define the requirements/plan for implementing an Army SWM information infrastructure - focus on multi-level decision information needs
- Adapt GFEBS to support systemic SWM data collection

What We Have Learned

- Estimating software maintenance is much more difficult than estimating software development:
 - Complex cost, funding, and management constructs
 - Lack of a consistent data environment
 - Focus on system/organizational funding - not cost of output products/services
 - Lack of visibility into leveraged contractor efforts and expenditures
- Two significant cost categories:
 - Fixed infrastructure - maintenance of capability costs
 - Variable change driven software modification costs
- What is paid for and what is done are two different things - SWM task volatility
- The emerging estimation methodology more closely aligns with the SWM work that is actually being accomplished
- If requirements continue to grow beyond the projected SWM budgets - we will need to be much better at estimating, allocating, and tracking SWM costs

Objective Cost-Capability Trades



“It's All About the Money”, Dr. Chien Huo, CAPE, November 2011

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