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

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

107 - AH-64As

1620 - AH-64Ds
Software System Configuration Complexity

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

4,300 - M1A1 & variants
580 - M1A2 & variants
580 - M1A2 SEP & variants
# Army Software Engineering Center Requirements Growth

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

Do More, Without More

• Achieve Affordable Programs

• Achieve Dominant Capabilities While Controlling Life Cycle Costs

• Incentivize Productivity in Industry and Government

Frank Kendall
Under Secretary of Defense for AT&L
**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

Development | Production | Maintenance

Cost

A B C

Data Availability

Software Maintenance

Technical Debt

Minimal Maintenance

Design Obsolescence

9 June 2015

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Distribution Statement A: Approved for Public Release
Software Maintenance Release Profile

Maintenance Rhythm

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

1.0 Software Change
- Change requirements
- Change development
- B/L Integration & Test
- System Project Management
  - Planning
  - Execution management
  - Configuration management
  - Resource & team management
  - Contracting management
  - Measurement - reporting

2.0 Project Management
- Integrated Into 1.0 Software Change

3.0 Software Licenses
- License - Right to Use
- License - Maintenance
  - COTS
  - NDI
  - Other

4.0 Certification & Accreditation
- Security
- Safety
- Networthiness
- Airworthiness

5.0 System Facilities
- Hardware
  - Software development assets/workstations
  - System integration & test facilities
  - Test equipment - tools
- Facility Operations

6.0 Sustaining Engineering
- Engineering Support
  - Test Support
  - Software Delivery
  - Technical Studies
- User Support

7.0 Field Software Eng.
- On-Site Technical & Operational Assistance
- S/W Installation
- Problem Resolution
- On-Site Training

8.0 Operational Management
- Operations
- Organization management
- Personnel management
- Financial management
- Information management
- Process management
- Change management

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

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

Regression analysis results for 27 Engineering (ENG) domain data points
## CER - Project Data

<table>
<thead>
<tr>
<th>Build</th>
<th>Equivalent SLOC</th>
<th>Hours</th>
<th>Start Date</th>
<th>End Date</th>
<th>Months Duration</th>
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<td>15,648</td>
<td>01/01/08</td>
<td>07/10/09</td>
<td>18.0</td>
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<td>1a</td>
<td>6,085</td>
<td>1,806</td>
<td>07/01/09</td>
<td>09/15/09</td>
<td>2.0</td>
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<tr>
<td>1b</td>
<td>6,609</td>
<td>1,441</td>
<td>09/10/09</td>
<td>11/03/09</td>
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<td>2a</td>
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<td>2b</td>
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<tr>
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**CER Data**

**Rhythm Data**

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Distribution Statement A: Approved for Public Release
CER Derivation

Historical Data

y = 3.3388x^{0.7531}  
R² = 0.8983

- Data based on development builds
- Covers WBS 1.0 - 2.0
## Cost Projection - WBS 1.0 and 2.0

<table>
<thead>
<tr>
<th>Release</th>
<th>SLOC</th>
<th>Effort (staff hours)</th>
<th>Cost (@ $90/hour)</th>
<th>Duration (months)</th>
<th>Monthly Burn Rate</th>
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<td>4</td>
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<td>87,936</td>
<td>$7,914,281</td>
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<td>$1,321,056</td>
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<td>$204,616</td>
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<td>$204,616</td>
</tr>
</tbody>
</table>

(cont.)

### Estimate by Release

### Cost Estimate by Year
Software System Classification Method

Super Domain

Real-Time

Engineering

Support

Automated Information Systems

Application Domain

- Microcode & Firmware
- Signal Processing
- Vehicle Payload
- Vehicle Control
- Other Real Time Embedded
- Command & Control
- Communication
- System Software
- Process Control
- Scientific & Simulation
- Test, Mea, Diag, Equip.
- Training
- Software Tools
- Mission Planning
- Custom AIS Software
- Logistics
- Enterprise Service Sys
- Enterprise Info Sys

Software Configuration Item
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

Availability
- Underlying business and technical processes exist to produce objective data when needed or on a periodic basis
- Support tools (IT systems) exist, enable timely data collection, and allow access and configuration
- Available data is consistent or methods exist to address conflicts

Integrity
- Data collection methods minimize subjectivity and bias
- Data is defined, consistent, and can be correlated with related parameters
- Data aggregation structures and methods exist to combine data from multiple sources and periods into useful information (information models)

Usability
- Data is aligned with decision information needs, and collected and analyzed to support those needs
- Data is sufficiently detailed and in a form usable for decisions
- Potential emerging information requirements have been considered
## SWM Data Assessment

<table>
<thead>
<tr>
<th>Organization</th>
<th>Program</th>
<th>Profile Data</th>
<th>Size</th>
<th>Effort/Cost</th>
<th>Schedule</th>
<th>Overall</th>
<th>Size</th>
<th>Licenses</th>
<th>C&amp;A</th>
<th>FSE</th>
<th>Overall</th>
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<tbody>
<tr>
<td>Org 1</td>
<td>Pgm 1</td>
<td>0.41</td>
<td>0.10</td>
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</tbody>
</table>
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
"It's All About the Money", Dr. Chien Huo, CAPE, November 2011
Contact Information

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