Performance Outcomes of CMMI®-Based Process Improvements

By Peter J. McLoone and Sharon L. Rohde

Trends of Key Business Indicators During the Journey from SW-CMM® Level 2 to CMMI® Level 5

Introduction

Lockheed Martin Integrated Systems & Solutions (IS&S) specializes in developing horizontally-integrated solutions for network-centric operations, to enable defense and intelligence organizations to act with greater speed, precision and effectiveness. IS&S is a Business Area of Lockheed Martin Corporation, headquartered in Gaithersburg, MD, and geographically distributed throughout the United States and the world. IS&S has approximately 15,000 employees with an estimated $5 Billion in annual revenues. IS&S was formed primarily from the Lockheed Martin Management & Data Systems (M&DS) and Mission Systems business units in late 2003.

IS&S has a long history of process improvement based upon Capability Maturity Models (CMMs). Specific milestones in this journey are as follows:

• 1993-1995: Performing at Software Capability Maturity Model Version 1.1 (SW-CMM®) Level 2
• 1996-1997: Performing at SW-CMM® Level 3; formally certified at this level in 1996
• 1998-1999: Performing at SW-CMM® Level 4; formally certified at this level in 1998
• 2000-2001: Performing at SW-CMM® Level 5; formally certified at this level in 2000
• 2002-present: Performing at Capability Maturity Model®, Integrated (CMMI®) Version 1.1 Staged SE/SW Level 5; formally certified at this level in 2002, maintained certification at this level in 2005 for SE/SW/IPPD/SS.

While IS&S has improvement related data for specific CMMI® based improvement projects, we wanted to discern whether there was noticeable effects (positive or negative) on indicators typically used by senior management for setting business objectives.

Analyses of these indicators show consistent value in pursuing CMM®-driven process improvement. For example, award fees increased and overhead rates declined; software productivity increased, while unit software cost and defect find and fix costs decreased. The purpose of this article is to review the yearly results and trends of these key business indicators since 1993. The data through 2003 reflect history from the M&DS business unit. The IS&S Business Area is continuing to use and improve the M&DS process architecture, policy, and practice framework.

Business Objectives Mapped to Indicators

Successful achievement and maintenance of process maturity comes from a strong thread of enterprise-level objectives and implementation plans flowing down to program-level objectives, information needs, and indicators. At the enterprise level, annual goal-setting is conducted by executive management; and each goal is assigned to a senior executive. Each goal has a plan which is statused at the monthly executive review with emphasis on quantitative information. Implementation plans for engineering goals include process changes piloted by a set of target programs prior to rollout to a wider audience of programs across the enterprise.

Enterprise goals for process efficiency and product quality are flowed down to programs through the management chain. Programs are required to have smooth process initiation using early intervention to manage risks, with senior functional engineering managers persistent in process focus. The following indicators address process efficiency of IS&S’ program process standard, end-to-end, as well as the quality of the products produced by our processes:

1. Award Fee
2. Overhead Rate
3. Software Productivity
4. Software Unit Cost
5. Defect Find & Fix Cost

The discussion that follows addresses the analysis of each of these indicators in more detail.

Results of Enterprise Analyses of Key Business Indicators Award Fee

Award fees are an important indicator of customer satisfaction for programs using this contract mechanism. The following graph compares award fee results to CMM® Levels and shows customer satisfaction continuing to increase as process maturity becomes higher.

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STN 10-1: Performance Results from Process Improvement

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Overhead Rate

The trend in overhead rate indicates if overhead costs are affected by CMM® related-process improvement. There can be concern that overemphasizing CMM® high maturity levels increases overhead, and therefore, total cost. However, the following graph shows IS&S overhead rate has steadily declined since the SW CMM® Level 3 time-period. This decline in overhead rate demonstrates that CMM®-related efforts have likely had a positive effect on overhead costs, as well as direct engineering labor. CMMI®-based process improvements do not come with overhead baggage.

Software Productivity

The graph below illustrates a comparison of productivity rates before and after implementing two IS&S initiatives, NW/IPQ. Both are defined as follows:

- New Ways of Doing Business (NW) is a collective term for several methodology/tools/process initiatives including Architecture Based Design, Scenario Based Testing, and Design Adequacy Assessments.

Near the end of the SW CMM L2 period, the overhead pools were changed. A SW CMM L2 Overhead is therefore not included.
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• In-Process Quality (IPQ) refers to Quality Awareness throughout the lifecycle, early defect detection through the use of inspections, and defect prevention driven by defect causal analysis.

This analysis refers to these two initiatives collectively as NW/IPQ.

Pre-NW/IPQ corresponds to the time-period of SW CMM® Levels 3 and 4 while Post-NW/IPQ corresponds to the time-period of SW CMM® Level 5 and CMMI® Level 5. Software productivity increased in Programs A and B as compared to the Pre-NW/IPQ Baseline. Post-NW/IPQ programs during CMMI® L5 use showed steady and consistent increases in software productivity with CMM*-based process improvement.

**Software Unit Cost**

Software Unit cost was computed based upon labor rates, overhead rate, and productivity. To compute Software Unit Cost (UC) = LR x WR x UL x ADJ where

- LR = average hourly labor rate for engineers and technicians
- WR = wrap rate, or overhead rate
- UL = Unit Labor (i.e., Hours/LOC or the inverse of productivity)
- ADJ = Adjustment factor to provide a constant dollar value over time

A reduction in Software Unit Cost was realized with Post-NW/IPQ and CMMI® L5, a real “bottom-line” savings for the enterprise.
Defect Find & Fix Cost

In this analysis, the defect find & fix cost of software developed by a SW CMM® Level 3 program was compared to that of a CMMI® Level 5 program. The defect densities (Defects/KLOC) for each phase are multiplied by the number of hours to “Find & Fix” a defect, obtaining Hours/KSLOC for each phase as shown below.

Hours/KLOC (Find & Fix)

<table>
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<tr>
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<th>SW CMM Level 3 Program</th>
<th>CMMI Level 5 Program</th>
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<tr>
<td>Architecture Design</td>
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<td>Software Design</td>
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<td>Code &amp; Unit Test</td>
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<td>Product Integration &amp; Verification</td>
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Dollars per KLOC (Find & Fix)

Hours/KSLOC values for each phase of the life cycle are added together and multiplied by the cost of an engineering hour. The graph below shows the Defect Find & Fix Cost (i.e., Dollars/KLOC) for software from a CMMI® Level 5 program is less than that of a SW CMM® Level 3 program. These analyses of Defect Find & Fix costs show improved product quality and realizable cost savings for the enterprise.

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Conclusion

Enterprise analyses of several key business indicators consistently show value in pursuing CMM®-driven process improvement. IS&S senior management believes a process focus has positive effects on other functions within the company; and, it does make a difference to our customers.

Necessary to achieve these business objectives is a commitment to CMM®-based process improvement at all levels of management and staff. In addition, a strong enterprise process infrastructure, supporting tools, training, and communications are also critical to its success. Sufficient enterprise, function, and program resources are essential to implementing the process infrastructure, together with customers who fully support a mature way of doing business.

About the Authors

Peter McLoone, Lockheed Martin Integrated Systems & Solutions (IS&S), has over 20 years experience with systems and software engineering within the defense industry plus ten more in the commercial world. During the last nine years, he has managed the IS&S Enterprise Measurement Program that has used the CMM® and earlier maturity models as a framework.

Sharon L. Rohde, Lockheed Martin Integrated Systems & Solutions (IS&S), has over 16 years experience with systems and software engineering within the defense industry. In the last 8 years, her focus has been process and quantitative management. As Deputy Coordinator of the IS&S Enterprise Measurement Program, she assists in providing the measurement process infrastructure, data analyses to facilitate program-level quantitative management, establishing the organization’s process capability baselines, and aligning organizational process performance with business goals.

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