Lockheed Martin Benefits Continue Under CMMI®

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Agenda

● Context

● Background on Lockheed Martin’s (LM) CMMI® transition approach

● Benefits in the Software CMM® and CMMI® eras
  - LM Systems Integration (Owego, NY)
  - LM Maritime Systems & Sensors – Radar Systems (Syracuse, NY)
  - LM Maritime Systems & Sensors – Undersea Systems (Manassas, VA)
Context

- Lockheed Martin organizations that tracked quantitative process improvement benefits during their SW-CMM® high maturity journey have now transitioned to CMMI®

- Previously reported data showed these benefits continued with CMMI® implementation
  - This trend continues in 2004

- However, benefits derived are not attributable only to CMMI®
  - Many initiatives are underway concurrently with CMMI® deployment (and were underway when the SW-CMM® was in use)

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Key Tenets of Lockheed Martin’s CMMI® Transition

- Address CMMI® in the context of your organization’s business requirements
  - Lockheed Martin’s Integrated Engineering Process (LM-IEP) standard includes CMMI®, in addition to other standards and requirements (e.g., ISO/IEC 15288, ISO 9001:2000)

- Use SCAMPI\textsuperscript{SM} A for benchmarking

- Adopt an incremental appraisal approach for process improvement and SCAMPI\textsuperscript{SM} readiness
  - Lockheed Martin Continuous Appraisal Method (CAM) has been successfully deployed with CMMI®

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Continuous Appraisal Method (CAM) Design Goals

- Minimize appraisal preparation and reduce cost
- Integrate process improvement with process appraisal activities
- Facilitate appraisal scheduling and minimize disruption for participants
- Provide an appraisal environment conducive to process improvement
- Promote institutionalization

CAM was originally developed for use with EIA/IS 731 and is being used with CMMI®
Overview of Incremental Appraisal Using CAM

Planning

Appraise OSP  Fix Weaknesses  Re-appraise

Appraise PA 1  Fix Weaknesses  Re-appraise

Appraise PA 1  Fix Weaknesses  Re-appraise

Appraise PA 1  Fix Weaknesses  Re-appraise

...
Feedback on CAM usage

- 14 CAMs have been completed or are underway at Lockheed Martin operating units using CMMI®
  - 6 prior CAMs have been completed using EIA/IS 731
- Experience with CAM has been positive:
  - More focus on process improvement
    - Facilitated by the incremental approach
  - Less invasive to programs
  - Less stressful to the organization
  - More value-add, in-depth findings
  - More cost effective
  - Effective method to prepare for SCAMPI™

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Lockheed Martin Systems Integration - Owego Process Credentials

- **Q-100 Award** (2002)
- **Lean / Six Sigma** (2000)
- **SW CMM Level 5** (1997)
- **RIT / USA TODAY Quality Cup Finalist** (1995)
- **New York State Excelsior Award** (1994)
- **IBM Baldrige Gold Award** (1993)
- **TQM** (1990)

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Lockheed Martin Systems Integration Owego - Software Productivity

Software Productivity (All Software including Reuse)

**Improvements Since 1993:**
12.7% Average per Year

- **Contributors:**
  - Increased Reuse (Domain Specific)
  - Process Maturity and Compliance
  - Process Consistency
  - Increased use of High Order Language / 4th Generation / Object Oriented
  - Use of development and test tools
Software Defects per Million Delivered Source Lines of Code

Note: Started counting defects differently in 2004. Redefined from “Latent” to “Open at Delivery”.

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LM Maritime Systems & Sensors Tactical Systems
Process Improvement Credentials

- Oct. 1999 – Attained SW-CMM® level 4
- Dec. 2000 – Attained Systems Engineering Capability Model (EIA 731) level 3
- Jan. 2001
  - Began focus on integrated process improvement
  - Began transition to CMMI®
- June 2002 – May 2003 CAM Appraisal
  - OSP: Target profile 5 for CMMI®-SE/SW/IPPD/SS
  - Projects: Target profile 3 for CMMI®-SE/SW
- August 2003 – SCAMPISM Appraisal
  - Achieved maturity level 3 using CMMI®-SE/SW

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LM Maritime Systems & Sensors Tactical Systems
2004 Initiatives

- Implement CMMI®-SE/SW maturity level 4
- Streamlining of references and guidance documents which supplement the OSP
- Conduct LM-IEP gap analysis
- Risk management methodology best practice
- Populate Process Asset Library (PAL)
- Self audit process compliance
- Mechanical engineering guidebook
- Airworthiness manual
- Work product templates
- Cost Estimation Relationships Guide
LM Maritime Systems & Sensors Tactical Systems
Software Productivity

Source Statements per Hour vs. Year

- Level 3 CMM®
- Level 4 CMM®
- Level 3 CMMI®
LM Maritime Systems & Sensors - Syracuse
Process Improvement Credentials

- SW-CMM® level 5 (CBA IPI^{SM}) in Dec. 1999
- Systems Engineering Capability Model (EIA/IS 731) level 3+ (CAM) in Dec. 1999
- Focus on integrated process improvement including hardware began in 2000
- Transition to CMMI® began in 2000
- CMMI®-SE/SW/IPPD target profile 4 (CAM) in Nov. 2002
- CMMI®-SE/SW maturity level 4 (SCAMPI^{SM}) in May 2004

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LM Maritime Systems & Sensors - Syracuse
2004 Functional Excellence Initiatives

- LM21 Business Excellence
- Design for Six Sigma (DFSS)
- Technical Assurance
- Integrated Product Development
- Digital Dashboard
- CMMI®-SE/SW Maturity Level 4
- Continuous Process Improvement
  - Process Development
  - Quantitative management
LM Maritime Systems & Sensors – Undersea Systems Process Credentials

- **Systems & Software Engineering**
  - Software CMM® Level 4 (CBA IPI) - June 1995
  - Software CMM® Level 5 (CBA IPI) - February 1999
  - CMMI® & EIA-731 target profile 3 (CAM) - October 2001
  - CMMI®-SE/SW/IPPD/SS target profile 5 (CAM) - October 2002

- **Quality Management**
  - AS9000 - November 1997
  - Defense Contract Management Agency (DCMA) ISO 9001 Qualified - December 1997
  - AS9100A – December 2002

*Assessed programs comprise over 80% of the Undersea Systems development programs, and all parts of the development cycle.*
LM Maritime Systems & Sensors – Undersea Systems
Process Chronology

1970s
- Top-down Structured Programming
- Design & Code Inspections
  1980-2
- Functional Decomposition
- SW Engineering Workshop
- Advanced Design Workshop
  1983
- SW Management Workshop
  1984
- Ada Workshop
  1985
- Requirements Inspections
  1986
- FSC Practices & Measurements
  1988
- SW Technology Steering Group
- Organizational Operating Procedures
  1990
- SW Engineering Process Group Formed
- First SW-CMM® Assessment (Level 3)
- Formal Estimation Procedures
  1991
- Market Driven Quality
- Reuse Focus

1992
- Defect Prevention Process
  1993
- Integrated Teams
- Standard Development Environment
- Integrated Process Group
  1994
- Automated Metrics
- Process Coordination Group (PCG)
  1995-6
- Integrated Process Library
- ISO 9001 Registration
- Software CMM® Level 4
  1997-9
- ISO 14001 Registration, AS9000 & DCMA ISO 9001 qualification
- Software CMM® Level 5
  2000->
- ISO 9001: 2000 Certification
- EIA-731 Level 3
- AS9100A Certification
- CMMI®-SE/SW/IPPD/SS Target Profile 5 (CAM)
LM Maritime Systems & Sensors – Undersea Systems
Software Product Quality

Note: CMM® levels were achieved via CBA IPI. CMMI® levels indicate the result of CAM assessments using CMMI®-SE/SW/IPPD/SS with a lead appraiser outside of Undersea Systems.
### Product Quality Level is in Five Sigma Range

**Sigma** | **Defects / MS**
--- | ---
1 | 690,000.0
2 | 308,537.0
3 | 66,807.0
4 | 6,210.0
5 | 233.0
6 | 3.4

MS = Million

Source Statements

Our quality rate is 20 times better than the average industry rates.

5 Sigma
Cost Performance Index (CPI) & Schedule Performance Index (SPI)

Data from 8 programs in 2Q 2003

Reference: “A Correlational Study of the CMM® and Software Development Performance”
Lawlis, Flowe & Thordahl, CROSSTALK, September 1995
LM Maritime Systems & Sensors – Undersea Systems
Process Maturity Benefits

Continuous process improvement is rooted in Manassas’ culture...and the benefits are so ingrained in our approach, we tend to take them for granted:

• Consistency
  • More likely to get the same results each time within a small range
  THIS IS A VERY REAL MEASURE OF QUALITY IN TODAY’S MARKETPLACE

• Predictability
  • Much easier to estimate work
  • Better able to assess impact of change

• Manageability
  • Able to measure and track progress
  • Better able to change and improve
  • Better able to control costs and meet schedule

• IT ALL ADDS UP TO
  • IMPROVED QUALITY
  • IMPROVED PROFITABILITY
Example of Defect Discovery Profile for Another LM Organization

Example Defect Discovery Goals & Actuals To Date

Normalized Defects Per KSLOC

90% Confidence Range

Verification Stage

HLD LLD C CT/UT/ST RT/ESI/SWIT I&T Latent
Summary

- The trend previously reported continues:
  - Benefits derived during SW-CMM® implementation continued to be realized as CMMI® maturity evolves
- Allocating benefits to their sources is difficult when implementing multiple models/standards and initiatives
- SW-CMM® and CMMI® are viewed as significant (but not sole) contributors to process improvement benefits to date
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Acronyms

- ARC – Appraisal Requirements for CMMI®
- CAM - Continuous Appraisal Method
- CMM® - Capability Maturity Model
- CMMI® - Capability Maturity Model Integration
- ESLOC or ESS – Equivalent SLOC/SS; a normalized value derived from new development, plus SLOC/SS that are modified, retained, ported, etc.
- IPPD - Integrated Product and Process Development
- LM - Lockheed Martin
- LM-IEP - Lockheed Martin Integrated Engineering Process
- OSP – Organizational Standard Process
- PA - Process Area
- SLOC – Source Line of Code
- SS – Source Statement (sometimes called a “Logical SLOC”)