The Airborne Electronic Attack Integrated Product Team (AEA IPT)

Point Mugu, California

AEA IPT Process Improvement
April 2009
Agenda

• Introduction of AEA IPT
• Process Improvement Objectives for FY09
• Customizing processMax®
  ▪ processMax® overview
  ▪ Customize for System and Software Development Project
  ▪ Customize for Data Base Development Project (EWDS)
  ▪ Customize to integrate Lean Six Sigma (LSS) and CMMI high maturity level practices
• Integrate NAVAIR Lean Six Sigma into AEA IPT critical processes
  ▪ Quantitative Defect Management (QDM)
  ▪ Quantitative Requirements Management (QRM)
  ▪ Causal Analysis and Resolution (CAR)
Sponsor Product Alignment

Platform Products
- Litening & IT Pod
- ICAP II OFP
- ICAP II BLK MMGT

AEPA Products
- DSMU
- EA-6B MPE
- USQ-113
- Trainers

Site Services
- Help Desk / Fleet Support
- Test
- Laboratory Support

IPT
- IPT Leadership
- IPT Management

CAO

AEA IPT
AEA Products / Services

- **Electronic Warfare Database Support (EWDS)**
  - EOB product to all Navy Aircraft using JMPS
    - ETIRMS & EWDS to Navy, Air Force, NSA, JSF, MMA and other customers
- **AEA Mission Planning**
  - EW Tactical Information and Report Management System (ETIRMS)
    - Unique Planning Component (UPC) for EA-6B & EA-18G
  - EA-18G AEA UPC
  - EA-6B Mission Planning Environment (MPE) + MH-60/E-2C HAWK Tool
- **AEA Jammer Techniques Optimization (J ATO)**
- **EA-6B ICAP II and ICAP III Block & GWOT Upgrades**
  - Software Maintenance, Integration, and Test (including Aircrew Trainers)
  - Block System Upgrade Design, Development, Integration and Test
- **EA-18G AEA Block Upgrades**
  - Including AEA Systems Engineering + Integrated Test & Evaluation
- **Intrepid Tiger Pod Software Support Activity**
AEA IPT Team Composition

78 Support Contractor Personnel
- Northrop Grumman
- L-3 Corporation
- Wyle Labs
- Digital Wizards
- GBL, JTI & SIMSUM

130+ Direct Funded Government Employees
2 Military Officers (Excluding 1 vacancy)

Personnel with AEA Expertise:
- Over 85% Engineers
- AEA On-site System Engineering Expertise is Still Largest in Nation
- Depth of AEA Experience averages over 10 years per individual
Process Status

AEA IPT achieved CMMI Level 3 in June 2007
Improve Performance by implementing Continuous Process Improvement (CPI)

NAVAIR Lean Six Sigma (LSS)

per

DoD Directive 5010.42
DoD Directive 5010.42

• **Strengthen joint operational Combatant Command and Military Department capabilities including making improvements in:**
  
  (1) Productivity
  
  (2) Performance against mission (availability, reliability, cycle time, investment, and operating costs)
  
  (3) Safety - Flexibility to meet DoD mission needs - Energy efficiency

• **CPI/LSS programs shall be used to help meet organizational objectives**
  
  ▪ CPI/LSS methods, terminology, training plans, and other program elements may be adapted as required
  
  ▪ Given diverse operational requirements, the DoD Components shall have full flexibility to identify CPI/LSS focus areas and training plans and may adapt other CPI/LSS program elements for their use
AEA IPT Strategy to Implement DoDD 5012.42 (1)

• Responsible Parties
  - AEA IPT Management Team and Competency Aligned Organization (CAO)
  - Product Leads, Project Managers and Team Members
  - Process Management Team

• Define and align AEA IPT Performance Objectives with NSPS
  - For each product release:
    - Improve Cost by X%
    - Improve Schedule by X%
    - Improve Quality by X%
AEA IPT Strategy to Implement DoDD 5012.42 (2)

• **Ensure consistent Organizational performance**
  - Customize processMax® to integrate Lean Six Sigma (LSS) tool sets and to support non-software products (EWDS, JATO)
  - Integrate LSS Tool Sets into Critical Process Activities
    - Quantitative Defect Management (QDM)
    - Quantitative Requirements Management (QRM)
    - Earned Value Management (EVM)
    - Causal Analysis and Resolution (CAR)

• **Integrate AI RSpeed LSS Methodology into AEA IPT Culture**
  - Conduct Lessons Learned to evaluate past performance, identify improvement opportunities and implement Organizational Change Requests (OCRs) using LSS projects:
    - Black Belt, Green Belt, etc.
Customizing processMax®

DOD-NAVAIR Directed Continuous Process Improvement (CPI) by Integrating Lean Six Sigma into critical processes
processMax® Tool Overview

• A web-based project management software tool used for project and organization personnel to follow a defined process.
  - Includes all processes, procedures, guidelines, criteria, templates, and forms used by the organization
  - Serves as a document repository for project and organizational work products
    - Provides configuration management capabilities that include version control, change control, and process history
  - Supports project management activities such as project planning, tracking of Actions/Issues, Decisions, Risks, Role Assignments, Defects, Training status, etc.
  - Provides the structure to ensure that a standard project process is followed by all projects and allows for the tailoring of those processes as needed
AEA IPT
processMax® Customization

• A Decision Analysis and Resolution (DAR) process activity supported the decision to customize the existing CMM processMax® tool

  ▪ Critical factors in this decision included:
    ➢ Pragma Systems delay in releasing a completed CMMI Level 3 version of processMax®
    ➢ Concerns that the new release might not align with AEA IPT best practices
    ➢ Costly manual transfer of project data to the new version
    ➢ Modifications could be made quickly by AEA Process Management Team to existing processMax® interface to rapidly deploy CMMI across the Organization
    ➢ Projects Team would not have to learn a new tool
      ✓ Training efforts could be concentrated on the new CMMI Process Activities
Measurement & Analysis (M&A) Process Activity

- **Simplify pMax**
  - Helps projects by facilitating collaboration and collection of M&A artifacts

- **M&A Artifact repository contains:**
  - Meeting agenda, minutes and measurement indicators
  - Action item logs and decisions
  - Electronic approvals of M&A Plan

Added new Project Measurement and Analysis work product and process steps to processMax®
## Modified Process Steps

**Process developed and aligned with NAVAIR Engineering Guidelines**

*Added new process steps to implement AEA IPT best practices*

### Process step description reflects actual practices

<table>
<thead>
<tr>
<th>Process step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modified Process Steps</strong></td>
<td></td>
</tr>
</tbody>
</table>
Accurate defect data capture is critical for project performance using the LSS Measure and Analysis Phase.

Defect categories were redefined to accurately reflect project environment and source of defects.

LSS: DEFINE – MEASURE – ANALYZE – IMPROVE – CONTROL
Incorporation of Lean Six Sigma (2)

LSS tool sets and procedures, like Fish Bone and Five Whys, are integrated into processMax® to guide users in performing cause and effect analysis.

As defects are fixed, improvement proposals are identified and LSS projects are initiated via OCRs.
Defect data can be extracted from processMax® into an Excel file to perform cause and effect analysis.
Improve Performance with Quantitative Defect Management

DoD-NAVAIR Directed Continuous Process Improvement (CPI) by Integrating Lean Six Sigma into critical processes
Quotations

Quality is never an accident, it is always the result of high intention, intelligent direction and skillful execution; it represents the wise choice of many alternatives.” William A. Foster

“If we are busy doing rework for defects, we’re not innovating AND we are costing the company lots of money.” Anonymous

“Finding and fixing defects accounts for much of the cost of software development and maintenance.” – Watts S. Humphrey

“It is much less expensive to prevent errors, than to rework, scrap, or service them.” Philip Crosby
Introduction
Quantitative Defect Management (1)

Defect Removal by Phase

Facilitate gradual shift from “Fix-on-Failure” to Prevention
Defect removal effort can increase by 10 times for each stage it goes undetected.
AEA IPT Lessons Learned

• AEA IPT Best Practices
  ▪ Test processes sufficiently robust to detect most defects
    ➢ Quality of released product is consistently high across the AEA IPT

• AEA IPT Improvement Opportunities
  ▪ Need to improve defect detection during Requirements, Design and Code phases
    ➢ Consistency in counting defects, in capturing effort / size & in logging defects
Three AI RSpeed Black Belt Projects

- Three AI RSpeed Black Belt Projects Improved the Defect Removal Effectiveness (DRE) Process for Software Intensive Products:
  - Requirements Development Phase
  - Design Phase
  - Code & Unit Testing Phase

- Quantitative Defect Management Process Goals
  - Discover and remove more defects earlier in the development lifecycle to support ‘On-time’ delivery objectives
  - Reduce rework efforts to improve Cost and Schedule
  - Improve Quality Performance
  - Evolve Defect Detection Model
Strategy to Implement Quantitative Defect Management

- **Improve and Maintain Defect Prevention Techniques**
  - Measure the Effectiveness of each Peer Review
  - Statistically Analyze
    - Performance of each Peer Review
    - Defect removal effectiveness at the completion of each phase

- **Introduce Quantitative Defect Management Method**
  - Statistically Analyze Project performance against AEA IPT Performance baseline
  - Predict Quality and Cost Performance using a Defect Detection Model (DDM)

- **Introduce Causal Analysis and Resolution Process**
  - Determine Root Causes, take Corrective Actions to improve quality and prevent reoccurrence
Quantitative Defect Management
(AEA IPT 7 Step Process)

Step 1: Establish Baselines
Using Historical Data

Step 2: Establish Project Goals

Step 3: Establish Quality Control Target

Step 4: Statistically Manage Peer Reviews

Step 5: Statistically Manage Defect Removal Effectiveness

Step 6: Perform Phase End Review

Step 7: Perform Causal Analysis and Resolution (CAR)
Establish AEA IPT Performance Baselines

**Product Quality:**

<table>
<thead>
<tr>
<th>Defect Density:</th>
<th>Mean</th>
<th>UCL</th>
<th>LCL</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defect Density (All Phases)</td>
<td>38</td>
<td>39</td>
<td>33</td>
<td>KLOC</td>
</tr>
<tr>
<td>Residual Defect Density</td>
<td>0.2</td>
<td></td>
<td></td>
<td>KLOC</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Defect Originated - Distribution</th>
<th>Mean</th>
<th>UCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>25.00%</td>
<td>25.00%</td>
</tr>
<tr>
<td>Design</td>
<td>25.00%</td>
<td></td>
</tr>
<tr>
<td>Coding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software Integration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Testing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Process Performance:**

Defect Removal Effectiveness:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Mean</th>
<th>UCL</th>
<th>LCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>50%</td>
<td>53%</td>
<td>48%</td>
</tr>
<tr>
<td>Design</td>
<td>50%</td>
<td>53%</td>
<td>48%</td>
</tr>
<tr>
<td>Coding</td>
<td>45%</td>
<td>65%</td>
<td>57%</td>
</tr>
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**Sub Process Performance:**

<table>
<thead>
<tr>
<th>Sub Process</th>
<th>Attributes</th>
<th>Mean</th>
<th>UCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req. Peer Review</td>
<td>Defects/Unit Size</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Defects/Review Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Peer Review</td>
<td>Defects/Unit Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Defects/Review Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review Time/Unit Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Code Peer Review</td>
<td>Defects/Unit Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Defects/Review Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review Time/Unit Size</td>
<td></td>
<td></td>
</tr>
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</table>

**Peer Review Coverage:**

<table>
<thead>
<tr>
<th>Sub Process</th>
<th>Required</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req. Peer Review</td>
<td>100%</td>
<td>+/-10%</td>
</tr>
<tr>
<td>Design Peer Review</td>
<td>100%</td>
<td>+/-10%</td>
</tr>
<tr>
<td>Code Peer Review</td>
<td>50%</td>
<td>+/-10%</td>
</tr>
</tbody>
</table>

- Establish performance baselines for:
  - Defect Density (all phase)
  - Residual Defect Density
  - Defect Distribution (by Phase)
  - Defect Removal Effectiveness
    - Requirement
    - Design
    - Code & UT
  - Peer Review (by Phase)
    - Defects/Unit Size
    - Defects/Review Time
    - Review Time/Unit Size
Establish Project Objectives

Define Project & Quality Performance Objectives

- **Project establishes objectives based on:**
  - Customer (PMA)
  - IPT Objectives
  - Project Past Performance

- **Project defines Quantitative Objectives for each phase of Defect Removal Effectiveness**
  - Requirements
  - Design
  - Code & UT

<table>
<thead>
<tr>
<th>Description of Measure</th>
<th>Mean</th>
<th>USL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRE - Requirements Phase</td>
<td>65%</td>
<td>67%</td>
</tr>
<tr>
<td>DRE - Design Phase</td>
<td>62%</td>
<td>65%</td>
</tr>
<tr>
<td>DRE - Code and Unit Test</td>
<td>45%</td>
<td>49%</td>
</tr>
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</table>
**Establish Quality Control Target**

### Define Project Parameters & Estimates

<table>
<thead>
<tr>
<th>Name of the Project</th>
<th>AEA IPT PI</th>
<th>Name of Project Manager</th>
<th>Tuan Le</th>
</tr>
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<tbody>
<tr>
<td>Project Size Estimates</td>
<td>9.50 KLOC</td>
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</table>

#### Defects Origination Estimates

<table>
<thead>
<tr>
<th>Phase</th>
<th>Mean</th>
<th>UCL</th>
<th>LCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>86</td>
<td>95</td>
<td>76</td>
</tr>
<tr>
<td>Design</td>
<td>86</td>
<td>91</td>
<td>80</td>
</tr>
<tr>
<td>Coding</td>
<td>154</td>
<td>159</td>
<td>149</td>
</tr>
<tr>
<td>Software Integration</td>
<td>10</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>System Testing</td>
<td>7</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>342</td>
<td>368</td>
<td>316</td>
</tr>
</tbody>
</table>

#### Defect Detection - Target

<table>
<thead>
<tr>
<th>Phase</th>
<th>Mean</th>
<th>UCL</th>
<th>LCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>56</td>
<td>57</td>
<td>54</td>
</tr>
<tr>
<td>Design</td>
<td>72</td>
<td>74</td>
<td>69</td>
</tr>
<tr>
<td>Coding</td>
<td>113</td>
<td>118</td>
<td>110</td>
</tr>
<tr>
<td>Software Integration</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Testing</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OT/DT</td>
<td>34.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Project Manager estimates the target number of defects originated & removed by phase to establish project objectives.**

**Defect estimation model will be based on historical data and organizational performance baseline.**
**Statistically Manage Peer Review Performance**

### Design Phase - Peer Review

<table>
<thead>
<tr>
<th>Peer Review Date</th>
<th>Total Hours</th>
<th>Total Size</th>
<th>Number of Defects Discovered</th>
<th>Requirement</th>
<th>Defects / Hour</th>
<th>Defects / Unit of Size</th>
<th>Hours / Unit of Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-May-08</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0.71</td>
<td>0.63</td>
</tr>
<tr>
<td>22-May-08</td>
<td>9.25</td>
<td>93</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0.54</td>
<td>0.05</td>
</tr>
<tr>
<td>1-Jul-08</td>
<td>6.5</td>
<td>12</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0.46</td>
<td>0.25</td>
</tr>
<tr>
<td>28-Aug-08</td>
<td>6.75</td>
<td>44</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0.15</td>
<td>0.02</td>
</tr>
<tr>
<td>8-Sep-08</td>
<td>7</td>
<td>65</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0.43</td>
<td>0.05</td>
</tr>
<tr>
<td>4-Sep-08</td>
<td>6.25</td>
<td>53</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0.32</td>
<td>0.04</td>
</tr>
</tbody>
</table>

**Under Statistical Control**

Project team members statistically manage peer reviews and take corrective actions as required.
Statistically Manage Defect Removal Effectiveness Performance

Project team members statistically review project performance at the end of the phase and take corrective actions as required.

**Defects - Origination Estimate Vs Detection Target**

- Defects Origination Estimates (Based on New Size Estimates)
- Defect Detection - Target (Based on New Size & Actual Defects Found So Far)
- Actual
Perform Cause and Effect Analysis (CAR)

Project team members perform cause and effect analysis to determine root cause and take corrective action:
- Improve process when required
- Continue to reinforce the process
### AEA IPT DRE Dashboard

#### Navigator

#### Control Charts:

<table>
<thead>
<tr>
<th>Process Attribute</th>
<th>Requirements Phase</th>
<th>Design Phase</th>
<th>Code &amp; UT Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects/Hr</td>
<td><img src="#" alt="Click" /></td>
<td><img src="#" alt="Click" /></td>
<td><img src="#" alt="Click" /></td>
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<tr>
<td>Defects/Unit Size</td>
<td><img src="#" alt="Click" /></td>
<td><img src="#" alt="Click" /></td>
<td><img src="#" alt="Click" /></td>
</tr>
<tr>
<td>Hrs./Unit Size</td>
<td><img src="#" alt="Click" /></td>
<td><img src="#" alt="Click" /></td>
<td><img src="#" alt="Click" /></td>
</tr>
</tbody>
</table>
Selected Lean Six Sigma Tools for Quantitative Defect Management Process

- Control Charts
- Pareto Chart
- Histogram
- Ishikawa (“Fish Bone”)
- Five Whys
- Process Mapping

Together, Lean Six Sigma and CMMI help AEA IPT improve performance and achieve objectives faster.
Improve Performance with Quantitative Requirements Management

DoD-NAVAIR Directed Continuous Process Improvement (CPI) by Integrating Lean Six Sigma into AEA IPT critical processes
Optimal Process Model

• Requirements Management Process Model

Elicitation
- Identify Stakeholders
- Conduct Fact Finding
- Capture Candidate Technical and Non-Technical Requirements

Analysis
- Categorize and Prioritize
- Establish Database Attributes
- Establish Traceability
- Reconcile and Capture Decision Rational

Planning
- Assess
- Verify Traceability
- Facilitate Agreement
- Resolve Deficiencies
- Establish a Baseline

Commitment
- Concepts
- Specifications
- Statement of Work
- SDD
- PRS
- ORD
- FRD
- IRS
- SRS
- SDD
- IDD

Verification
- Transform to Engineering Artifact
- Formalize Traceability
- Place under CM

Acceptance
- System
- Sub System
- Functional Adaptation
- Detailed Adaptation
- Simulations, Models, Benchmarks, Prototypes

Formalization
- Categorize and Prioritize
- Establish Database Attributes
- Establish Traceability
- Reconcile and Capture Decision Rational

CUMULATIVE REQUIREMENTS GROWTH
Progress Through Steps

Concept of Operation
System Adaptation
System
Sub System
CSCI HWCI
OPNAV
SYSCOM
LAB
Dept

SDD IDD
PRS
SRS
ORD
FRD
IRS
SDD
IDD

Detailed Adaptation
Transform to Engineering Artifact
Formalize Traceability
Place under CM
• Unsettled requirements in acquisition programs can create significant turbulence

• Sixty-three percent of the programs we received data from (72 programs) had requirement changes after system development began

• These programs encountered cost increases of 72 percent, while costs grew by 11 percent among those programs that did not change requirements
NAVAIR LESSONS LEARNED

- **Engineers tend to resist documenting traceable requirements**
  - Inability to trace requirements back to customer’s / sponsor’s requirements
  - Requirements creep – adding requirements not necessary to meet user’s / customer’s desires

- **Lack of concurrence among the stakeholders of the requirements (collaboration)**
  - Key contributor to requirements instability, which leads to cost and schedule problems

- **Lack of requirements volatility measures (metrics)**
NAVAIR LESSONS LEARNED

- Tendency to begin preliminary design before requirements are verified and validated:
  - Can result in extensive rework
  - Impacts accuracy of cost and schedule estimates

- Resistance to having a Requirements Change Control Board early in the requirements phase

- Requirements too loose/broadly written, complicating requirements decomposition

- Insufficient time dedicated to Requirements Phase
AEA IPT Strategy to Manage Requirements Volatility

- **Stabilize Requirements Development Process**
  - Improve estimation of effort to develop SRS and ensure the SRS is completed and ready for design
  - Control and Improve the Quality of Requirements Specification

- **Stabilize Requirements Management Process**
  - Institutionalize the Requirements Change process

- **Develop Quantitative Requirements Management (QRM) Measures for a Requirement Volatility Index (RVI):**
  - By using NAVAIR Lean Six Sigma initiatives
  - Provide a CMMI Level 4 and Level 5 Framework
Quantitative Requirements Management - 7 Step Process

Step 1: Establish RVI Performance Baselines using Historical Data

Step 2: Establish Project Goals

Step 3: Plan for RD and RM

Step 4: Monitor and Control development progress and quality of SRS

Step 5: Statistically Analyze Requirements Change Index at end of Design/Code/System Test phase

Step 6: Calculate and Predict CPI and SPI

Step 7: Perform Causal Analysis and Resolution (CAR)
Quality is never an accident, it is always the result of high intention, intelligent direction and skillful execution; it represents the wise choice of many alternatives.”

William A. Foster
Questions?

- AEA IPT LEAD
- AEA IPT CHIEF ENGINEER
- AEA IPT PROCESS IMPROVEMENT
Information Sources

• Improve Quality Performance
  ▪ Raja Anantharaman, Applied Process Solution

• Defect Prevention
  ▪ David LongStreet, Softwaremetrics.com

• Incorporating Quality Throughout the Lifecycle
  ▪ Betty Schaar, BenchmarkQA

• Advancing Defect Containment to Quantitative Defect Management
  ▪ Alison A. Frost and Michael J. Campo, Raytheon

• NAVAIR’s Software Engineering Policies and Processes
  ▪ Barbara Williams, NAVAIR