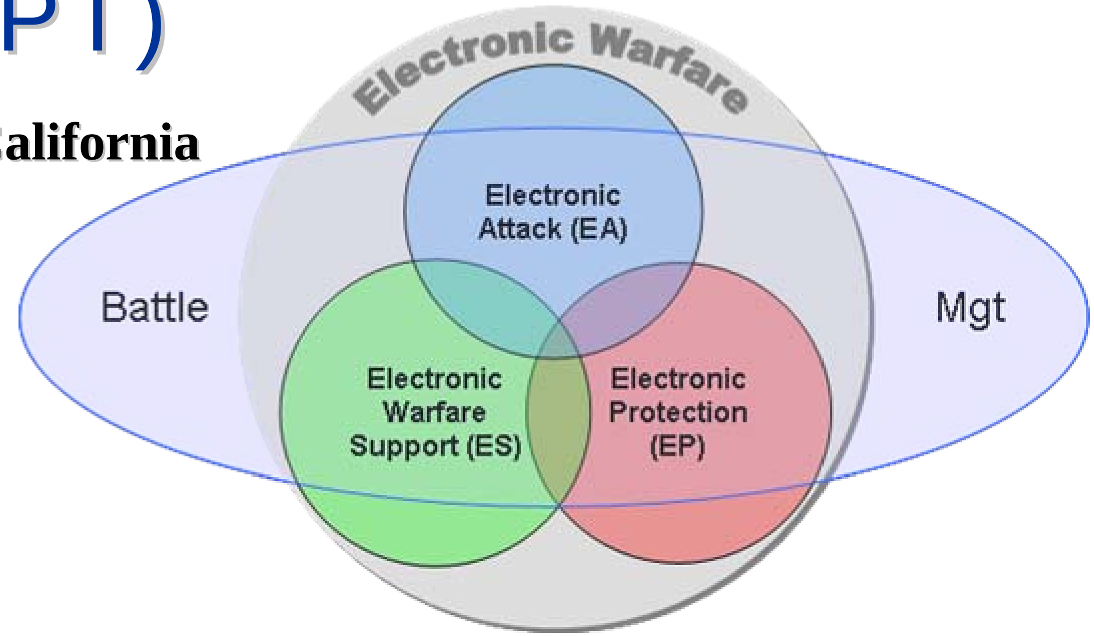
The Airborne Electronic Attack Integrated Product Team (AEA IPT)

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)

Organization Structure
Airborne Electronic Attack IPT

AEA IPT Lead

Military Lead | **Chief Engineer** | **Deputy, Planning** | **Deputy, Operations**

Lead BFM

EA-6B ICAP II Block

EA-6B ICAP III Block

EA-18G / AEA

CORE AEA
Functional Group POC

- Intelligence Operations
- EW Sensor Engineering
- Jammer Techniques Optimization
- EA Systems Engineering
- Software Development
- Avionics / Sensors Laboratories
- EA Integrated Test & Evaluation
- EW Battle Space Management
- EA Interference Cancellation
- EA Jammers

ACQUISITION AND FLEET SUPPORT
Product Teams

- EW Database Support (EWDS)
- ETIRMS UPC
- EA-6B MPE / UPC
- EA-6B Aircrew Trainers
- Next Generation Jammer Pod
- EA-18G AEA UPC
- E-2C/MH-60 HAWK Tool
- Intrepid Tiger Pod
- Joint EW Effects Lab

Fleet Help Desk

Process Improvement Lead
Contracting Officer Rep
Training Manager

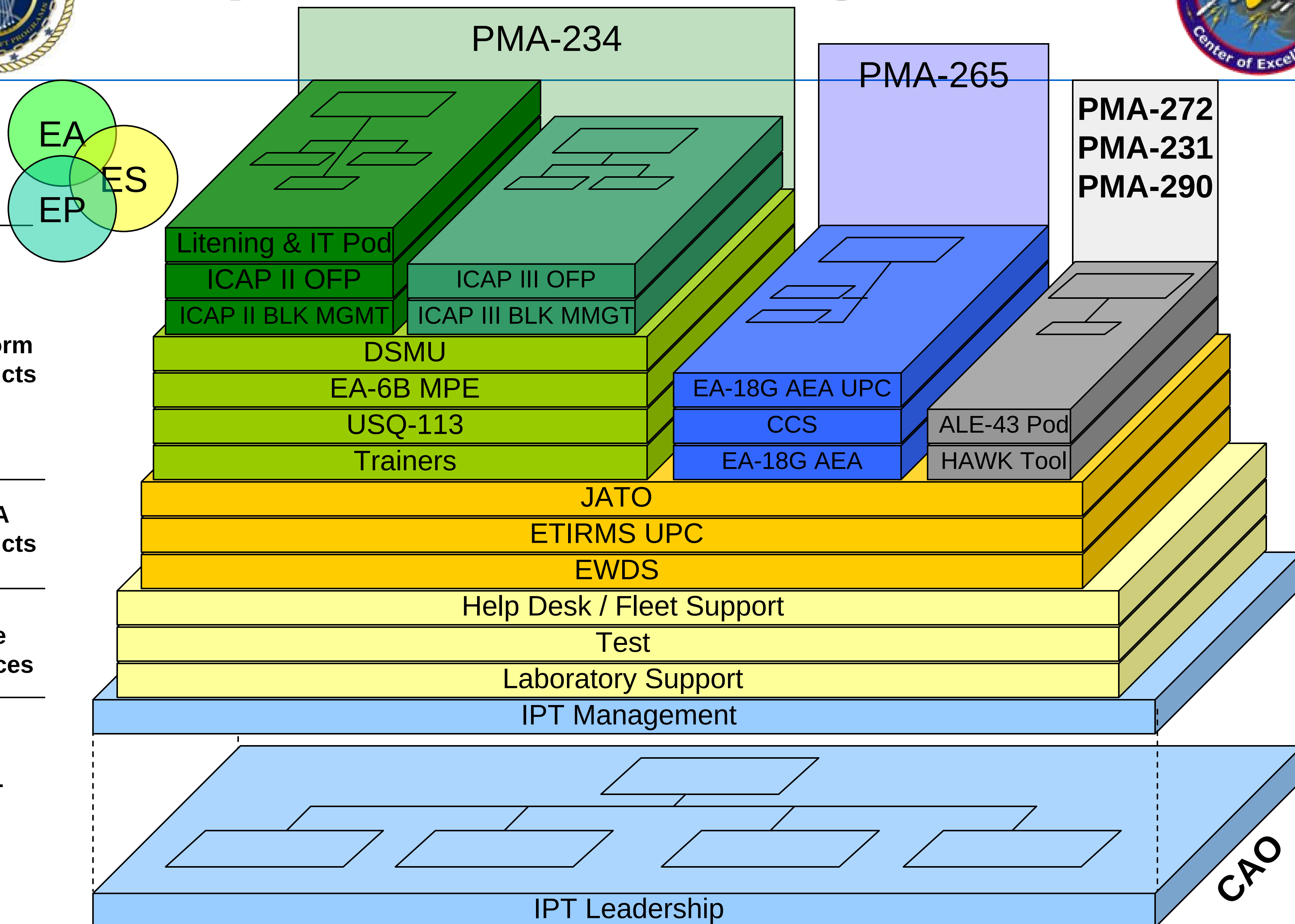
Sponsor Product Alignment

Platform Products

AEA Products

Site Services

IPT



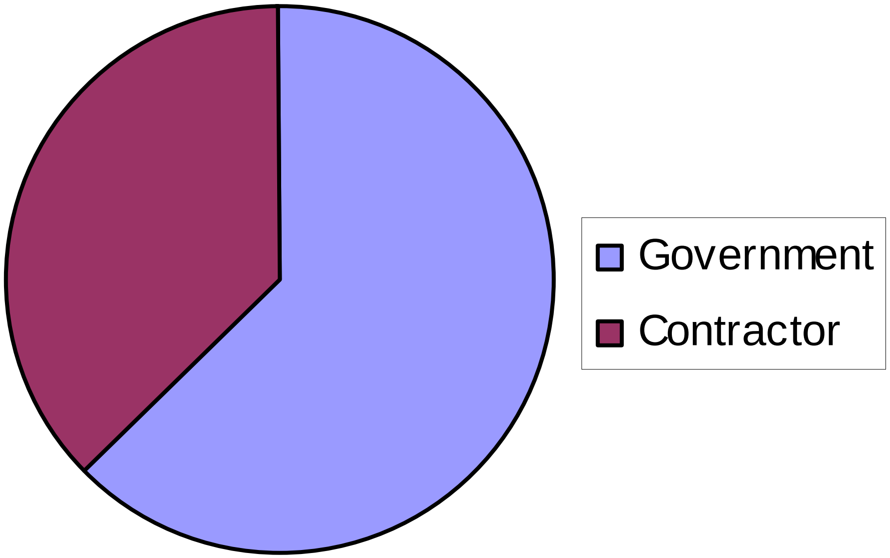
AEA Products / Services

- **Electronic Warfare Database Support (EWDS)**
  - EOB product to all Navy Aircraft using JMPS
    - EA-6B, EA-18G, F/A-18C/D, F/A-18E/F, MH-60, E-2C, AV-8B, ...
    - 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 (JATO)**
- **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

FY 09 Process Objectives

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%

NSPS
National Security Personnel System

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 AIRSpeed 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

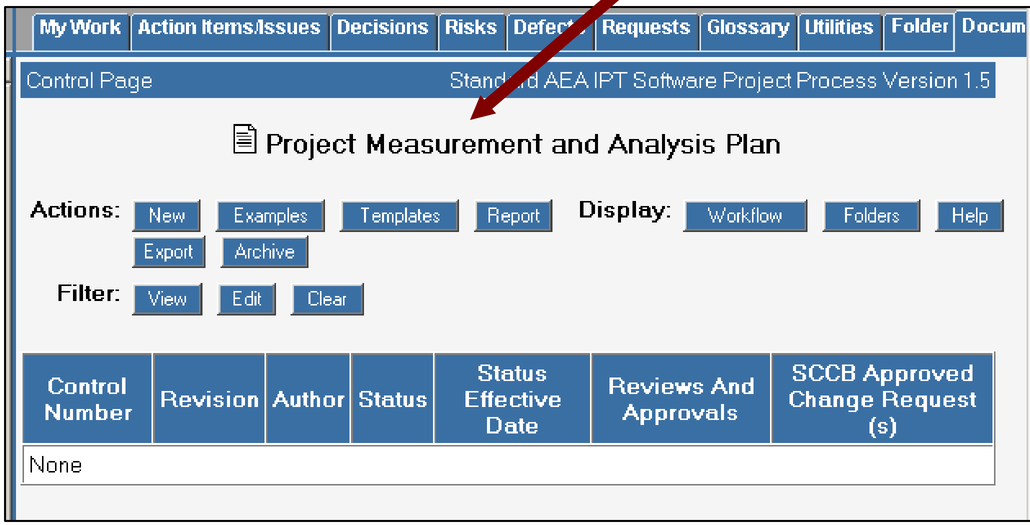
- **A Decision Analysis and Resolution (DAR) process activity supported the decision to customize the existing CMM processMax® tool**
  - Critical factors in this decision included:
    - Pragma Systems delay in releasing a completed CMMI Level 3 version of processMax®
    - Concerns that the new release 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

AEA IPT processMax®
Customization Examples (1)

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®

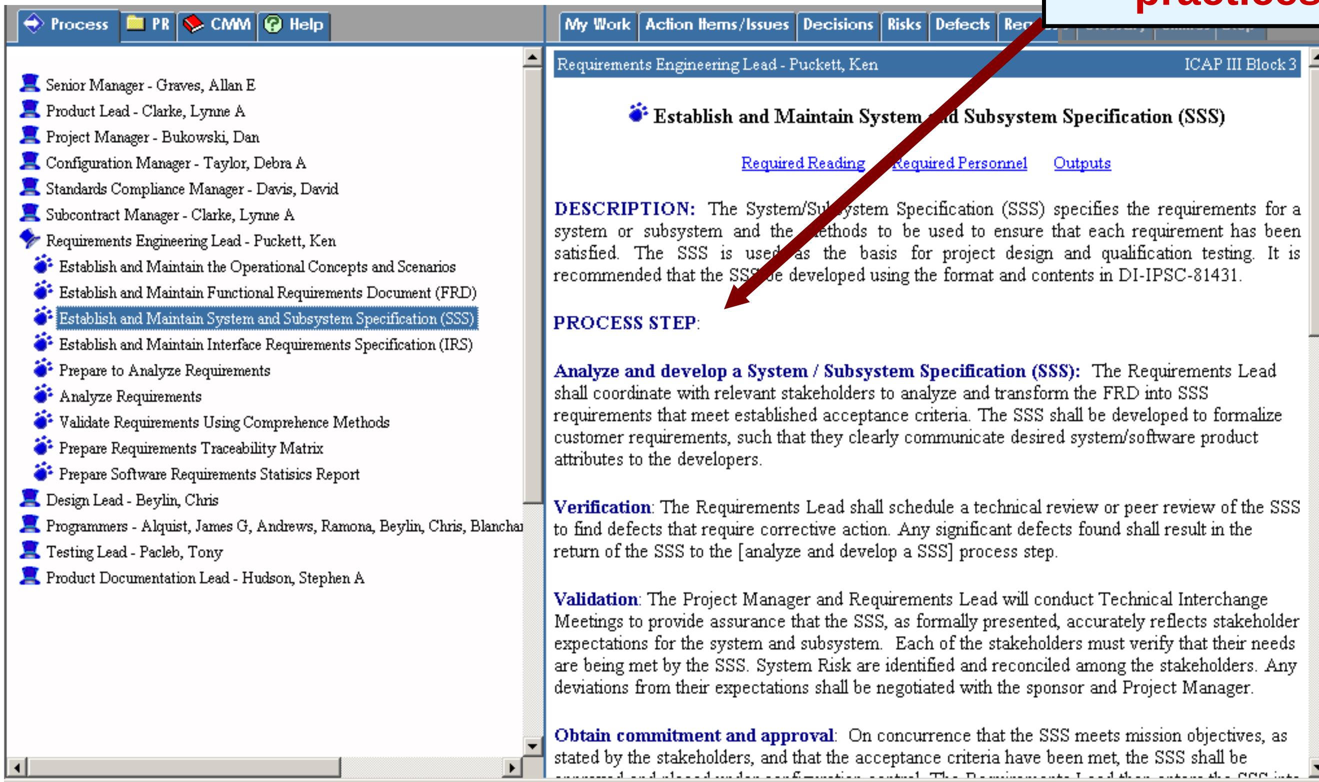


AEA IPT processMax®
Customization Examples (2)

Modified Process Steps

Process developed and aligned with NAVAIR Engineering Guidelines

Process step description reflects actual practices



Added new process steps to implement AEA IPT best practices

Incorporation of Lean Six Sigma (1)

processMax 5.0e - Dry Run - Update Form - Defect - 3 - Microsoft Internet Explorer provided by N

Set Seve

Severity: *	Critical
Number of Actual Defects: *	1

Select Defect Category — Required Reading

Requirement Defect Category: *	*Hold the Control key down while using the mouse to select or deselect items.* Correctness / Completeness / Consistency
Design Defect Category: *	*Hold the Control key down while using the mouse to select or deselect items.* Logic / Input / Data Handling
Code Defect Category: *	*Hold the Control key down while using the mouse to select or deselect items.* Logic / Input / Data Handling

Select Quality Characteristics — Required Reading

Quality Characteristics Affected: *	*Hold the Control key down while using the mouse to select or deselect items.* Functionality / Functionality .... / Reliability / Usability / Efficiency / Maintainability
Discovered Via: *	Peer Review
Life Cycle Phase Originated: *	Planning
Life Cycle Phase Discovered: *	Code and Unit Test

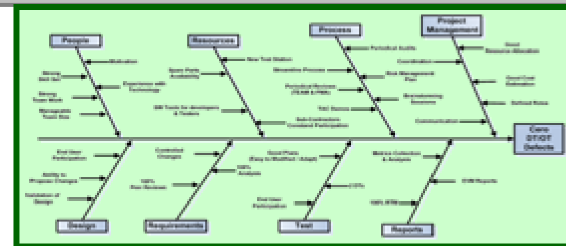
Accurate defect data capture is critical for project performance using the LSS Measure and Analysis Phase

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

Cause and Defect Analysis | Required Reading

Root Cause Description: *

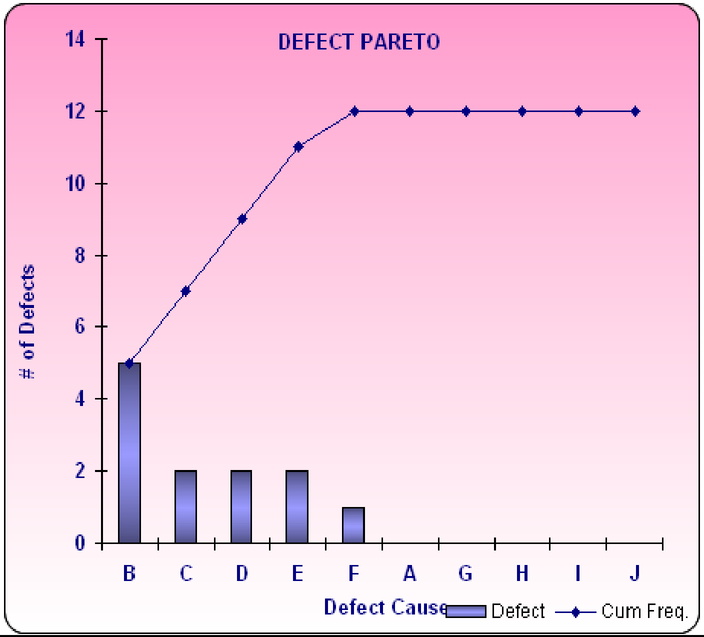
Improvement Proposal Type: *

Hold the Control key down while using the mouse to select or deselect items.

Tools
Methods
Communications

Improvement Proposal Description: *

Incorporation of Lean Six Sigma (3)



Defect data can be extracted from processMax® into an Excel file to perform cause and effect analysis

Phase Detected	Phase Originated					
	Requireme	Design	Coding	System	OT/DT	Total
Requirements	46					46
Design	5	19				24
Coding	1	18	66			85
Software Integration	0	0	0			0
System Testing	1	9	54			64
OT/DT	0	0	0			0
Total	53	46	120			219

Improve Performance with Quantitative Defect Management

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

Quotations

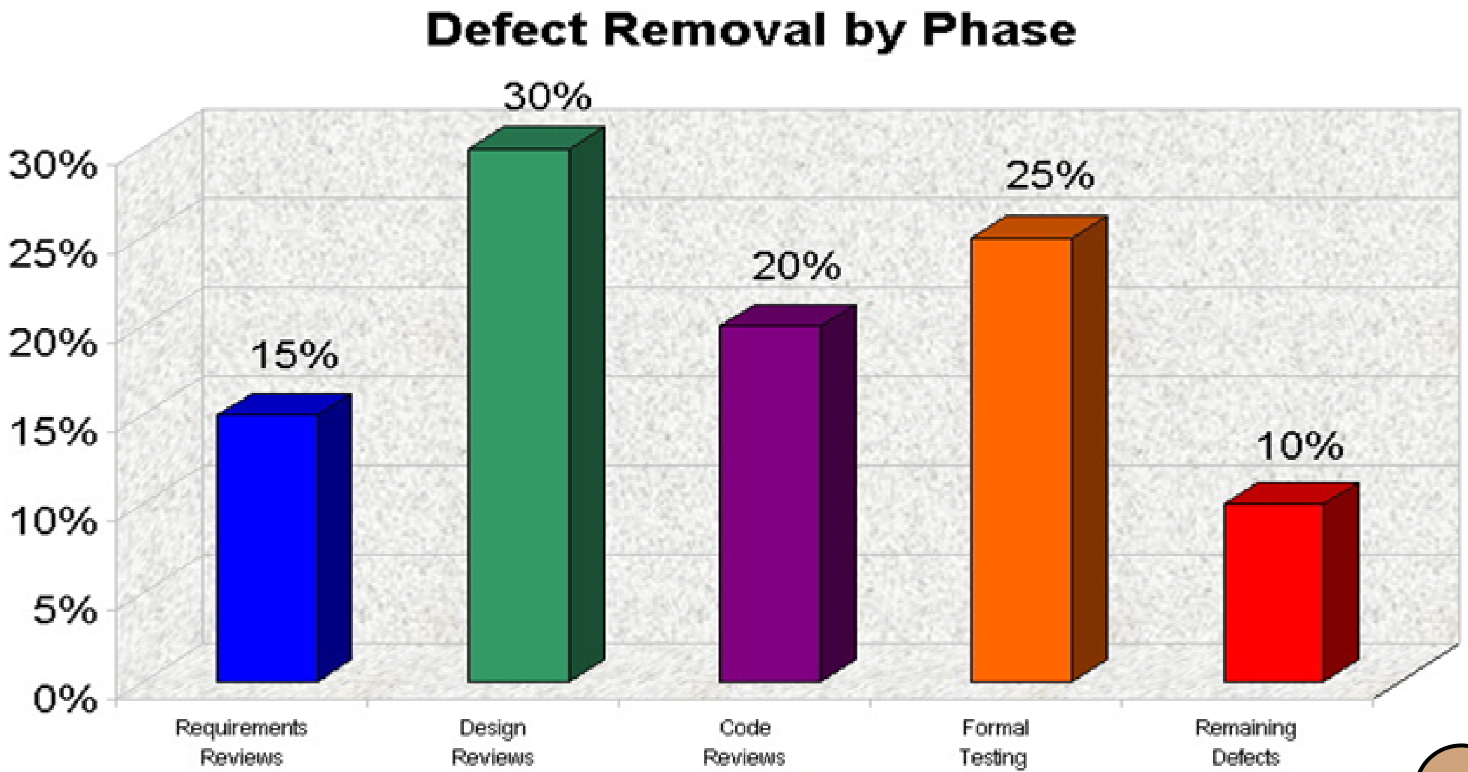
Quality is never an accident, it is always the result of high intention, intelligent direction and skillful execution; it represents the wise choice of many alternatives." *William A. Foster*

"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)



Facilitate gradual shift from “Fix-on-Failure” to Prevention

Introduction
Quantitative Defect Management (2)

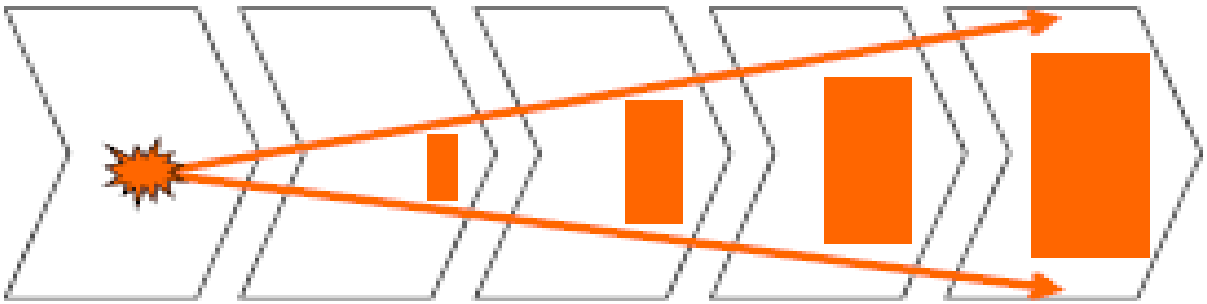


Table 1: *Time to Fix Defect That Escapes Stage (in hours)*

Requirement	Design	Coding	Development Test	Acceptance Test	During Operation
1	3-6	10	15-40	30-70	40-1,000

24 CROSSTALK The Journal of Defense Software Engineering

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 AIRSpeed Black Belt Projects

- **Three AIRSpeed 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: Lean Six.Sigma
Establish Baselines Using Historical Data

→

Step 2: Lean Six.Sigma
Establish Project Goals

→

Step 3:
Establish Quality Control Target

↓

Step 4 Lean Six.Sigma
Statistically Manage Peer Reviews

↓

Step 5: Lean Six.Sigma
Statistically Manage Defect Removal Effectiveness

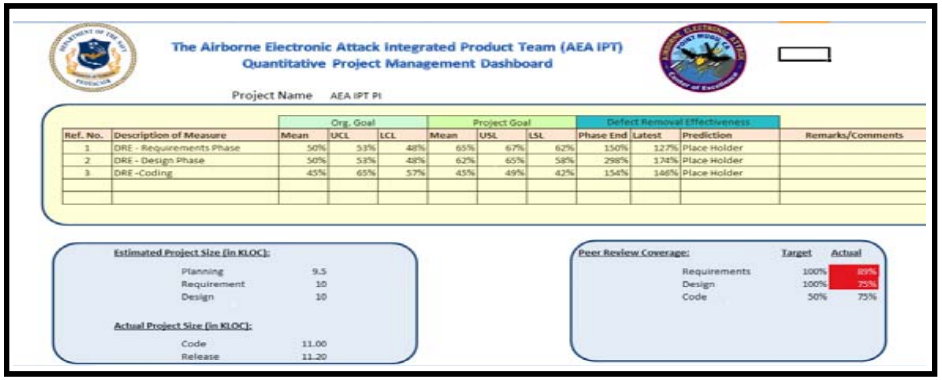
←

Step 6:
Perform Phase End Review

←

Step 7: Lean Six.Sigma
Perform Causal Analysis and Resolution (CAR)

D a s h b o a r d



The Airborne Electronic Attack Integrated Product Team (AEA IPT)
Quantitative Project Management Dashboard

Project Name AEA IPT PI

		Org. Goal			Project Goal			Defect Removal Effectiveness			
Ref. No.	Description of Measure	Mean	UCL	LCL	Mean	USL	LSL	Phase End	Latest	Prediction	Remarks/Comments
1	DRE - Requirements Phase	50%	53%	48%	65%	67%	62%	150%	127%	Place Holder	
2	DRE - Design Phase	50%	53%	48%	62%	65%	58%	298%	174%	Place Holder	
3	DRE -Coding	45%	65%	57%	45%	49%	42%	154%	146%	Place Holder	

Estimated Project Size (in KLOC):

Planning	9.5
Requirement	10
Design	10

Actual Project Size (in KLOC):

Code	11.00
Release	11.20

Peer Review Coverage:

	Target	Actual
Requirements	100%	89%
Design	100%	75%
Code	50%	75%

Establish AEA IPT Performance Baselines

AEA IPT Quality & Process Performance Baseline

Baseline Last Revised On:

Product Quality:

Defect Density:

	Mean	UCL	LCL	Unit
Defect Density (All Phases)	36	39	33	KLOC
Residual Defect Density	0.2			KLOC

Defect Originated - Distribution

	Mean	UCL
Requirements	25.00%	
Design	25.00%	
Coding		
Software Integration		
System Testing		

Process Performance:

Defect Removal Effectiveness:

Phase	Mean	UCL	LCL
Requirements	50%	53%	48%
Design	50%	53%	48%
Coding	45%	65%	57%

Sub Process Performance:

Sub Process	Attributes	Mean	UCL
Req. Peer Review	Defects/Unit Size	1	
	Defects/ Review Time		
	Review Time/Unit Size		
Design Peer Review	Defects/Unit Size		
	Defects/ Review Time		
	Review Time/Unit Size		
Code Peer Review	Defects/Unit Size		
	Defects/ Review Time		
	Review Time/Unit Size		

Peer Review Coverage:

Sub Process	Required	Tolerance
Req. Peer Review	100%	+/- 10%
Design Peer Review	100%	+/- 10%
Code Peer Review	50%	+/- 10%

- **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

AEA IPT Business Goals and Objectives

<Document the Business Goals & Objectives - Protect this spa>

AEA IPT Quality & Process Perfromance Objectives

<Document the Quality & Process Performance Objectives>

Customer and Other Stakeholder's Objective

Project Objective

<It can be same as Org. objectives or PM can add more to meet the customer and other staheholder's objective>

Project Goals:

Description of Measure	Mean	USL	LSL
DRE - Requirements Phase	65%	67%	
DRE - Design Phase	62%	65%	
DRE -Code and Unit Test	45%	49%	

- **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

Establish Quality Control Target

Define Project Parameters & Estimates

Name of the Project	AEA IPT PI
Name of Project Manager	Tuan Le

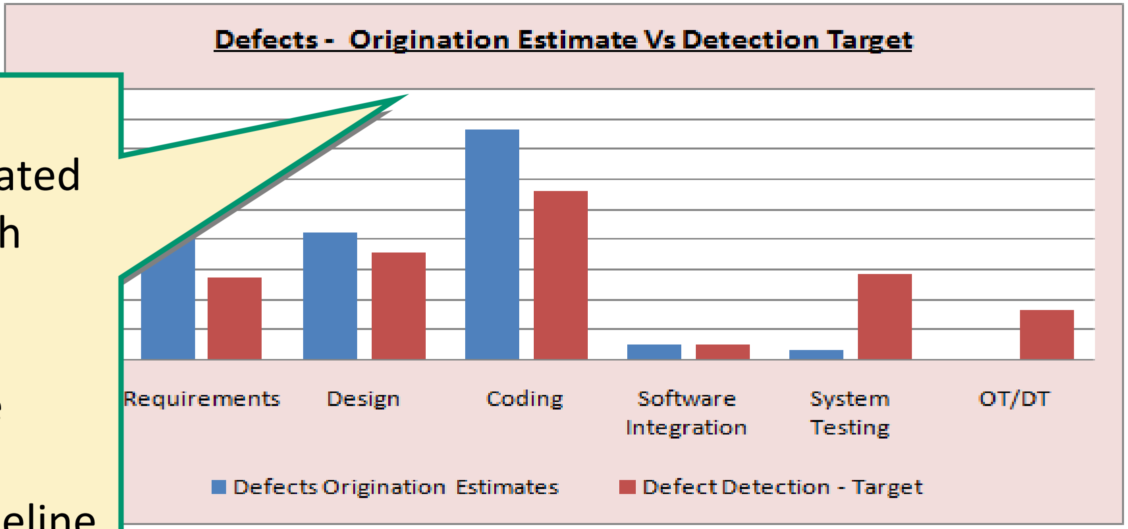
Project Size Estimates 9.50 KLOC

Defects Origination Estimates

Phase	Mean	UCL	LCL
Requirements	86	95	76
Design	86	91	80
Coding	154	159	149
Software Integration	10	13	7
System Testing	7	9	4
Total	342	368	316

Defect Detection - Target

Phase	Mean	UCL	LCL
Requirements	56	57	54
Design	72	74	69
Coding	113	118	110
Software Integration	10		
System Testing	57		
OT/DT	34.2		



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

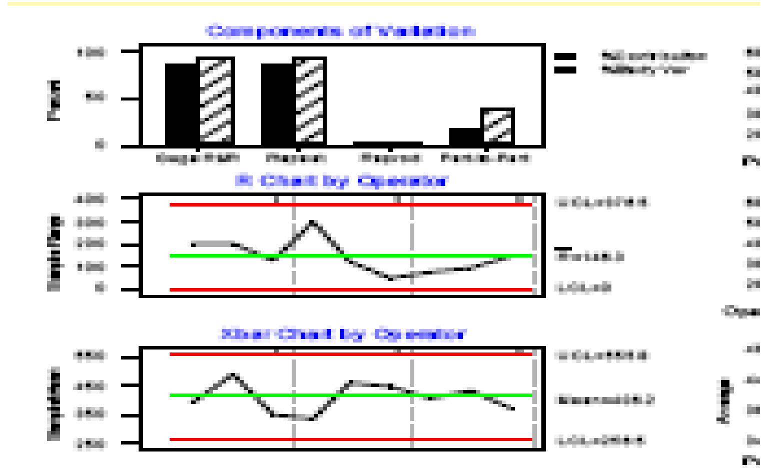
Defect estimation model will be based on historical data and organizational performance baseline

Statistically Manage Peer Review Performance

Design Phase - Peer Review

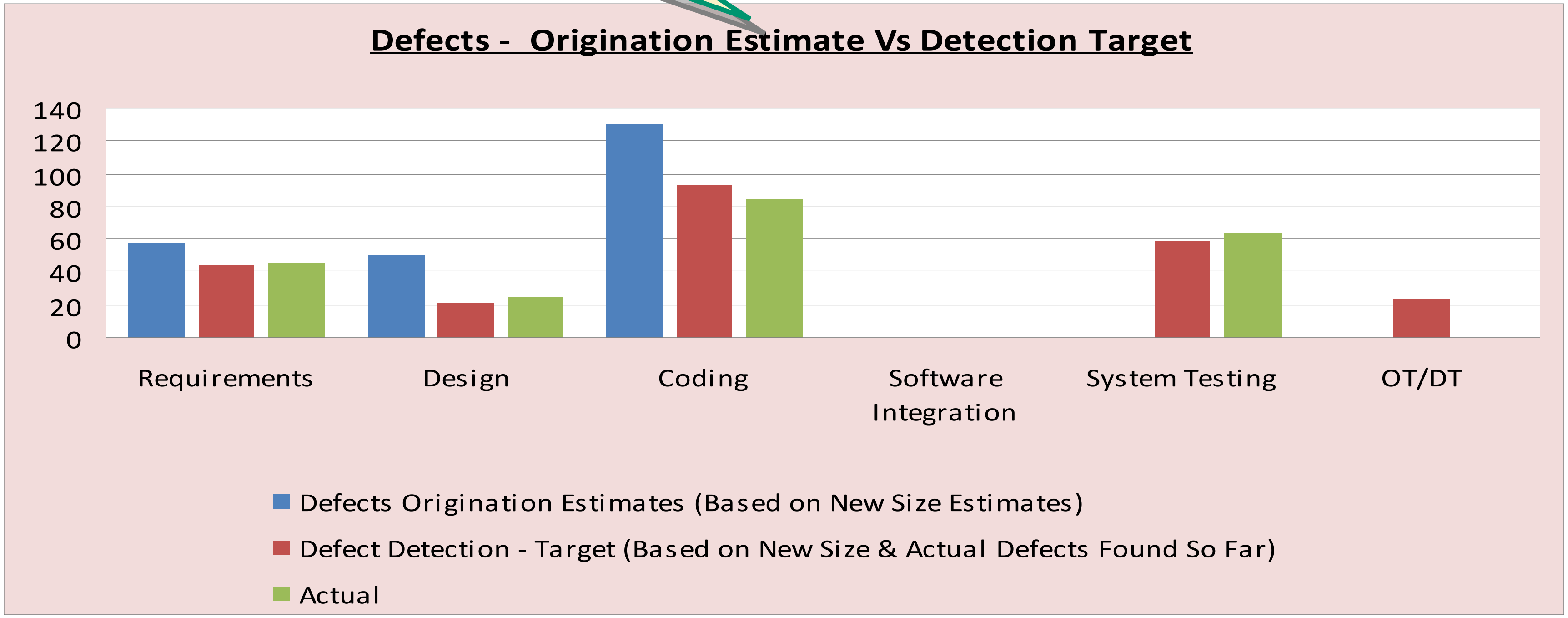
				Phase Originated							
Peer Review Date	Total Hours	Total Size	Number of Defects Discovered	Requirement	Design	Code & UT	Sys Testing	Defects / Hour	Defects / Unit of Size	Hours / Unit of Size	
13-May-08	7	8	5	0	5			0.71	0.63	0.88	**Under Statistical Control**
22-May-08	9.25	93	5	0	5			0.54	0.05	0.10	
1-Jul-08	6.5	12	3	3	0			0.46	0.25	0.54	
28-Aug-08	6.75	44	1	1	0			0.15	0.02	0.15	
8-Sep-08	7	65	3	1	2			0.43	0.05	0.11	
4-Sep-08	6.25	53	2	0	2			0.32	0.04	0.12	
To						0	0				

Project team members statistically manage peer reviews and take corrective actions as required



Statistically Manage Defect Removal Effectiveness Performance

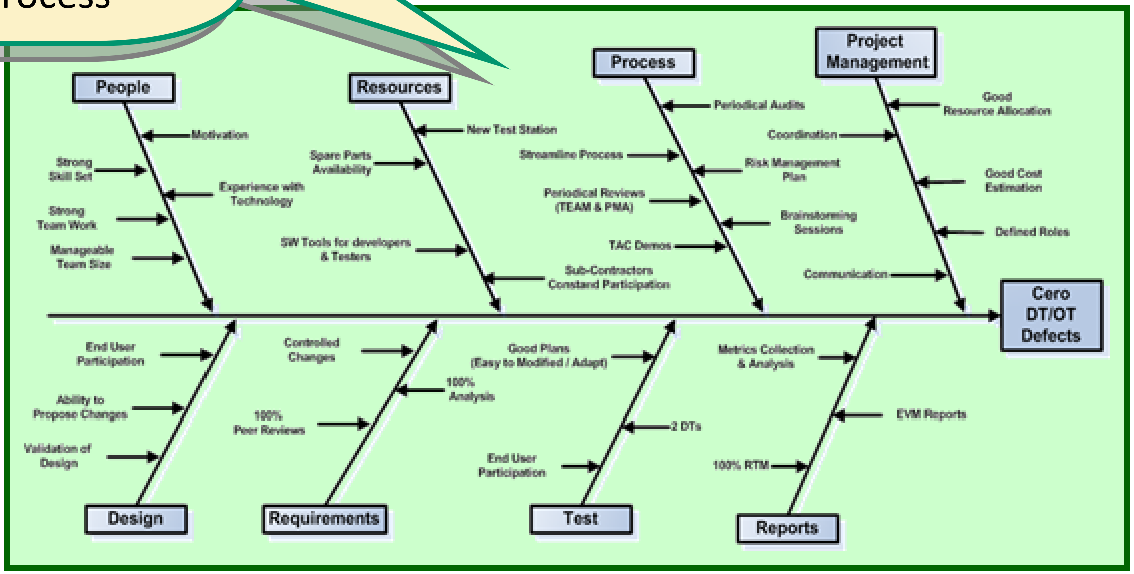
Project team members statistically review project performance at the end of the phase and take corrective actions as required



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

Dashboard

Organizational

Objectives

Planning Phase

Control Charts:

Process Attribute	Requirements Phase	Design Phase	Code & UT Phase
Defects/Hr	Click	Click	Click
Defects/Unit Size	Click	Click	Click
Hrs./Unit Size	Click	Click	Click

Requirements

Design Review

Coding & Unit

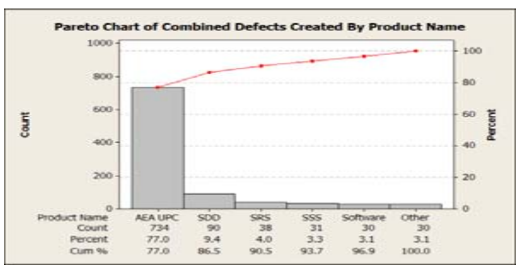
Integration

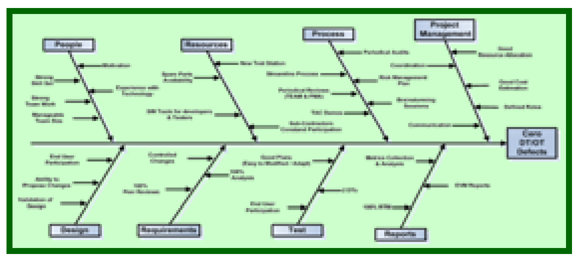
System Testing

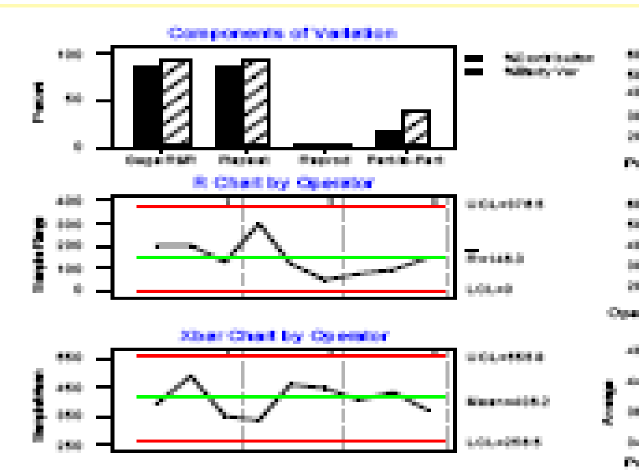
DT/OT

Selected Lean Six Sigma Tools for Quantitative Defect Management Process

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







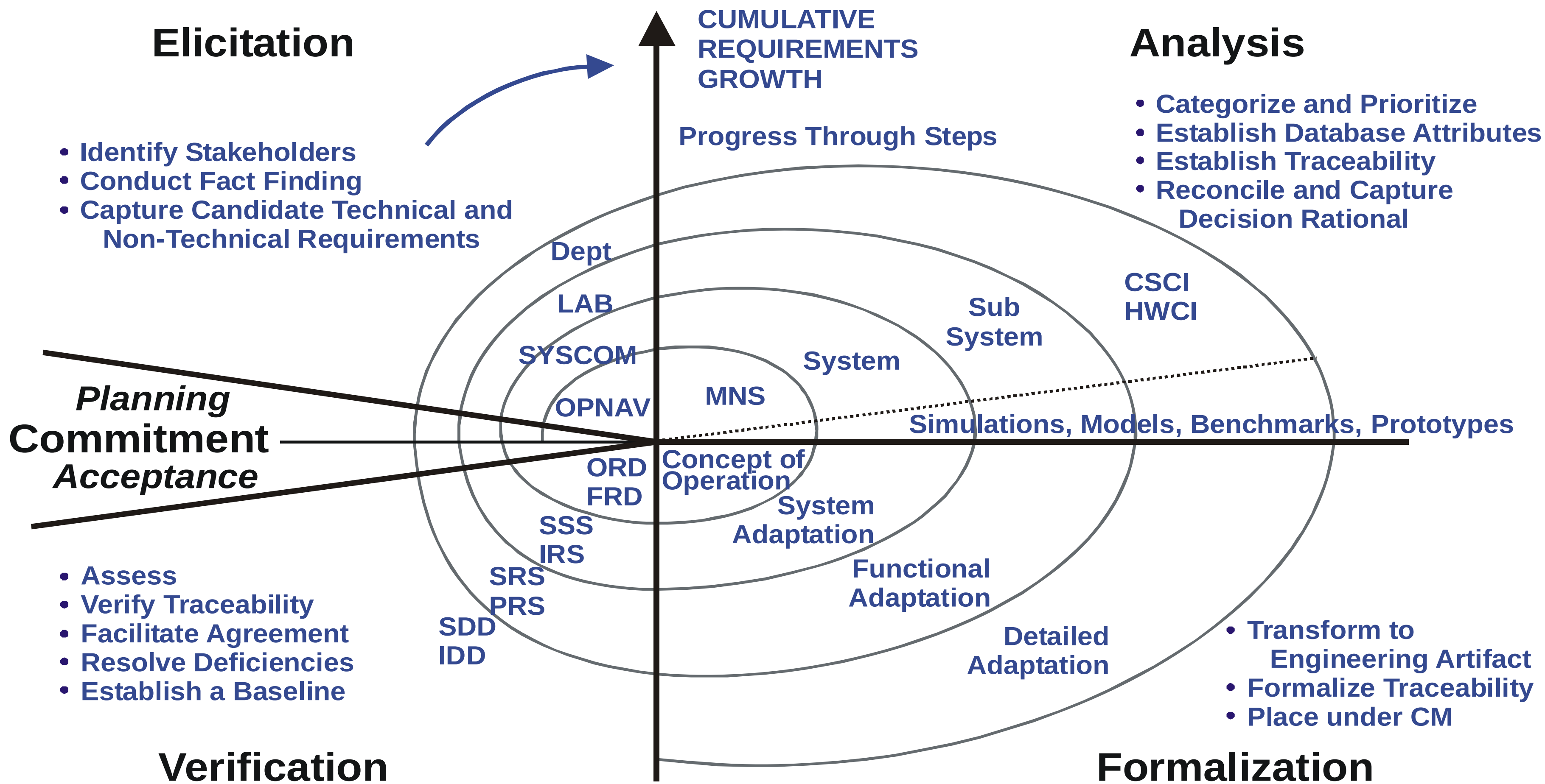
Together, Lean Six Sigma and CMMI help AEA IPT improve performance and achieve objectives faster

Improve Performance with Quantitative Requirements Management

DoD-NAVAIR Directed Continuous Process Improvement (CPI) by Integrating Lean Six Sigma in to AEA IPT critical processes

Optimal Process Model

- Requirements Management Process Model



GAO Reported Acquisition Concerns

- 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: Lean Six.Sigma

Establish RVI Performance Baselines using Historical Data

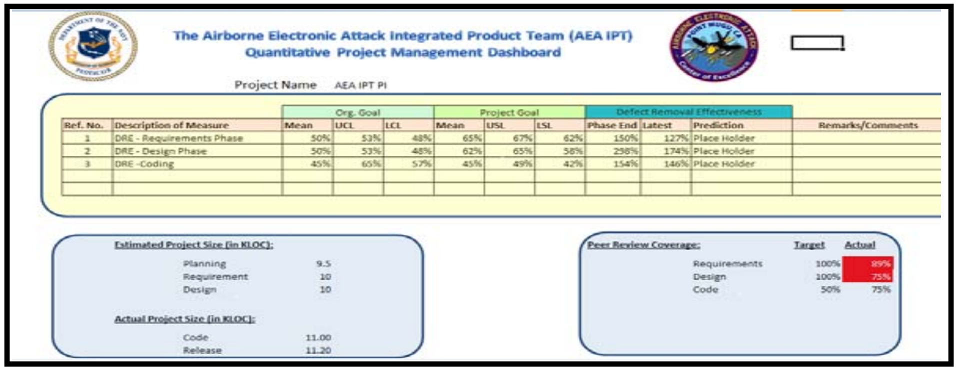
Step 2:

Establish Project Goals

Step 3:

Plan for RD and RM

D A S H B O A R D



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	Target	Actual
Requirements	100%	89%
Design	100%	75%
Code	50%	75%

Step 4:

Monitor and Control development progress and quality of SRS

Step 5: Lean Six.Sigma

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

Step 6: Lean Six.Sigma

Calculate and Predict CPI and SPI

Step 7: Lean Six.Sigma

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