BAE SYSTEMS

The High Road to Measurement Maturity

subtitled:
Applying PSM with Vengeance

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Organizational Process Optimization Lead

Topic Introduction

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- **Our Process Improvement Timeline**
  - **1989 – Achieved SW-CMM Level 1**
  - **1992 – Achieved SW-CMM Level 2**
  - **1995 – Achieved SW-CMM Level 3**
  - **1997 – Achieved SE-CMM & P-CMM Level 2**
  - **2000 – Achieved SE-CMM Level 3**
  - **2000 – Failed Attempt at SW-CMM Level 4**
    - **Failed both Key Process Areas (KPAs)**
  - **2001 – The Process Recovery Year**
    - **Major Process Set Update Undertaken**
    - **Hired Consultants from SSCI (Card, Bowers, etc.)**
    - **Implemented PSM Principles & Methods**
    - **Formed Organizational Metrics Analysis Group (MAG)**
  - **2002 – Achieved SW-CMM Levels 4 (May) & 5 (Dec)**
  - **2003 – Achieved CMMI Level 5!**

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General Observations from 2000 Assessment

Improvement Opportunities:

- The organization's standard process is seen as being too complex, while at the same time not always containing the "how-to" information necessary to ensure consistent implementation of the process and the collection of valid data
  - "The OMs [Operating Manuals] are overwhelming."
  - "Processes are too complex at systems and software level in OMs… compliance with 500+ requirements… no noticeable improvement."

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General Observations from 2000 Assessment

Improvement Opportunities:

- The number of stable organizational trends is relatively small; the correct things are being done, but the statistical evidence that the trends truly exist across the organization remains weak
- The implications of process and technology change are not yet fully understood in quantitative terms

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Level 4 KPA Ratings from 2000 Assessment

Managed KPAs (CMM Level-4)	Goal 1	Goal 2	Goal 3
Software Quality Management	●	●	●
Quantitative Process Management	●	●	●

● Goal Fully Satisfied
● Goal Not Satisfied

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Specific Findings from 2000 Assessment Team

Improvement Opportunities (QPM) :

- **Some required data/metrics are not considered by some programs to provide value …**
- **The criticism on the metrics is that "they are too late and not sharp enough an indicator to tell us what we really need to do in the short-term".**
- **Quantitative management charts are occasionally viewed by practitioners, but not as matter of course …**
- **The organization's process capability baseline is not well understood ...**

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Specific Findings from 2000 Assessment Team

Improvement Opportunities (SQM) :

- **Trend lines … are "noisy" because of variability, small number of data points, application domain differences, differing levels of process deployment in programs, "seasonal" variation in different phases, etc.**
- **Some OQMP goals, e.g., 50% defect density reduction, may not be met for various reasons, such as missing data for initial baseline in Jan 1999, operational definition issues, customer priorities, etc.**
- **There are no plans for taking corrective action to achieve the OQMP goals or re-planning to establish revised goals.**
- **Many programs do not manage to their plans for actually achieving the OQMP/PQMP quality goals.**

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2001 – The Process Recovery Year

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Major Process Set Update Undertaken

- **CMMI-focused Approach Adopted**
  - Process Subsets Broken Into CMMI-based Domains
  - Not a One-to-One Mapping to CMMI Process Areas (PAs)
- **Process Document Hierarchy Defined**
  - Process Documents Broken Into "Chewable" Subsets
- **Processes Re-Designed by "Process Users"**
  - Standard Process Document Templates Employed
  - Hired Consultants (if local "domain experts" unavailable)
- **Resulting Process Set Web-Deployed**
  - Allowed easier access by all users
  - Enabled easier update and deployment
- **Process Change Request Process Web-Deployed**
  - Allowed Process Users To Make Improvement Suggestions

Process Document Structure

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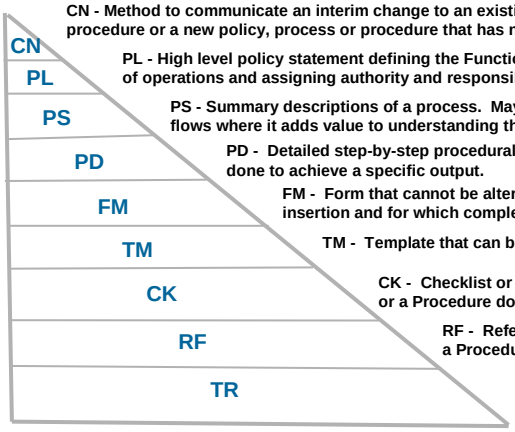

CN - Method to communicate an interim change to an existing policy, process or procedure or a new policy, process or procedure that has not been released to DOLLS.

PL - High level policy statement defining the Functional and/or Organizational conduct of operations and assigning authority and responsibility for implementation.

PS - Summary descriptions of a process. May include diagrams of process flows where it adds value to understanding the process.

PD - Detailed step-by-step procedural instructions of what precisely has to be done to achieve a specific output.

FM - Form that cannot be altered that identifies specific information for insertion and for which completion results require retention.

TM - Template that can be used by a project as a starting point.

CK - Checklist or other Aide to complement a Process or a Procedure document.

RF - Reference Doc to complement a Process or a Procedure document.

TR - Types of training material to include: Formal course material developed by the company, job aides, conference / brown bag presentations, etc.

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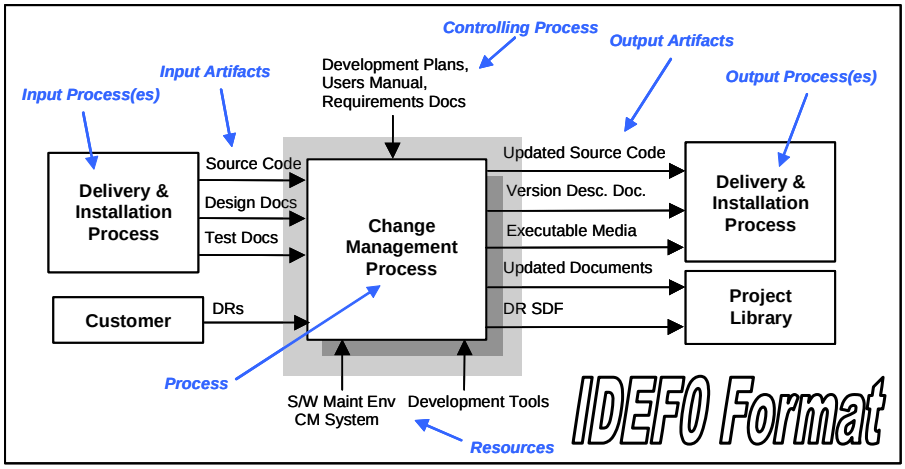
Process Document Context



For more information visit www.idef.com

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Formed Metrics Analysis Group

- **Metrics Analysis Group (MAG) Charter**
  - **Develop Measurement & Analysis Process Roadmap**
  - **Develop Metrics Analysis Methodologies, Models & Measures To Support Quantitative Management Activities**
  - **Assist Projects With Startup of Metrics Collection & Analysis Activities**
  - **Perform Organizational Metrics Analyses**
  - **Report Results to Projects & Organizational Process Groups**
  - **Sponsor Process Action Teams**
  - **Sponsor Causal Analysis Teams**
  - **Support Other Process Groups**
  - **Support Development & Implementation of Metrics-Related Training**

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Hired Industry & Academia Consultants

- **David Card (PSM Co-Author & SSCI)**
  - Measurement & Analysis
  - Quantitative Process Management
  - Software Quality Management
  - Organizational Process Performance
  - Causal Analysis & Resolution
- **Leila Bowers (SSCI)**
  - Organizational Process Focus
  - Organizational Process Definition
  - Project Planning
  - Project Monitor & Control
  - Risk Management
- **Other Consultants & University PhDs**
  - Modernized Development Technologies

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Implemented PSM Principles & Methods

- **Measurement Process Model**
  - **Developed, Documented & Web-Published Measurement & Analysis Process Model Roadmap**
  - **Included Ties To Level-4/5 Activities**
    - Definition of Causal Analysis Team (CAT) Activities
  - **Developed Measurement-Related Training Program**
    - Quantitative Management Awareness (all Employees)
    - Inspection Data Analysis (all Engineers)
    - Causal Analysis (Leads & CAT members)
    - Statistical Process Control Techniques (Leads & CAT members)
    - Private Project OJT Sessions (as needed)
    - Metrics Analysis Workshops (as needed)

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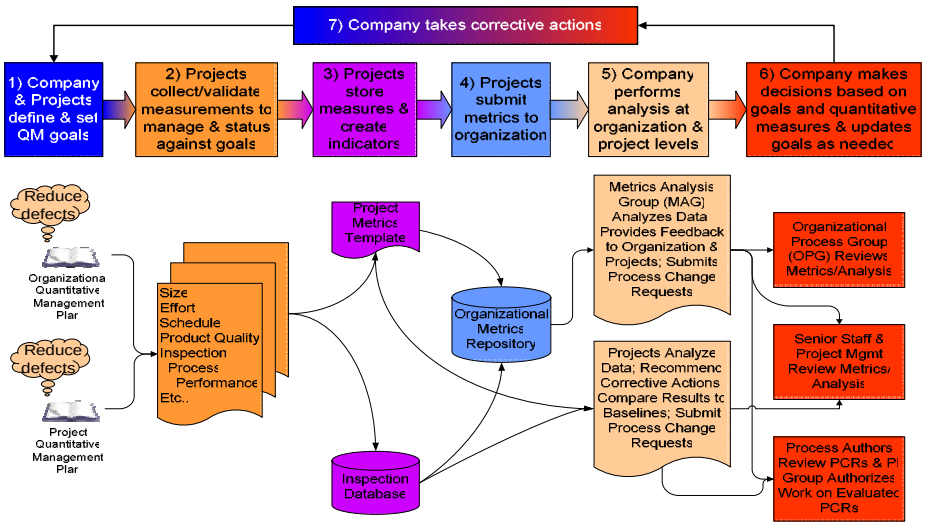
Measurement & Analysis Process Roadmap



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Implemented PSM Principles & Methods
(Continued)

- **Measurement Construct Definitions**
  - **Adopted PSM Construct Model & Terminology**
    - Leveraged Heavily Off Dave Card's Expertise
    - Goal-Driven Measurement Selection Implemented
  - **Defined Standardized Set of Base & Derived Measures**
    - Defined Over 400 Base & Derived Measures in 20 Categories
    - Prioritized & Down-Selected for Quantitative Management
    - Annual Metrics Reviews Held With Relevant Stakeholders
  - **Developed Standard Metrics Template for Projects**
    - Initial Measurement Requirements Determined by Project Type
    - Then Measurement Requirements Tailorable Via PCR Process
  - **Updated Tooling to Automate Collection Wherever Possible**
    - Approx. 75% of Engineering Measurement Collection Handled Semi-Automatically With Button Push in Source Application

Measurement Construct Model

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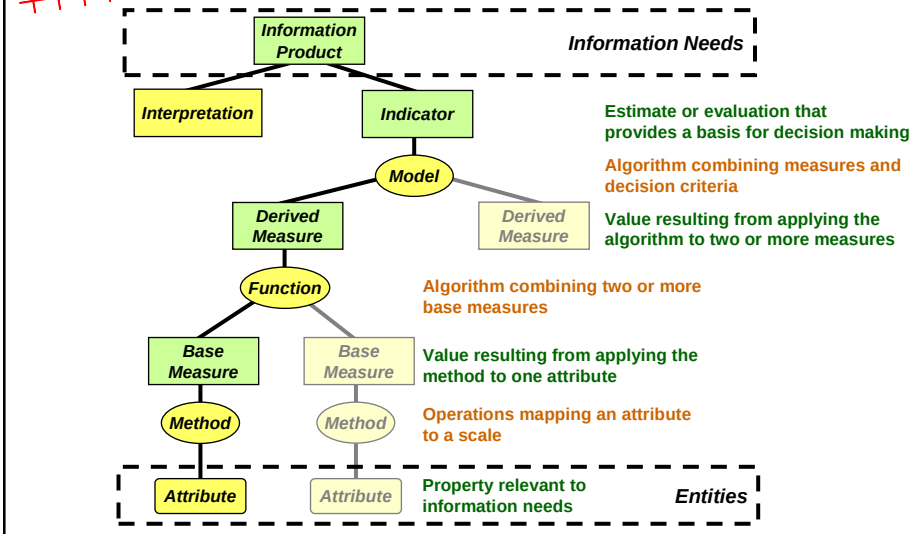

Source: Adapted from ISO/IEC 15939, *Software Measurement Process Framework.* Geneva:International Organization for Standardization, 2002.

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Implemented PSM Principles & Methods (Continued)

- **Measurement Plans**
  - **Developed Standard Template for Project Plans**
    - Mandatory Annual Re-Publication for Project Plans
    - Project Plan Adherence Tracked by Quality Assurance Group
    - Plan Re-Publication Aging Tracked by Metrics Analysis Group
      - 90-day, 60-day, 30-day Update Warning Emails Issued to Projects
  - **Developed Standard Organization Plan**
    - Annual (At a Minimum) Stakeholder Involvement Reviews
    - Mandatory Annual Full Publication
    - Mandatory Quarterly Appendices Updates
    - Web-Published For Easy Access by All Company Employees

Measurement Plans (Organizational Level)

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	Process Management					Project Management						Engineering						Support				
CMMI Capability Levels	OPF	OPD	OT	OPP	OID	PP	PMC	SAM	IPM	RSKM	QPM	REQM	RD	TS	PI	VER	VAL	CM	PPQA	MA	DAR	CAR
5		■	■										■	■	■	■			■			
4		■	■										■	■	■	■			■			
3	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

■ Current Capability Profile as of Dec '03 Class A SCAMPI (SE/SW)

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Measurement Plans (Organizational Level)

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CMMI Capability Levels	RD	TS	PI
BAE Objectives	Reduce the density of defects in requirements documents.	Improve the efficiency of the software design and code processes.	Reduce the density of defects in Test Plans and Procedures.
BAE SYSTEMS Processes	Develop Systems Requirements - (OM.12.13.14A001) Derive Software Requirements - (OM.12.13.14A002) Derive Hardware Requirements - (OM.12.13.14A003)	Design System - (OM.12.13.14A004) Design Software - (OM.12.13.14A005) Design Hardware - (OM.12.13.14A006) Code and Test Software - (OM.12.13.14A007)	Integrate and Test Hardware - (OM.12.13.14A011) Integrate and Test Software - (OM.12.13.14A010) Product Integration - (OM.12.13.14A012)
5	**Develop Systems Requirements** **Derive Software Requirements** • Systemic Defects • Pareto of types of defects • Analysis of Lessons Learned • Analysis of Defect Injection & Detection Profiles	**Design System** **Design Software** **Code and Unit Test Software** • Systemic Defects • Pareto of types of defects • Analysis of Lessons Learned • Analysis of Defect Injection & Detection Profiles	**Integrate and Test Software** • Systemic Defects • Pareto of types of defects • Analysis of Lessons Learned • Analysis of Defect Injection & Detection Profiles
4	**Develop Systems Requirements** **Derive Software Requirements** • Analysis of Defect Profile, Defect Injection, and Phase Containment	**Design System** **Design Software** **Code and Unit Test Software** • Analysis of Defect Profile, Defect Injection, and Phase Containment	**Integrate and Test Software** • Analysis of Defect Profile, Defect Injection and Phase Containment • Reliability Model (failure intensity model)
3	**Develop Systems Requirements** **Derive Software Requirements** • Defect Leakage (Requirements to Design) & Phase Containment • Defect Profile • Number of operational and minor de **All Collectively** • Process Health Scores • Monthly Customer Satisfaction Sco **Each Individually** • Number of PCRs • Number of PCARs • Lessons Learned	**Design System** **Design Software** • Defect Leakage & Phase Containment	**Integrate and Test Software** • Defect Leakage & Phase Containment • Defect Profile
2	**Develop Systems Requirements** **Derive Software Requirements** • Number of Requirements, Number • Number of allocated/ validated/ deri • Requirements volatility measured b modified, clarified, untestable • Categorization of Defects / DRs **Each Individually** • Action Items, Budget, Schedule		

2

Develop Systems Requirements
Derive Software Requirements
- Number of Requirements, Number of DRs
- Number of allocated/ validated/ derived requirements
- Requirements volatility measured by added, deleted, modified, clarified, untestable
- Categorization of Defects / DRs

Each Individually
- Action Items, Budget, Schedule

Measurement Plans (Organizational Level)

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Derive Software Requirements
• Defect Leakage (Requirements to Design) & Phase Containment
• Defect Profile
• Number of operational and minor defects

All Collectively
• Process Health Scores
• Monthly Customer Satisfaction Scores

Each Individually
• Number of PCRs
• Number of PCARs
• Lessons Learned

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Measurement Plans (Organizational Level)

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2	**Develop Systems Requirements** **Derive Software Requirements** • Number of Requirements, Number of DRs • Number of allocated/ validated/ derived requirements • Requirements volatility measured by added, deleted, modified, clarified, untestable • Categorization of Defects / DRs **Each Individually** • Action Items, Budget, Schedule	**All Individually** • Total Number of DRs, defects • LOC • Categorization of Defects / DRs • Action Items, Budget, Schedule	**Integrate and Test Software** **Product Integration** • DRs written during Integration and Test by type • Total number of requirements verified and test cases / test steps executed and passed **Each Individually** • Action Items, Budget, Schedule

4

Develop Systems Requirements
Derive Software Requirements
• Analysis of Defect Profile, Defect Injection, and Phase Containment

Measurement Plans (Organizational Level)

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CMMI Capability Levels	RD	TS	PI
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5

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Derive Software Requirements
- Systemic Defects
- Pareto of types of defects
- Analysis of Lessons Learned
- Analysis of Defect Injection & Detection Profiles

Measurement Plans (Organizational Level)

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Org	Title	Goal Description	Para
1	Cost Performance	Achieve a CPI of no lower than .XX with a stretch goal of .XX on all contracts.	3.1
2	Schedule Performance	Achieve an SPI of no lower than .XX with a stretch goal of .XX on all contracts.	3.2
3	Post-Delivery Defect Density Reduction	Reduce post-delivery defect density of software products from the 2004 baseline of X.XX DRs/KSLOC to maximum of X.XX DRs/KSLOC (includes critical DRs identified during test and operation).	3.3
4	Development Defect Leakage Reduction	Achieve development defect leakage of no greater than XX% for projects completing Integration Test in 2005 (includes defects identified during the requirements and design phases).	3.4
5	Design Defect Leakage Reduction	Achieve design defect leakage of no greater than XX% for projects completing development in 2005 (includes defects identified during the requirements phase)*	3.5

Measurement Plans (Project Level)

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Project:	
Date:	May 24, 2005
Critical Product:	Software
Organizational Goal:	Reduce post-delivery defect density of software products from the 2004 baseline of X.XX DRs/KSLOC to maximum of X.XX DRs/KSLOC (includes critical DRs identified during test and operation).
Project Goal:	Since v4.0 is built on software baselines established by v3.1, v3.2, v3.3, and v3.5, the goal for v4.0 is to reduce post-delivery defect density by XX% from the average post-delivery defect density for v3.1, v3.2, v3.3, and v3.5 combined.
Plan(s) to Achieve Goal:	Inspect XX% of requirements, XX% of design, and XX% of code. Conduct unit and integration testing on XX% of code.

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Implemented PSM Principles & Methods (Continued)

- **Measurement Analysis & Reporting**
  - **Standard Project Metrics Template Includes Canned Charts for Each Metrics Category**
    - 62 Canned Charts Forced Standardization Across Projects
  - **Developed Metrics Chart by Project Type Cross Reference**
    - Identified Required Indicator Charts by Project Type
    - Identified Start/Frequency of Review For Each Canned Chart
    - Identified Level of Reporting For Each Canned Chart
  - **Selected Standard Analysis Tool (NWA Quality Analyst Tool)**
    - Developed Standardized Queries & Data Formats in Projects' Source Data Stores to Speed Up Project Startup Activities
    - Implemented QM Workshop to Train/Mentor New Analysts

Metrics Chart By Project Type

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Category	Tab Name	Chart Title	Start of Chart Usage	Minimum Frequency of Update	Level of Reporting	ProjectType						
						1	2	3	4	5	6	7
Major Milestones Summary	MILE	(None)	Project Start	Monthly	MAG Use Only	X	X	X	X	X	X	X
Project Staffing Effort	STAFF-C1	Planned vs Actual and Forecast Staffing Profile	Project Start	Monthly	Functional Managers, Program Manager, Director	X	X	X	X	X	X	X
Overall Project Scheduling	SCHED-C1	Total Inchstone Status S-Curve	Project Start	Monthly	Functional Managers, Program Manager, Director, Vice President		X		X	X		X
Test Schedules (Optional Use[1])	TestSCHED-C1	Integration Testing Completion Projection X-Chart	Start of Integration Phase	Monthly	Systems Functional Manager, Program Manager, Director				X	X	X	
System Requirements Volatility (& Testability)	SyREQVOL-C1 (Upper)	System Requirements Unfunded Volatility - Monthly	Initial Baselining of System Requirements	Monthly	Systems Functional Manager, Systems Manager, Chief Engineer			X	X	X		
System Requirements Volatility (& Testability)	SyREQVOL-C1 (Lower)	System Requirements Unfunded Volatility - Cumulative	Initial Baselining of System Requirements	Monthly	Systems Functional Manager, Systems Manager, Chief Engineer			X	X	X		
System Requirements Volatility (& Testability)	SyREQVOL-C2 (Upper-Left)	System Requirements Volatility - Growth & Testability Gap Closure	Initial Baselining of System Requirements - Optional Use[1]	Monthly	Project & MAG Metrics Analysts, Systems Manager			X	X	X		

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Implemented PSM Principles & Methods
(Continued)

- **Measurement Evaluation**
  - **Standardized Project Metrics Auditing**
    - Monthly Audit Results Reported To Projects
    - Monthly Report Presented to Organization Process Group
      - Metrics Submittal Compliance (Level 1 Audit)
      - Metrics Data Integrity Check (Level 2 Audit)
      - Metrics Submittal Lateness
      - Causal Analysis Team Health Status
  - **Mission Assurance Personnel Perform Audits**
    - Project Audits Performed by MAG & Quality Assurance (QA)
    - Over 50% of Metrics Submittal Audits Are Project Self-Audits
      - Performed by Project's QA Representative

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Project Metrics Submittal (Level-1) Audit Results

May-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04	Jan-05	Feb-05	Mar-05	Apr-05
Blue	Yellow	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Blue
Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Green	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Blue	Blue	Green	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
								Grey	Blue	Blue	Grey
						Blue	Blue	Grey	Blue	Blue	Blue
Yellow	Green	Yellow	Green	Green	Green	Green	Blue	Green	Green	Green	Green
Green	Blue	Green	Green	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Green	Blue	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
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								Blue	Blue	Blue	Blue
								Green	Grey	Grey	Grey
Green	Green	Green	Blue	Blue	Blue	Blue	Green	Green	Green	Green	Blue
Green	Green	Green	Green	Green	Green	Blue		Green	Green	Green	Green
Green	Green	Green	Green	Green	Blue	Blue	Blue	Green	Green	Green	Green
								Grey	Blue	Blue	Blue
								Grey	Blue	Blue	Blue

Blue	100% Compliant
Green	90% to 99.9% Compliant
Yellow	80% to 89.9% Compliant
Red	< 80% Compliant
Grey	Not Evaluated
	Not Applicable

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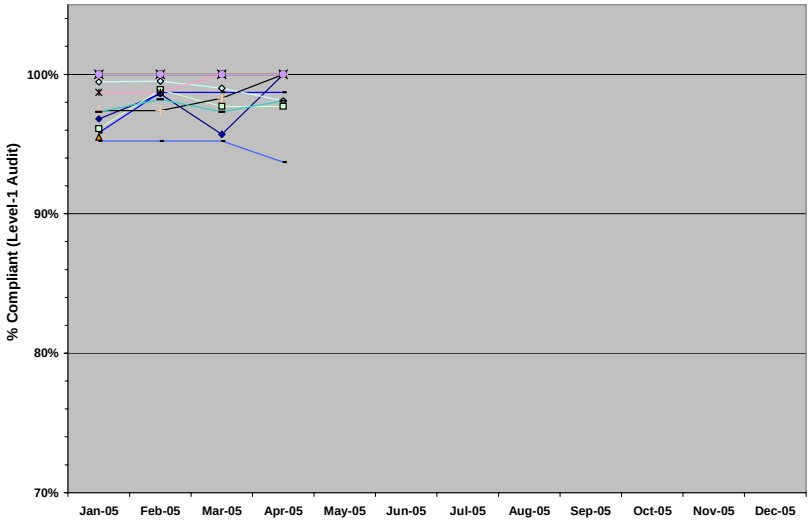
2005 Monthly Metrics Audit Results (By Project)



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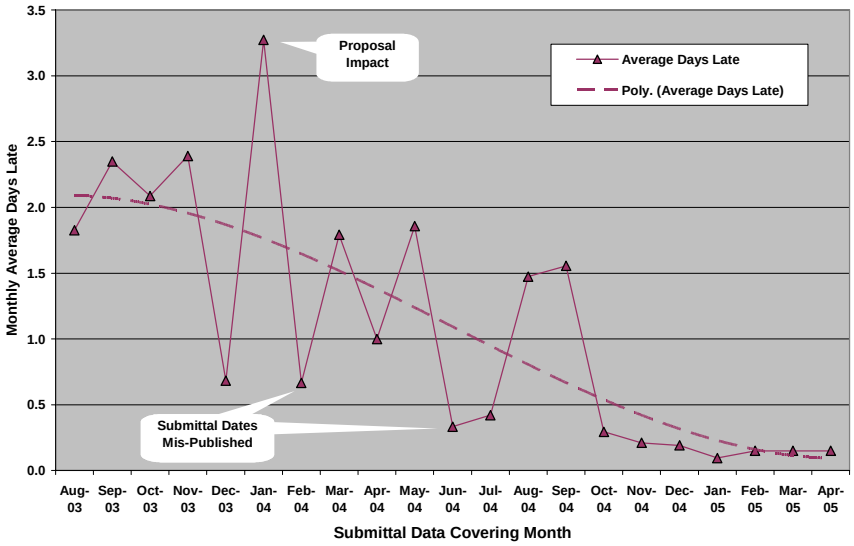
MAG Report - Monthly Average Days Late



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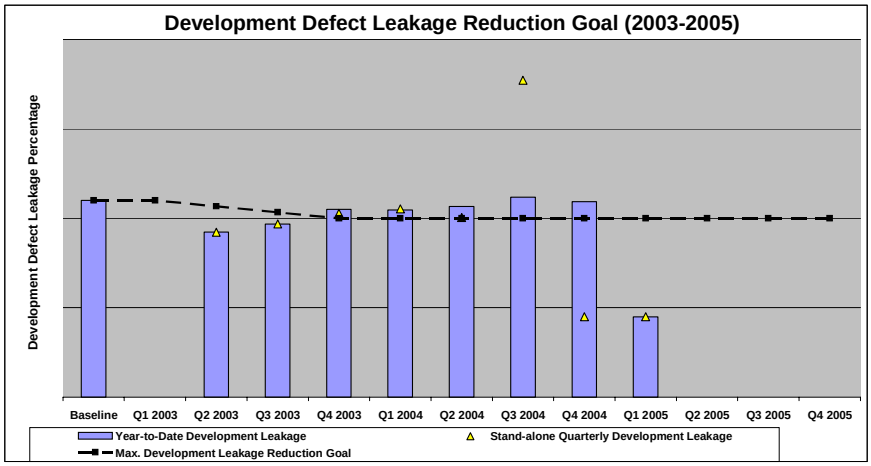
Development Defect Leakage Reduction Goal (2003-2005)



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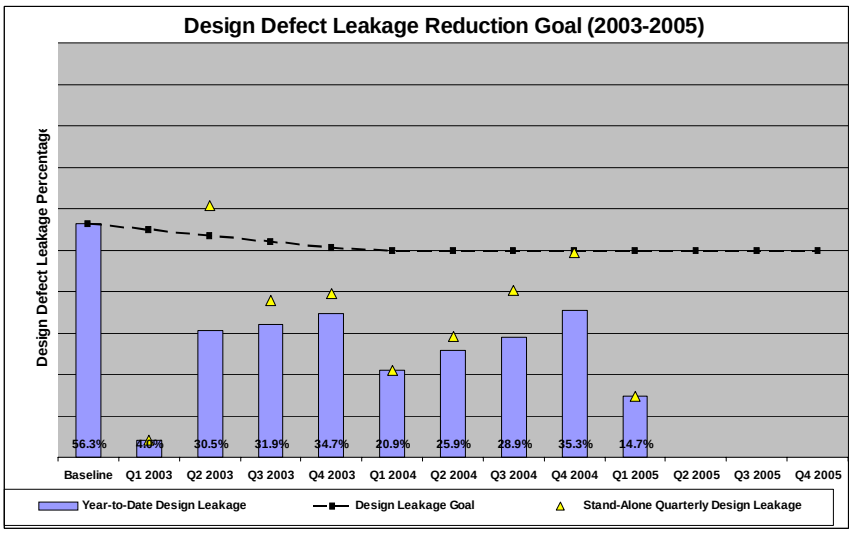
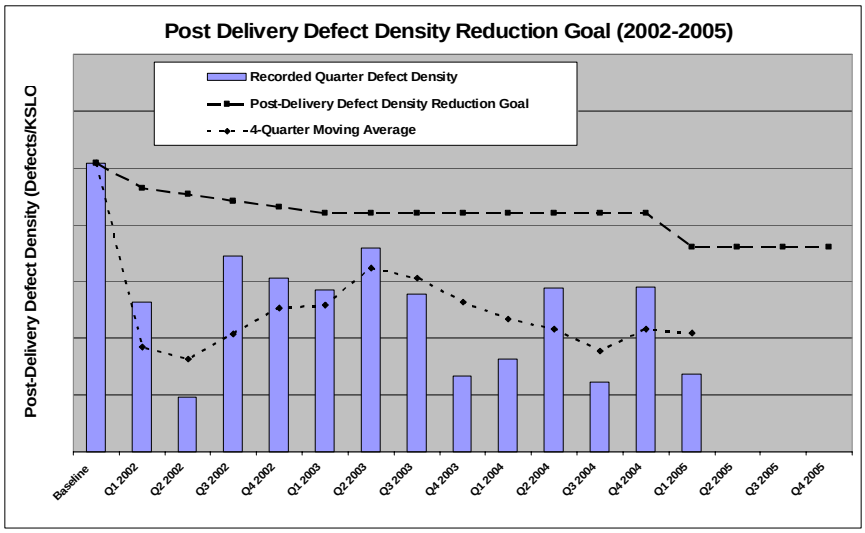


BAE SYSTEMS



Concluding Remarks

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- High Maturity Measurement Practices Include Rigorous Adoption of:

- Goal-Driven Measurement Selection
- Standardized Measurement & Analysis Processes
- Standardized Measurement Constructs
- Organizational & Project Measurement Plans
- Non-Invasive Measurement Collection Practices
- Standardized (& Automated) Reporting
- Continuous Evaluation of Projects' Measurement Collection, Analysis & Reporting Processes
- Periodic Review of Measurement Business Value
- Increased Consulting with Industry Experts!

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Questions?

Speaker's Bio

Kevin Domzalski is a seasoned engineer and member of the Process Improvement Group at BAE SYSTEMS National Security Solutions headquartered in San Diego, California, where he currently fulfills the role of Organizational Process Optimization Lead overseeing CMMI Level-5 practices.

He joined BAE Systems in 1983 (then General Dynamics Electronics Division), has served in several capacities in Software and Systems Engineering and has worked as an automotive industry consultant in Process Engineering during a 5-year hiatus from BAE Systems between 1993 and 1998.

Kevin also supports the Metrics Analysis Group (MAG) activities part-time where he performs metrics analyses on project and organizational measurements and metrics indicators. From 2002 through 2004 Kevin led the MAG activities during which time he was awarded two of his company's Bronze-Level Chairman's Awards for Innovation.

He has developed and teaches many company courses including Inspection Training, Inspection Data Analysis and Quantitative Management Awareness, and teaches the Systems Engineering Software Overview course at the University of California at San Diego (UCSD) Extension Studies Program as a adjunct faculty member and member of the UCSD Systems Engineering Program Advisory Committee.