Effective SE Metrics Tailored to the Acquisition Life Cycle

Armament Research, Development & Engineering Center
Armament System Integration Center
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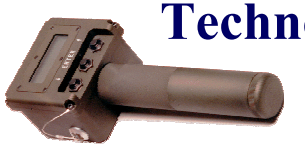
AGENDA

- ARDEC Background
- Measurement Approaches
  - Systems Engineering Plan
  - Level of Effort Assessment
- Tracking & Reporting
- Benefits
- Next Steps

ARDEC Background

Artillery & Mortar Systems



R&D

Advanced Fuze Technologies

Special Operations Weapons & Demolitions

Smart Munitions

DEMIL

SUPPORT TOTAL LIFE CYCLE

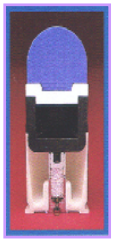
PROD

FIELD SUPPORT

Advanced Explosives & Warhead Development

Combat Vehicle Armaments & Fire Control

Logistics R&D



Non-Lethal Technologies

Future Small Arms

PROVIDING OVER 90% OF THE ARMY'S LETHALITY...

Planned versus Actual

Metric: SE Planning

- Purpose
  - Living Document for Planning
  - Drive Technical Execution
- Rolling Wave Concept
- Tailoring
  - Based on Acquisition Phase
  - Project Specific Technical Activities
    - Level of Risk Acceptance
  - Programmatic Factors to Consider
    - Resources
    - Complexity
    - Customer & Stakeholders Needs
    - Schedule

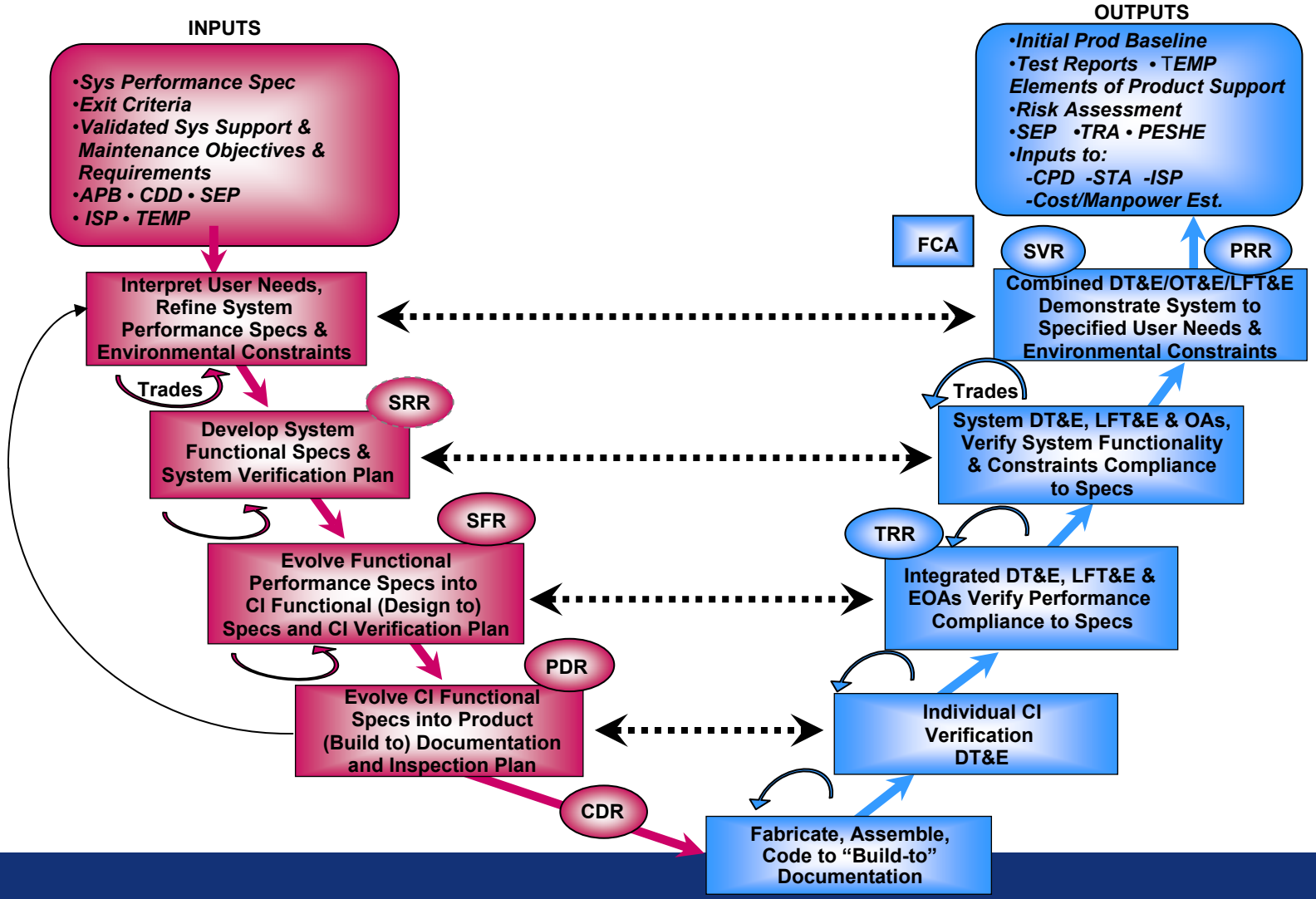
Metric: Level of Effort Assessment

- Based on Acquisition Phase
- Define Project SE status in Key Areas
  - Requirements
  - Functional Analysis & Allocation
  - Design Synthesis
  - Verification & Validation
  - System Analysis & Control
- Quantifies Remaining SE Work on Project
- Traced to OSD & ARDEC Guidance
  - Defense Acquisition Guide
  - Policies, Process, Procedures, Templates
- Validated with Other Factors to Consider
- Used to Develop SE Plans and Budgets

Other Factors to Consider

- Funding
- Customer
- Stakeholders & End User
- In-house Work Versus Outsourced
- ARDEC Priorities and Visibility
- Percent Complete
- Resources and IPT Members
- Technology Complexity & Domain
- Other Factors the Rater Wants SE to Consider

System Development and Demonstration Phase



System Development & Demonstration : Pre-Milestone C

SEL	Project Name	Type of Program (A-F)

		1	2	3	N/A & Rationale
Key Areas	System Engineering Plan	Drafted Updated Plan	Submitted Updated Plan	Approved Updated Plan	
Requirements	Interpret User Needs	Do not have defined requirements	Develop requirements from lifecycle considerations; use prototypes for stakeholder buy-in	Manage system requirements; address and characterize risk associated with requirements; conduct SRR if necessary	
		Requirements not yet decomposed; RM started	Utilized RM Tool	Requirements traced in database/tool	
	Refine System Performance Specs	Fundamental understand performance specs	Documented Performance Specs	Refined Performance Specs	
Functional Analysis & Allocation	Develop System Functional Specs & System Verification Plan	Have not yet developed subsystems	Partition the system into subsystems; define subsystem interfaces and integration	Developed subsystem integration, verification and validation plan/process	
Design Synthesis	Evolve Function Performance Specs into CI Functional Specs & CI Verification Plan	Have not allocated specs or defined CI performance/ functional requirements	Allocate system functional/performance specs; functional/ performance requirements defined for CI	Create test plan for verification of CI for [illegible]nctionality/ [illegible]formance	
	Evolve CI Functional Specs into Product Documentation & Inspection Plan	Have not begun documentation for "building" components	Complete [illegible]rawings/ [illegible]"building" t[illegible]	[illegible]lized detailed [illegible]gn; Completed CDR	
Verification & Validation	Success/Fail Criteria	Su[illegible] no[illegible]	[illegible]uc[illegible]	[illegible]umented/Approved [illegible]cess/fail criteria	
	Fabricate, Assemble, Code to "Built-to" Documentation	H[illegible] sy[illegible] co[illegible] re[illegible]	[illegible]de[illegible]e[illegible]ments; [illegible]ri[illegible]e a[illegible]ion; [illegible]est [illegible]ernative [illegible]gy if needed	Created prototypes/engineering development models	
	Individual CI Verification DT&E	H[illegible] v[illegible]idation p[illegible]	Assess technical progress against critical technical parameters	Demonstrate characteristics of components to be integrated	
	Integrated DT&E, LFT&E, EOAs Verify Performance Compliance to Specs	Have not planned for TRR, verification & validation	Conduct test and evaluation at subsystem level; Plan for TRR	Verified subsystem performance against defined subsystem design requirements; Validated intended subsystem use in environment	
	System DT&E, LFT&E, Oas, Verify System Functionality & Constraints Compliance to Specs	Have not worked to resolve interface/integration issues; do not monitor integration performance risks	Resolve interface and integration issues; monitor and analyze risks for performance of integrated system	Demonstrate integrated system under operational environment constraints	
	Combined DT&E/OT&E/LFT&E Demonstrate System to Specified User Needs & Environmental Constraints	Do not understand interface and interoperability issues; have not defined test environments/ scenarios	Defined developmental and operational test environments/scenarios	Resolve interface/interoperability issues; confirm operational supportability and manufacturing process control; assess technical risk and mitigate	
System Analysis & Control	DM & CM Requirements	Identify DM & CM Requirements	Develop & Maintain DM & CM Requirements	Maintain DM & CM Requirements	
	DM/CM Tool(s) that meet the DM/CM Requirements	Identify DM/CM Tool(s) that meet the DM/CM Requirements	Develop DM/CM Tool(s) that meet the DM/CM Requirements	Maintain DM/CM Tool(s) that meet the DM/CM Requirements	
	Create Risk Plan	Identified Risks (probabilities & consequences/impact)	Documented Risk Plan with Mitigation Strategy & Corrective Action Plan	Tracked Risk Plan with Mitigation Strategy & Corrective Action Plan	

Metric Tool

System Development & Demonstration

Requirements Metrics

Key Areas		1	2	3	N/A & Rationale
Requirements	Interpret User Needs	Do not have defined requirements	Develop requirements from lifecycle considerations; use prototypes for stakeholder buy-in	Manage system requirements; address and characterize risk associated with requirements; conduct SRR if necessary	
		Requirements not yet decomposed; RM started	Utilized RM Tool	Requirements traced in database/tool	
	Refine System Performance Specs	Fundamental understand performance specs	Documented Performance Specs	Refined Performance Specs	

System Development & Demonstration

Requirements Metrics

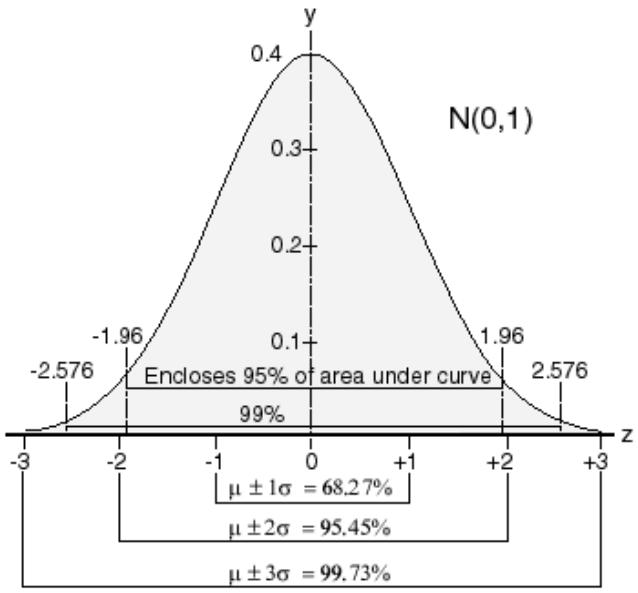
EXAMPLE

Key Areas		1	2	3	N/A & Rationale
Requirements	Interpret User Needs	Do not have defined requirements	Develop requirements from lifecycle considerations; use prototypes for stakeholder buy-in	Manage system requirements; address and characterize risk associated with requirements; conduct SRR if necessary	Documented plan for system availability, supportability, logistics footprint, developmental and operational test environments and scenarios, and disposal in SEP; present prototype to stakeholders Sept 05
		Requirements not yet decomposed; RM started	Utilized RM Tool	Requirements traced in database/tool	System Requirements Linked to user Requirements in DOORS Database
	Refine System Performance Specs	Fundamental understand performance specs	Documented Performance Specs	Refined Performance Specs	KPPs traced in database; translated requirements into performance specs

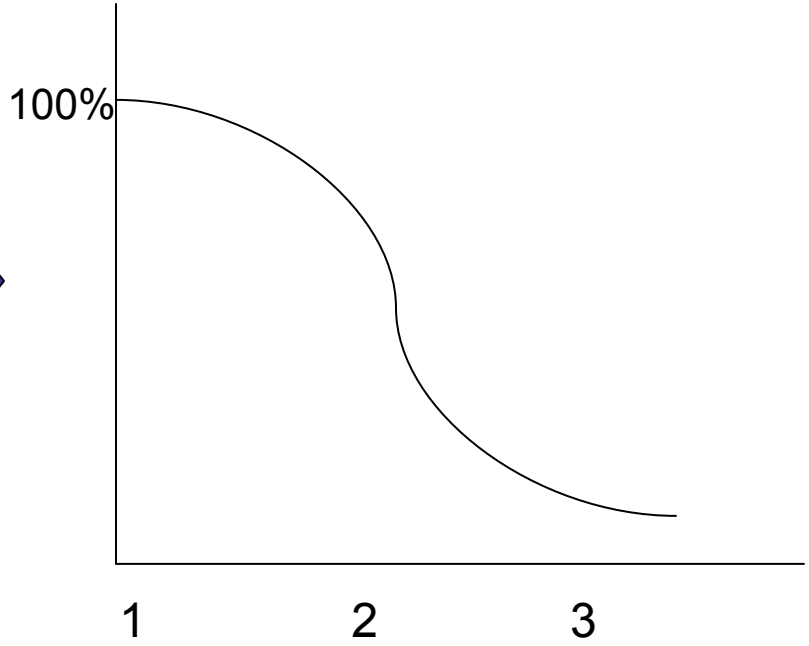
Calculations

- LOE: Translate Value to Percent out of 100

Normalized Gaussian



Remaining Work



Traceability & Budgeting

- Traced to OSD & ARDEC Guidance
  - Defense Acquisition Guide “Vee” Models
  - Policies, Process, Procedures, Templates
  - Linked on the SE Website for Ease

- Used to Develop SE Plans and Budgets

System Development & Demonstration : Pre-Milestone C

Key Areas	Defense AT&L "V" Model	DAG	ARDEC	INPUTS	OUTPUTS
System Engineering Plan	Approved SEP		102 ,115	All SE Activities	SEP
Requirements	Interpret User Needs	4.3.3.3.1	304	System Spec	SRR
	Refine System Performance Specs	4.3.3.3.1	305-308	System ICD	RTM to Functional/Physical Architectures
			309	System OCD	Environmental & Design Constraints
			310	Prelim. Development Spec	MOE/MOP
			802	Prelim CI ICD	
Functional Analysis & Allocation	Develop System Functional Specs & System Verification Plan	4.3.3.3.2	403, 404, 406-409 601	System Constraints	SFR RAS FMEA/FMECA ICD
Design Synthesis	Evolve Function Performance Spe… CI Functional Specs & C…				PDR
	Evolve CI Functional Documentation & Ins…				CDR
Verification & Validation	Fabricate, Assemble… Documentation	4.3.3.3.5	509-510	Specs, TEMP, MOE/MOP, ICD, etc.	IV&V Plan
	Individual CI Verification DT&E	4.3.3.8.1	803-913		Verification Procedures
	Integrated DT&E, LFT&E, EOAs Verify Performance Compliance to Specs	4.3.3.8.2			TRR Facility Request Staffing Request Data Request Equipment Request
	System DT&E, LFT&E, Oas, Verify System Functionality & Constraints Compliance to Specs	4.3.3.8.3			
	Combined DT&E/OT&E/LFT&E Demonstrate System to Specified User Needs & Environmental Constraints	4.3.3.8.4			PRR SVR
System Analysis & Control	DM Tool(s) & Architectures		111, 115	Team with NWA	WBS
	CM Tool(s) & Architectures		202, 205, 206	Milestones, Allotted Time, etc.	Project Schedule with Decision Points
	Track major risks and execute risk strategy		405 507-508	ECP, CR, etc.	CM Plan ICD
			603	Risk Analysis Reports Risk Mgmt Plan	Risk Assessment Report Risk Status Report

Reference Guide

Traceability Example

System Development & Demonstration : Pre-Milestone C					
Key Areas	**Defense AT&L "V" Model**	**DAG**	**ARDEC**	**INPUTS**	**OUTPUTS**
Requirements	Interpret User Needs	**4.3.3.1**	**304**	System Spec	SRR
	Refine System Performance Specs	**4.3.3.2**	**305-308**	System ICD	RTM to Functional/Physical Architectures
			309	System OCD	Environmental & Design Constraints
			310	Prelim. Development Spec	MOE/MOP
			802	Prelim CI ICD	

SE Resources Required

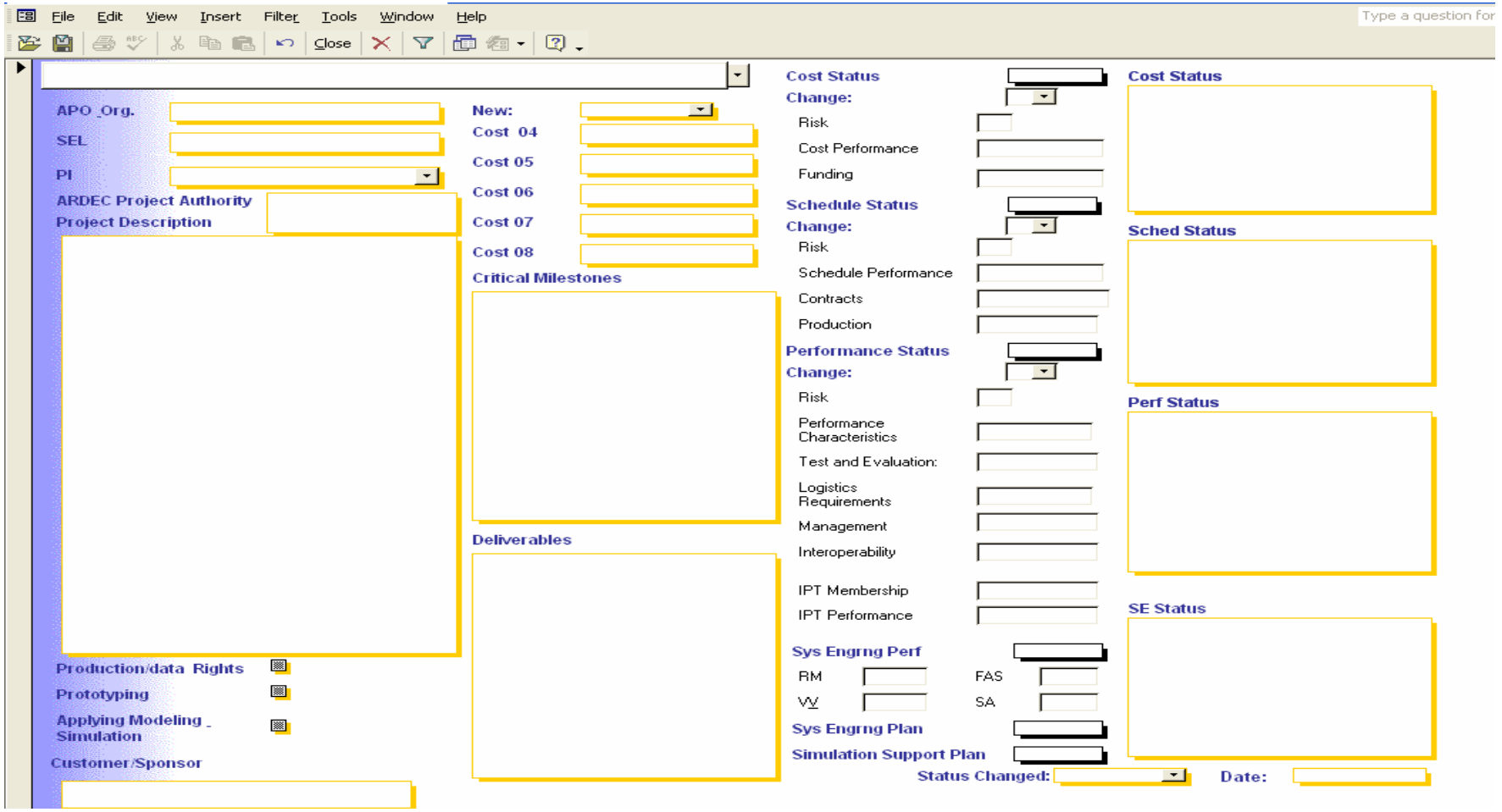
- Project SE WBS
  - Includes LOE Key Areas
  - Metrics to Obtain Actual Data
- Top Down Method
  - Step 1: Use Industry "Rules of Thumb" For Initial Estimate
  - Step 2: Refine Initial Estimates Using the LOE Assessment Tool

FY06 SE Resources ($) = Project FY06 Budget ($) X Rule of Thumb (%) X LOE (%)

Metric Tracking & Reporting

- Tracked Major ARDEC Priority Project Database
  - Status and Performance of LOE Key Areas
  - Note Significant Events and Changes
  - Projects Evaluated Monthly During Reviews
- Reported at Senior Leadership and Other Management Reviews Quarterly

Priority Project Database Snapshot



SE Status & Performance Summary

IPT Membership

IPT Performance

Sys Engrng Perf

RM

FAS

W

SA

Sys Engrng Plan

Simulation Support Plan

SE Status

Status Changed:

Date:

Reporting on Metrics

SE Process STATUS - Project XYZ

Phase/TRL

SEL: Name

SEP Status: (Not Started, Drafted, Submitted, Approved)

(MM/DD/YYYY)

Baseline SE Level of Effort (BLOE): XX%, (MM/DD/YYYY)

Previous SE Level of Effort (PLOE): XX%, (MM/DD/YYYY)

Current SE Level of Effort (CLOE): XX%, (MM/DD/YYYY)

Process Area	Perf.	Rationale
Requirements		
Functional Analysis		
Design Synthesis		
Verification & Validation		
System Analysis & Control		

Benefits

- Consistent Documentation and Tools for Evaluation
- Quantified and Comparable Results
- Collect Historical Data for Parametric Modeling
- Provides Senior Leadership Visibility to Technical Issues for ARDEC Projects
- Enforced Implementation Through Reporting
- Training the Workforce on SE
- Tailored to Provide Just Enough SE; Avoid “Process Paralysis” (too much SE)
- Allows Project Manager to Focus on Important Issues

BOTTOM LINE: Implementing Systems Engineering on Projects Brings Better Products to the Warfighter!

Next Steps

- Transition LOE from Pilot to Full Scale Implementation
- Estimate SE Resource for FY06 WBS
- Track Status and Performance at Major ARDEC Project Reviews and Management Reviews
- Gather and Incorporate Voice of the Customer Feedback
- Refine and Improve LOE Procedure and Training

Questions/Comments

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