Achieving a Systems Engineering Culture in a Science and Technology Laboratory Environment

Robert Rapson, James Malas, Robert Enghauser, Gerald Hasen, and William Kesling Materials and Manufacturing Directorate Air Force Research Laboratory Wright-Patterson Air Force Base, OH 45433

Carol Ventresca, Thomas Archer, Bryan DeHoff and Robert McCarty SynGenics Corporation Delaware, OH 43015

> THE AIR FORCE RESEARCH LABORATORY LEAD I DISCOVER I DEVELOP I DELIVER

> > 88ABW-2009-4045 WPAFB PA CLEARED 090918



Achieving Systems Engineering Culture in a Science and Technology Laboratory Environment



Presentation to NDIA Systems Engineering Conf 26-29 Oct 09

Background

- 2008 NDIA Systems Engineering Conf
 - An Air Force S&T Directorate's View on Applying Systems Engineering (SE) Principles to its Programs
 - Introduced an ongoing effort to instantiate the practice and thinking of SE in an early R&D organization,
 - Process that is Streamlined, tailorable and flexible to apply the depth needed to the specific problem



This Year's Focus: Culture and Community



- Share thoughts on Culture
 - The last thing to truly change in a transformation is the Culture
 - Our Team has a foundation in the streamlined process
 - Task at Hand is to get Systems Engineering into routine use by lab Scientists and Engineers (S&E's)
- Challenge: Many Laboratory people view Systems Engineering as Acquisition oriented and stifling to creativity





What is the Culture of a Laboratory?



Materials & Manufacturing Directorate

Lab Demographics

PERSONNEL 76% Civilian/Military Scientist & Engineers (S&E) 38% Government **Materials Engineers Chemists/Chemical Engineers** MS 87 % Civilian **Research Physicists** BS **Aero Engineers** 31% Safety/Environmental Engineers 13% Military PhD **Civil/Industrial Engineers Biologists/Microbiologists** 31% **Contractors (S&E, Technician, Ops Support) Mechanical Engineers** Contractor to Govt 1.2:1 **Electrical Engineers 19% Contractors have PhDs**

Typically, 70% are Task Oriented Personalities - 70% of those task oriented personalities are Drivers



DEGREES & SPECIALTY AREAS

Changing Culture of the Lab

- Changing from "Performance" objectives to "Capabilities" Focused objectives
- Continue to Restructure the Organization
- Emphasizing Integrated Programs with other organizations
- Increased competition for resources

Moving toward a prioritization of the entire portfolio

Range of R&D at the Lab

- Basic Research to Advanced Technology Development (ATD) and Manufacturing Technology (6.1 – 6.3 type of Funding)
- AFRL Designated Core Processes (CP)
 - CP-1 Generate Understanding of S&T Opportunities
 - CP-2 Deliver Needed Technology Options
 - CP-3 Innovate Solutions to Urgent Needs
- Focused Long Term Challenges

Educated, Adaptable, Very Busy

The Lab Scientists and Engineers deal with everything from Basic Research to fielded warfighter technology solutions



What then is our Culture? "Laboratories are Different"



- Great People
 - Heritage of government service, asking "What does the Air Force need?"
 - Strong history of emphasis on scientific advances and creativity
 - In-Depth relationships have been built across organizations based on technical expertise
 - Tend to be independent and self-guided
- Dealing with Dramatic Changes
 - Performance Based to Capability Based
 - Many Organizational and Technical Variables
 - Higher HQ policies and instructions impinge on scientists' view of mission
- Recently faced with Constrained Resources

How do we respond to this culture?





Timeliness of Culture Issue



How can SE Help in Such a Culture?

- <u>DoD</u> SE emphasis came out of Acquisition concerns
- Lab folks feel applying SE to S&T seems like a stretch
- <u>We</u> Believe:
 - Streamlined process fits our culture
 - Focused, Succinct, Tailored, Affordable, Owned by the SME
 - Applies across the Program Life Cycle, but EMPHASIS on the Program Planning phase (Greatest Benefit)
 - Hands-on, early experience "sells" the value of the process / methodology
 - Learning occurs during the process, the process is an opportunity for discovery
 - This is a creative activity



Current Streamlined Systems Engineering Process



Based on S&T IPPD Process (Version 3, 2002)

Approach to Affecting the Culture



Based on the Streamlined SE process

- View S&E Program Managers as "internal" customers
 - Tailor approach for each specific project
- Emphasize initial, manual, self-directed approach

(Computer can be a distraction)

- Hands on, with facilitated guidance
- First hand experience
- Familiarity and ownership of process



Tools to Implement the Approach



Air Force Research Laboratory Materials and Manufacturing Technology Directorate Guide for Applying a Streamlined Systems Engineering (SE) Approach To Program Planning

Spiral 2 of the AFRL/RX SE Initiative

VERSION 1.0 24 August 2009



Air Force Research Laboratory Materials and Manufacturing Technology Directorate

Self-Sufficiency Workbook for Applying a Streamlined Systems Engineering (SE) Approach to Program Planning

Spiral 2 of the AFRL/RX SE Initiative

Version 1.0

24 August 2009

Tools to Implement the Approach

- Guidebook Users manual for the Streamlined Process (description of "What Is It?")
- Workbook Means of capturing the preliminary data and decisions, (*the "How to Do It"*)
 - Can be used by informal team <u>or</u> individual Portfolio / Program / Project Manager
 - First Evaluation can provide basis for Approval Decision to proceed with Team based process – or provide sufficient information to the PM (Go/No Go)
 - Subsequent Streamlined Process work with full team results in detailed project definition / with Action Plans and Proposals

Guidebook Page 11

Applying AFRL/RX Streamlined SE Core Process

Figure 3 illustrates the RX Streamlined SE Core Process and indicates that it is a relatively simple process that generates five products.

Step 1	Step 2	Step 3	Step 4	Step 5
Form Team	Determine Requirements	Generate Alternatives	Evaluate Alternatives	→ Deliver S&T Plan
Do: • Define Problem • Identify all stakeholders • Establish Team	Define requirements Define tech challenges Define S&T Exit Criteria (KPP sets) Validate with customer	Understand applicable state-of-the-art & near term technologies Brainstorm different solution approaches	Compare alternatives across req'ts / S&T exit criteria Solicit customer approval for proposed solution	Finalize AF Problem / Goal / Solution Objectives Prepare for intended action course
Document: Problem Definition Team Directory (include roles & responsibilities) Team Charter (optional)	 Prioritized Requirement Set Performance Affordability Producibility Reliability Supportability S&T Exit Criteria 	 Alternative Definitions 	 Tech Readiness Assessment Manufacturing Readiness Assessment Risk Analysis Value Analysis Cost Estimate Schedule / Key Milestones 	 AF Problem / Goal / Solution Objectives statement Program Roadmap Action Plan

Figure 3. AFRL/RX Streamlined SE Core Process

Product 1 - Problem Definition and Team Directory

Product 2 - Prioritized Requirements and S&T Exit Criteria

Product 3 - Alternative Solutions

Product 4 - Evaluation of Alternatives

Product 5 - S&T Plan

Materials & Manufacturing Directorat

Guidebook Discussion Step 1 – Form Team

Step 1 Description

The Program Manager schedules a Team Orientation Meeting to review team member roles, ensuring that they are understood and obtaining commitments from Customer Representatives and Key Team Members. The SE Facilitator presents the SE Core Process and a Project Overview by conducting a review of all elements of Homework #0 with the team.

Homework #1 begins with the SE Facilitator providing a written overview of the Streamlined SE Core Process and the project or program as documented in Homework #0 to all Team Members for their review.

Next, all Team Members prepare worksheets for the Air Force Problem, Requirements and S&T Exit Criteria and then provide them to the SE Facilitator. These worksheets are available in the RX SE Self-Sufficiency Workbook.

The SE Facilitator compiles the Requirements defined by team members, and forwards them to the Program Manager.

Finally, the Program Manager obtains initial customer inputs on the Requirements developed by the team.

Step 1 Products

Product 1 under Step 1 of the Streamlined SE Process is a Problem Definition and Team Directory.

Homework 1 is the initial Requirements and S&T Exit Criteria worksheets (Form 1.1)

Materials & Manufacturing Directorate

Workbook, Two Approaches

- Individual or Informal Initial Review
- Full IPT Plan



Self-Sufficiency Workbook for Applying a Streamlined Systems Engineering (SE) Approach to Program Planning

Spiral 2 of the AFRL/RX SE Initiative

Version 1.0

24 August 2009

Workbook Pg 4, Initial Review



- (PM) Exploration and Info Gathering
 - White Papers
 - Presentations
 - Initial Discussions with SE Facilitator
 - Strawman Description of AF Problem
 - Use Form 0.1 'AF Problem, Requirements, S&T Exit Criteria'

Expanded discussion of this element of the RX SE Core Process is available in the RX SE Core Process Guide

Workbook PM Initial Review



Workbook Pg 13





• (PM) Kickoff/Team Orientation Meeting

Assumes Project Approved to Use SE Streamlined Core Process

- Ensure Team Member Roles are Understood
- (SE Facilitator) Presents Core Process and Project Overview
- (PM) Gains Commitment from Customer Rep & Key Team Members

Expanded discussion of this element of the RX SE Core Process is available in the RX SE Core Process Guide

13

Workbook pg 15

Step 1: Form Team

Form 1.1 'AF Problem, Requirements, S&T Exit Criteria'

> IPT Member Name:_____ Member Role: __Team Members_____

Worksheet for Problem, Requirements, S&T Exit Criteria

Provide a "Problem Statement" that captures major issues and scopes problem space. What is the Air Force problem to be solved? Just 1 or 2 sentences.

15

Summary and Conclusions

- Instantiation of SE in S&T Culture is continuing
 - 2008 Streamlined Process and Early Applications
 - Today Hands on approach to reach our culture, and enhance the disciplined creativity of discovery
- Invitation to the Community (SE and NDIA)
 - Very little literature on the application of SE to this S&T culture
 - DoD emphasizing Communities of Interest
 - We have a "Systems Engineering in S&T" Technology Area in DoDTechipedia
 - https://www.dodtechipedia.mil/dodwiki/x/UINkAQ
 - Please visit and continue the conversation

DoD Techipedia Screen

	Systems Engineer	ering in S&T - Techipedia - Microsoft Internet Explorer provided by USAF		- F 🗙 🛛				
b b bt yew farce in the definition of the defin	Google 🗶 https://www.dodtechipedia.mil/dodwiki/pages/viewpage.action?pageId=23364432							
	Eile Edit View Favorites Iools Help							
Decision of access of acccess of access of access of access of access of access of acce	🖕 🏘 😢 🖷 Project Workspace: We 🗶 Systems Engineering 🗴							
Constraint Constraint<	Home > DoDTechipedia > Technology Areas > Systems Engineering in \$&T							
 Current Information Contraction 		Welcome Bryan DeHof	<u>History</u> <u>Preferences</u> <u>Log Ou</u>	<u>it 🔁 🖶</u>				
Sarch	TELHipedia	UNCLASSIFIED ONLY DoDTechipedia is open to DoD, Federal agencies and contractors for broad collaboration. Do not post: DoD Only, company proprietary, acquisition sensitive, Privacy Act, or other information not appropriate for this audience. DoD does not warrant the a information posted. Opinions expressed are not official. See <u>Guidelines</u> .	ccuracy or effectiveness of	* 🖄				
 Control Control Contecontrol Control Control Control Control Control Control Cont	Search	Systems Engineering in S&T						
Added by Bother Rappan. last edited by Bother Rappan. Use 32.009 • Long • Long <tr< td=""><td>Go</td><td>Article Edit this page Attachments (0) History</td><td>ete 📑 Add Page 🛛 🦻 Add Disc</td><td>ussion</td></tr<>	Go	Article Edit this page Attachments (0) History	ete 📑 Add Page 🛛 🦻 Add Disc	ussion				
• Korregularies • Korregularie	Navigation	Added by <u>Robert Rapson</u> , last edited by <u>Robert Rapson</u> on Jul 29, 2009 TinyLink (useful for email): https://www.dodtechipedia.mil/dodwiki/x/UINkAQ						
 Interview Interview		Labels EDIT LABELS (None)						
General Information • Security and Privacy Notice • Help • EAQ • Tutorial • Guidelines • Sandbox • Eeedback • Release Notes	Home Recently Updated Acronyms Ierminology Technology Areas Interest Areas Organizations Countries How to Do Business Related Resources Blogs Inside DoDTechipedia My Favorites Random Article	Systems Engineering Tailored to be Effective in the Culture of a Laboratory The Obepartment of Defense (DOD), and the Air Force (AF), is emphasizing the value of systems engineering (SE) at all levels of defense development programs. The Air Force Research Laboratory (AFRL) has di applied to programs in science and technology (S&T) as well. The challenge is that, in the laboratory culture, some people view SE as acquisition-focused and counter to the creativity inherent in many aspects of envisioned is to place the SE principles in a format and context compatible with the culture of laboratory people in order to gain their acceptance. That culture is one of highly educated and very busy people who new "requirement" (which is how they will look at SE) and will desire some ownership before they will embrace it. The approach is to provide a streamlined process and the education/training to tailor it for use in each laboratory. Add Discussion	rected that SE principles must I f research. The solution which is need to understand the value of the unique situations encountered	De B any ⊟ bdin				
	Seneral Information Security and Privacy Notice Help FAQ Intorial Suidelines Sandbox Feedback Release Notes People Finder							
	<							
Done	Done	v v t	rusted sites 🔍 10	0% • .::				

Materials & Manufacturing Directorate





Presentation to NDIA Systems Engineering Conf 26-29 Oct 09

Achieving Systems Engineering Culture in a Science and Technology Laboratory Environment