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

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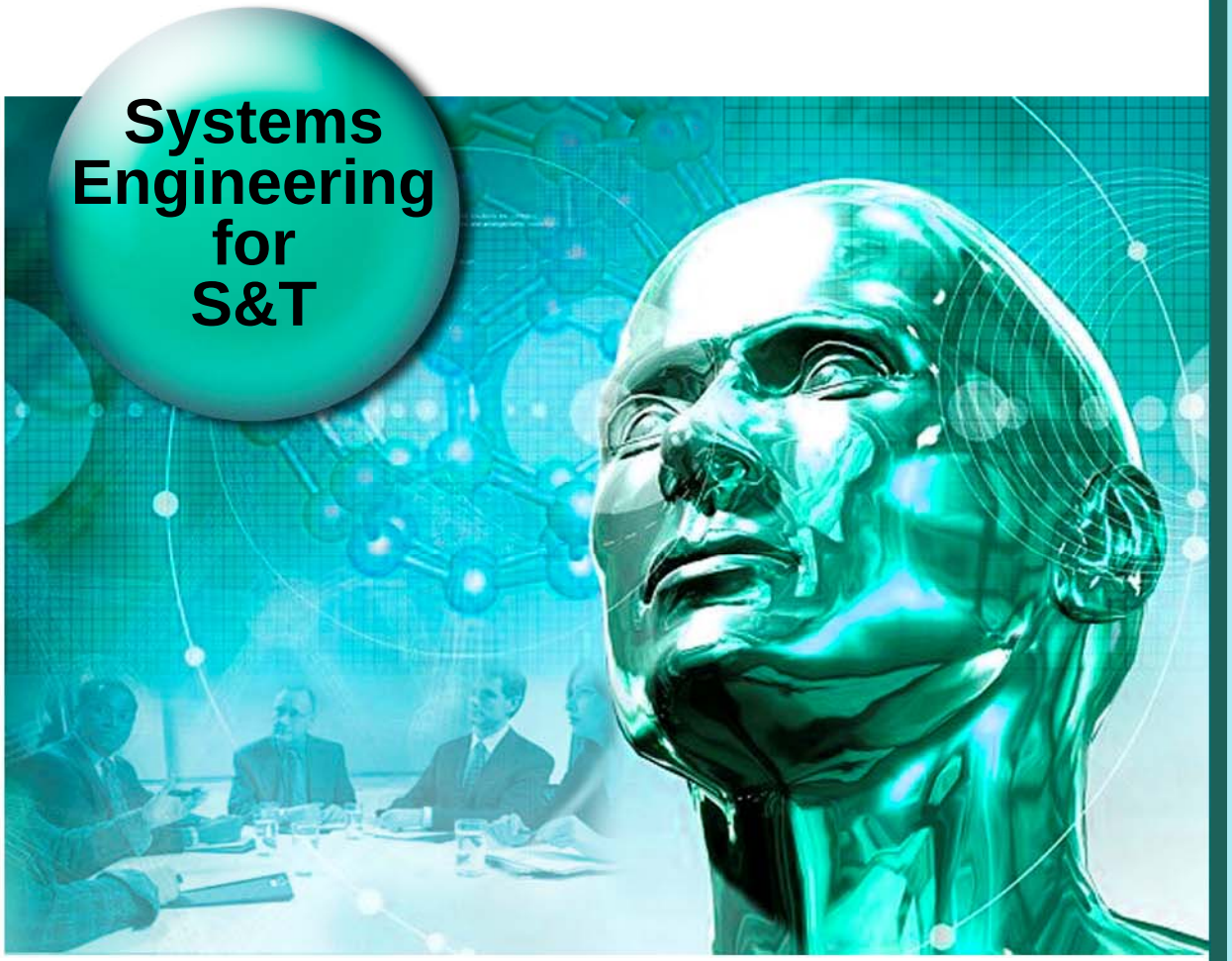

Achieving Systems Engineering Culture in a Science and Technology Laboratory Environment

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

Presentation to

NDIA Systems Engineering Conf

26-29 Oct 09

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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?

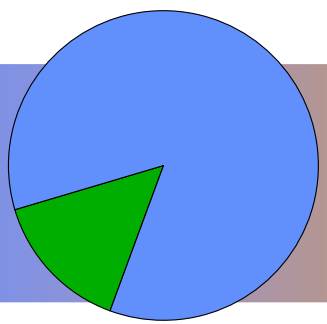
Lab Demographics

PERSONNEL

Government

87 % Civilian

13% Military



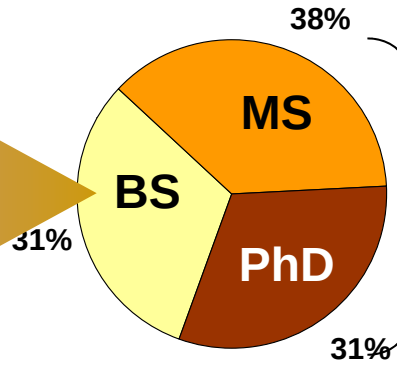
Contractors (S&E, Technician, Ops Support)

Contractor to Govt 1.2 : 1

19% Contractors have PhDs

DEGREES & SPECIALTY AREAS

76% Civilian/Military Scientist & Engineers (S&E)



- Materials Engineers
- Chemists/Chemical Engineers
- Research Physicists
- Aero Engineers
- Safety/Environmental Engineers
- Civil/Industrial Engineers
- Biologists/Microbiologists
- Mechanical Engineers
- Electrical Engineers

Typically, 70% are Task Oriented Personalities

- 70% of those task oriented personalities are Drivers

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**

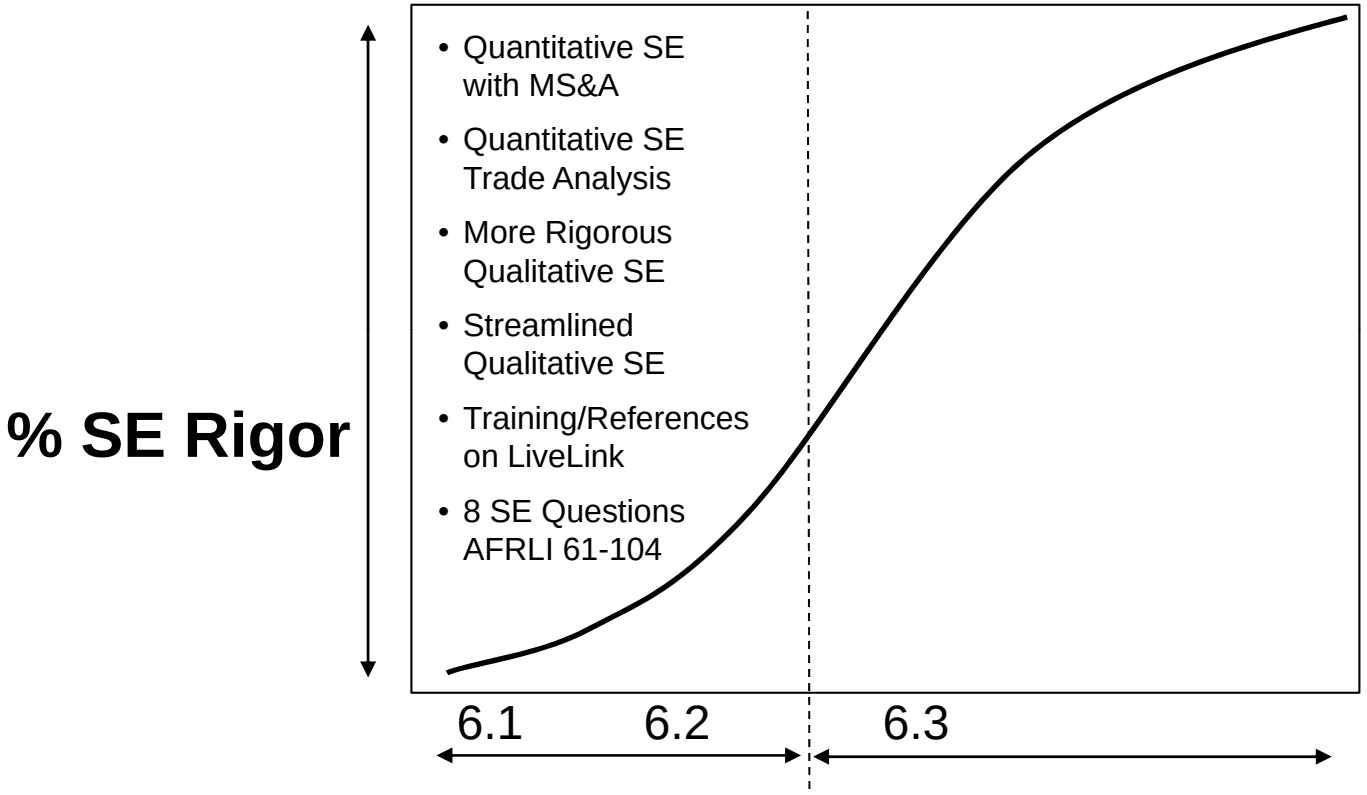
The Lab Scientists and Engineers deal with everything from Basic Research to fielded warfighter technology solutions

Educated, Adaptable, Very Busy

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?

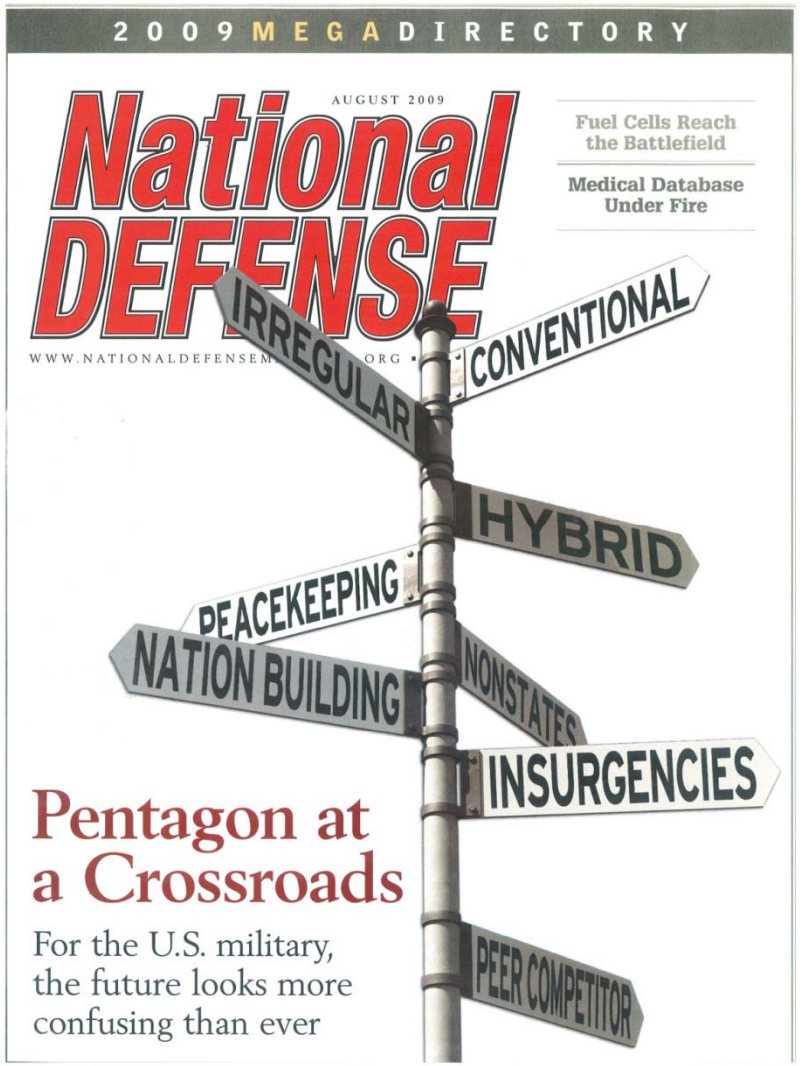


"The Conversation"

Some without tools

Some without tools or tools tailored to need

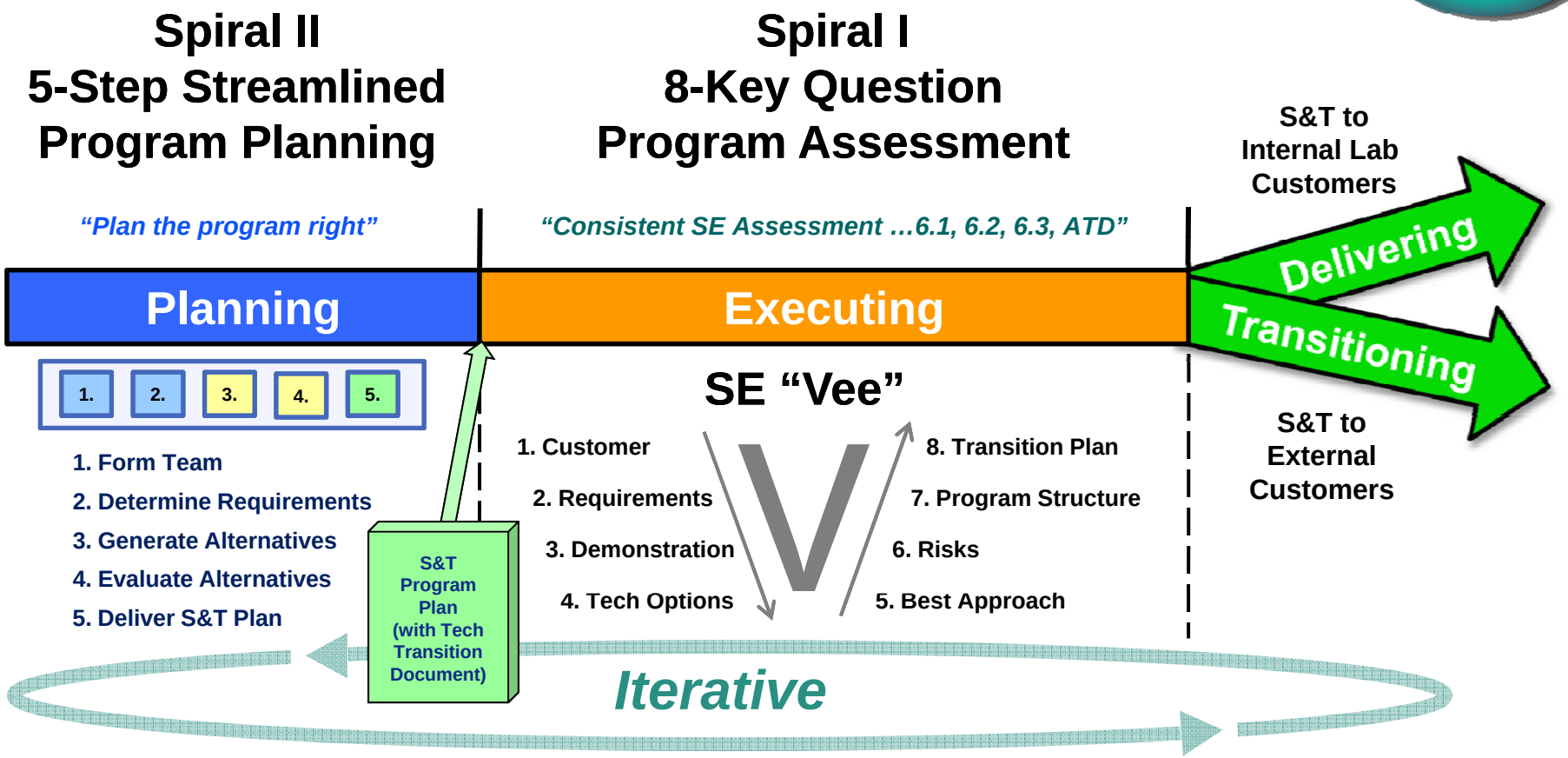
Timeliness of Culture Issue



How can SE Help in Such a Culture?

- DoD SE emphasis came out of Acquisition concerns
- Lab folks feel applying SE to S&T seems like a stretch
- We 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

Our Current Approach



Spiral III – Sharing – Community of Practice

Current Streamlined Systems Engineering Process

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

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

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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 or 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**

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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.

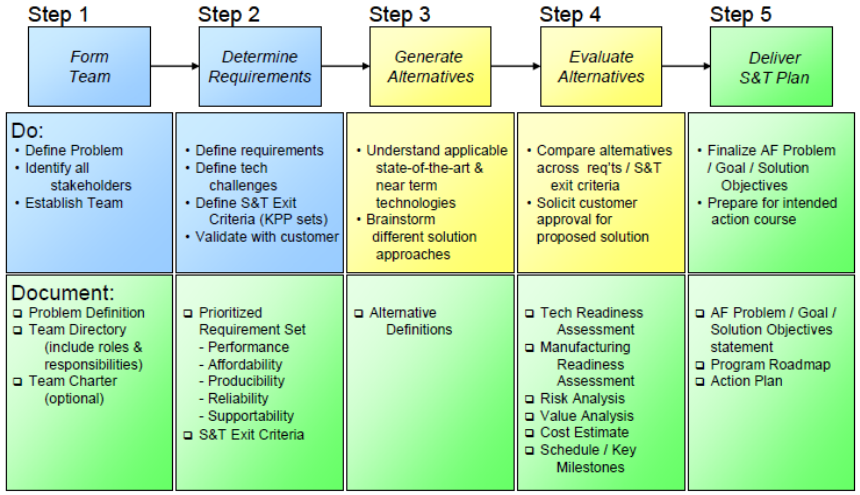

Figure 3. AFRL/RX Streamlined SE Core Process

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

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Guidebook Discussion
Step 1 – Form Team

Step 1 Description	Step 1 Products
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.	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)
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.	

Workbook, Two Approaches

- Individual or Informal Initial Review
- Full IPT Plan

Workbook Pg 4, Initial Review

Project Exploration Decision

- **(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

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Workbook PM Initial Review

Project Exploration Decision

Form 0.1 *'AF Problem, Requirements, S&T Exit Criteria'*

Program Manager: _____

Worksheet for AF 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.

_____

_____

_____

_____

_____

_____

5

Workbook Pg 13

* Step 1: Form Team

- (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

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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.

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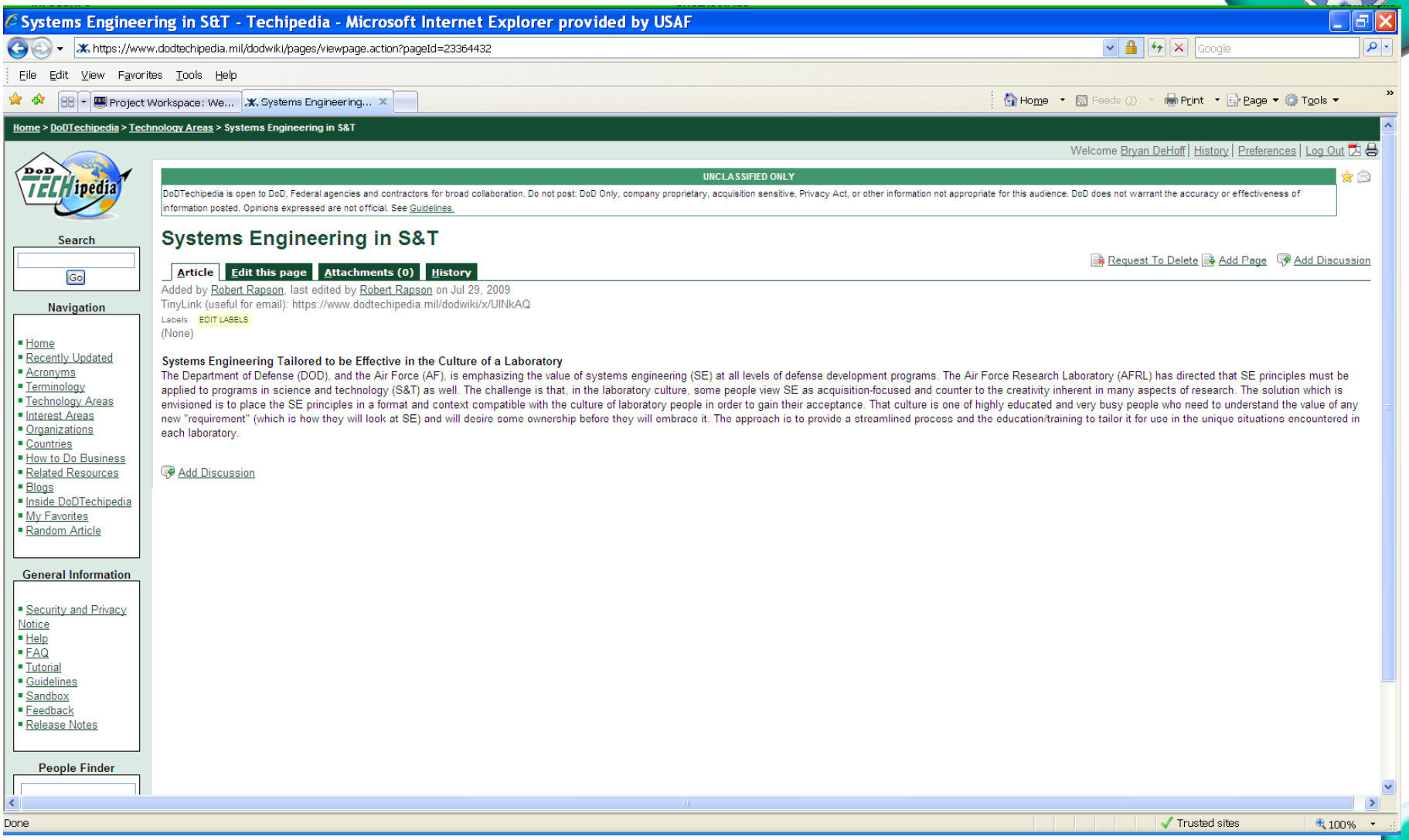
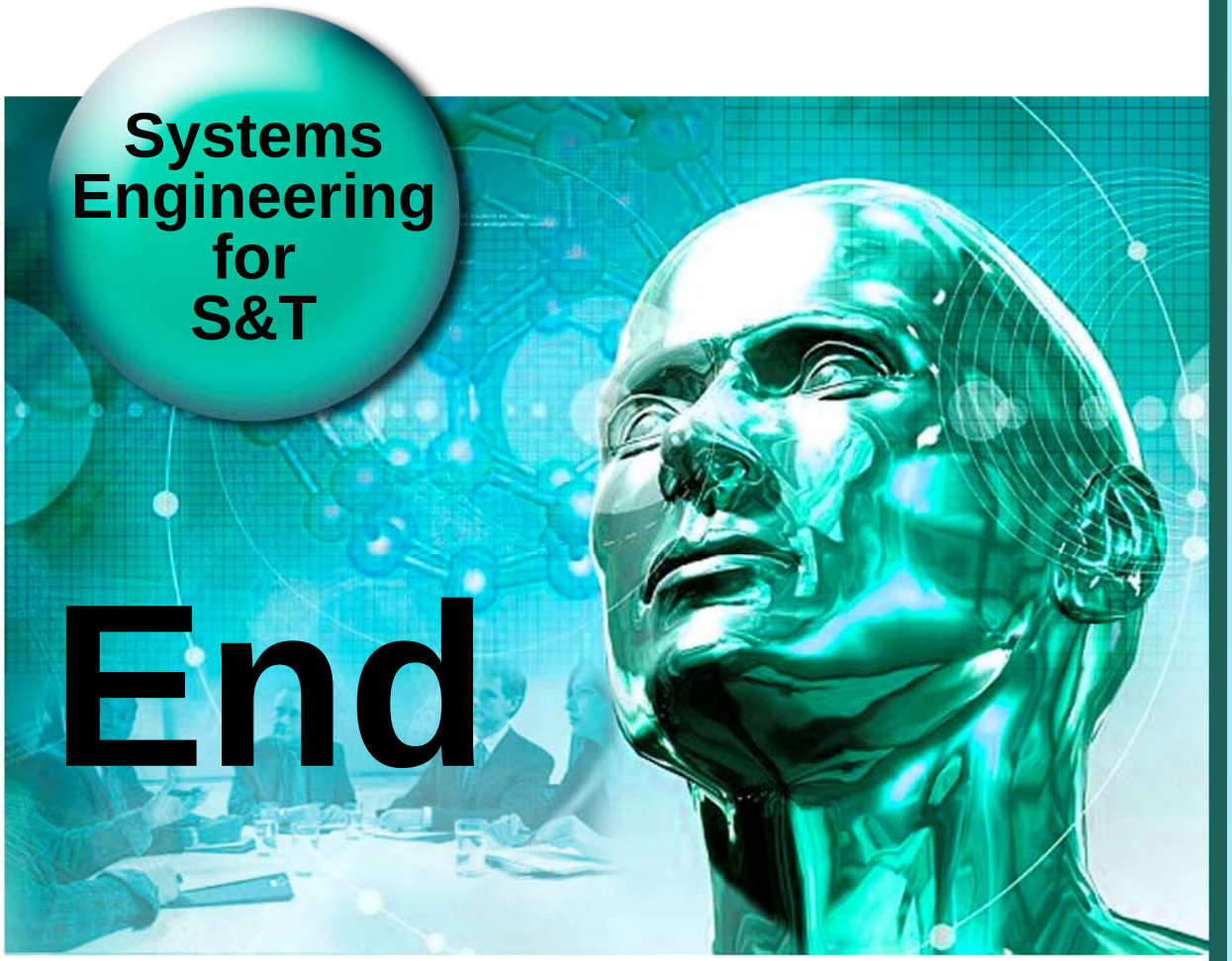
Summary and Conclusions

- **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





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