Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula

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Overview

- Background

- Project Overview

- Work to Date

- Way Forward

Background

- M&S Acquisition/T&E Mission - Enable the Department of the Navy to effectively use M&S within and across the Acquisition Enterprise
  - Need a unified approach for enabling the workforce to determine WHICH tools to use, WHEN to use them, and HOW to use them across development lifecycle
  - Need education and options to improve workforce capabilities to select and use M&S tools effectively and efficiently. These include
    - Initial education and training, refresher training, continuing education, and certification opportunities once in a career path
- <u>Ultimate Goal:</u> M&S savvy DoD acquisition workforce
  - Able to apply M&S tools appropriately to enhance warfighting capability, reducing lifecycle development time and costs.
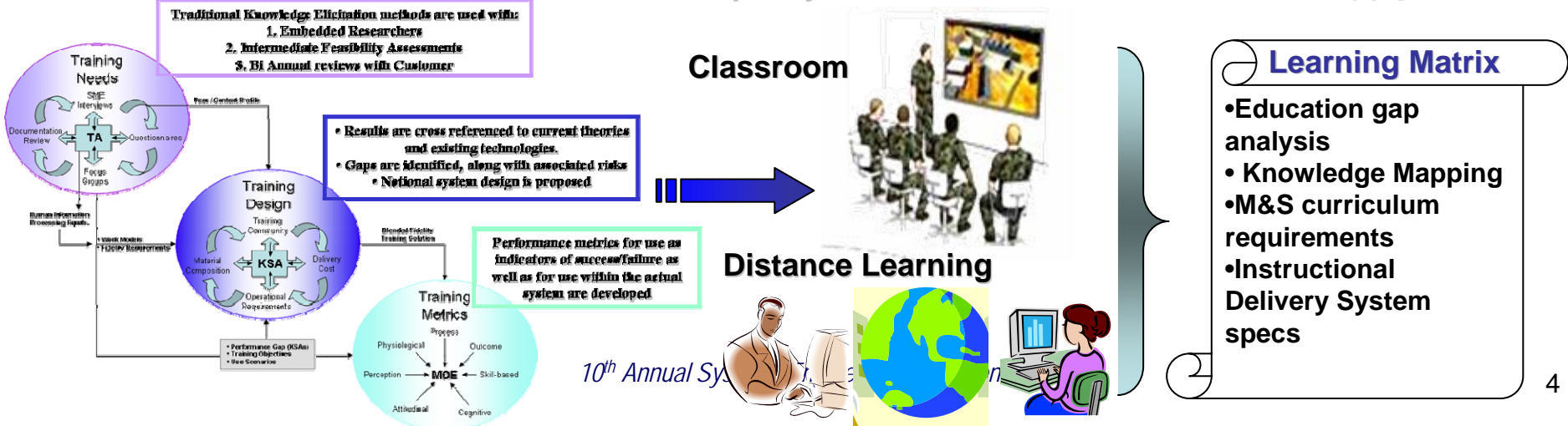
Spiral One: Requirements

- <u>Emphasis</u>:
  - Developing and refining the needs assessment and performance metrics
    - Identify partner requirements (Joint Curriculum Definition)
  - Content requirements
  - Individual KSA assessment and knowledge mapping tool
  - Instructional Vehicle Delivery specifications
  - Guidelines linking training content to knowledge gaps
- <u>Methods will include:</u>
  - State of the art assessment- Cross Service
  - Task Analysis: Content requirements/System capabilities
- <u>Deliverable:</u> Learning Matrix
  - Integrates: Individual educational background, learning style, and workforce role, and desired education end state

Curriculum Needs Assessment

Traditional Knowledge Elicitation methods are used with:
1. Embedded Researchers
2. Intermediate Feasibility Assessments
3. Bi Annual reviews with Customer

• Results are cross referenced to current theories and existing technologies.
• Gaps are identified, along with associated risks
• Notional system design is proposed

Performance metrics for use as indicators of success/failure as well as for use within the actual system are developed

Specify Instructional Vehicle

Classroom

Distance Learning

Tools

Learning Matrix

- Education gap analysis
- Knowledge Mapping
- M&S curriculum requirements
- Instructional Delivery System specs

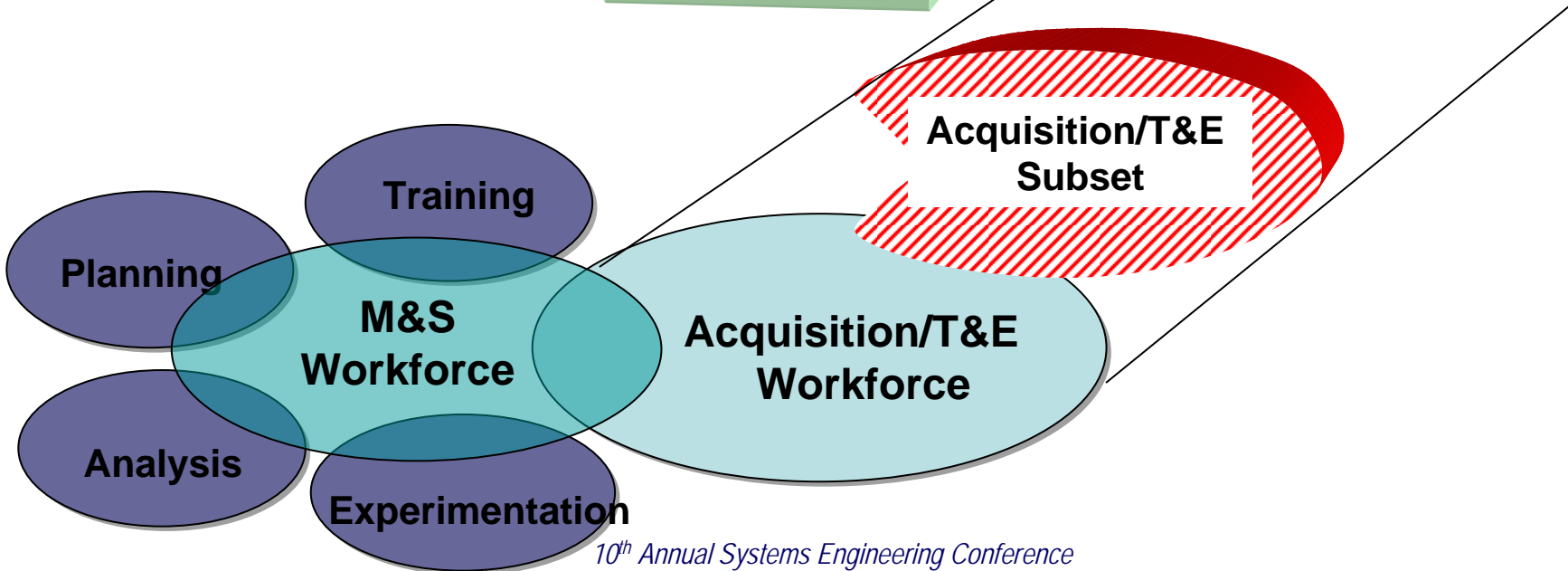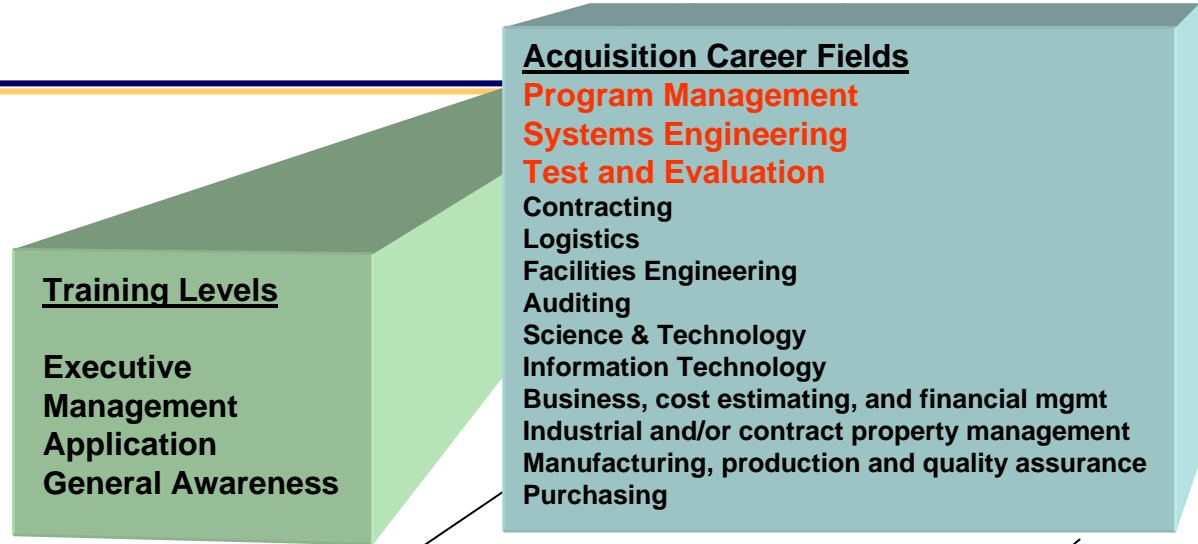*10th Annual Sy...*

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Stakeholder Group

- Consists of members from throughout DoD
  - DASN RDT&E
  - AFAMS
  - HQDA
  - CVN
  - SPAWAR
  - COMOPTEVFOR
  - Future Combat System
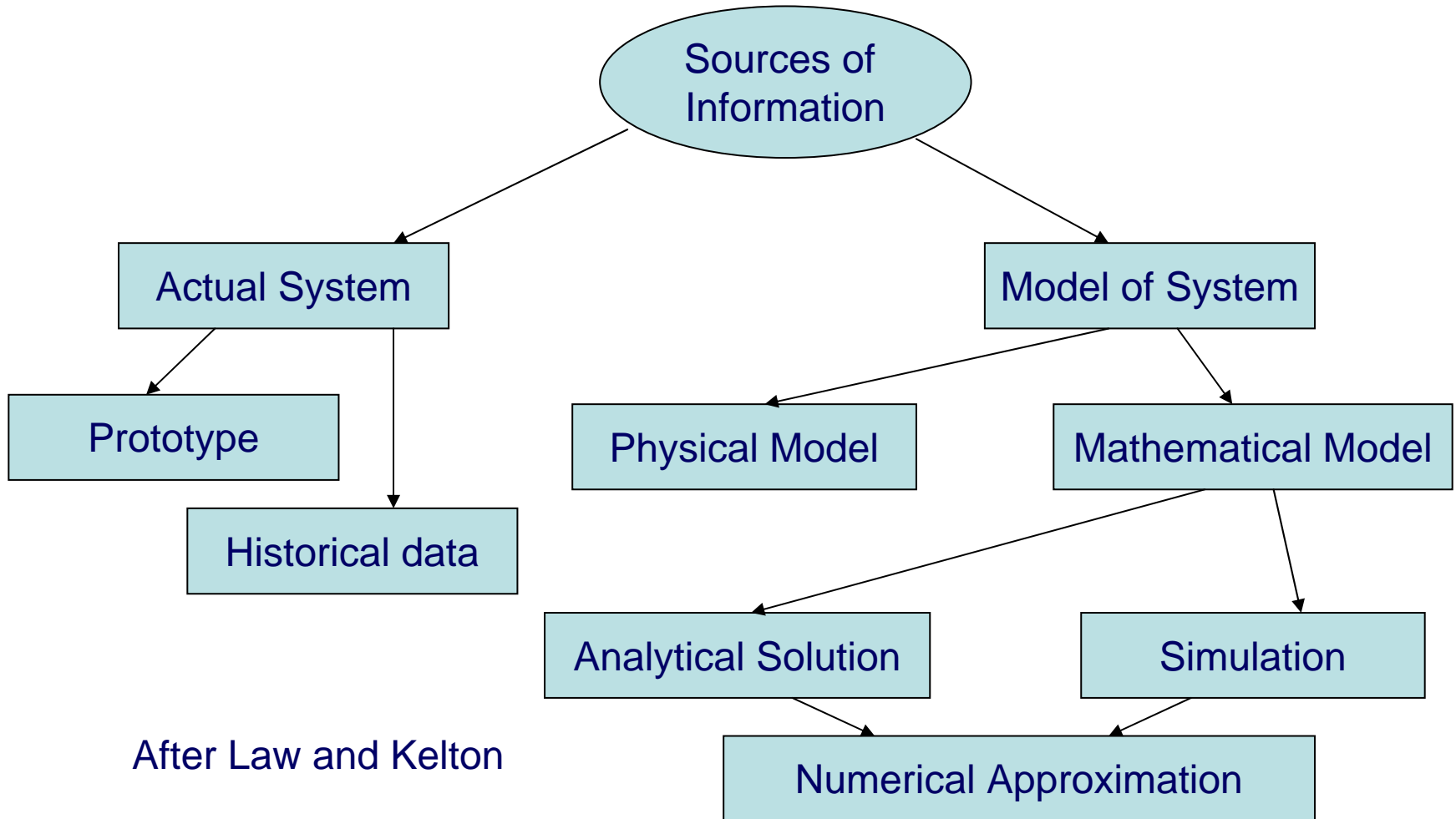- Embodies broad educational discipline representation

Market Segmentation

Educating the Acquisition and T&E Workforce in the More Effective Use of M&S:

Market Schema

Acquisition Career Fields
Program Management
Systems Engineering
Test and Evaluation
Contracting
Logistics
Facilities Engineering
Auditing
Science & Technology
Information Technology
Business, cost estimating, and financial mgmt
Industrial and/or contract property management
Manufacturing, production and quality assurance
Purchasing

Training Levels

Executive
Management
Application
General Awareness

Acquisition/T&E Subset

Training

Planning

M&S Workforce

Acquisition/T&E Workforce

Analysis

Experimentation

Information Trade Space

Sources of Information

Actual System → Prototype

Actual System → Historical data

Model of System → Physical Model

Model of System → Mathematical Model

Mathematical Model → Analytical Solution

Mathematical Model → Simulation

Analytical Solution → Numerical Approximation

Simulation → Numerical Approximation

After Law and Kelton

Identified Gaps

As a result of the Gap Analysis we conducted, four gaps were found in the area of workforce development:

- Lack of clearly articulated competency statements.

- Lack of a widely accepted disciplinary specification or body of knowledge.

- Lack of structured implementation of training and education vehicles.

- Lack of a widely applied process for certifying professionals based on a community-accepted disciplinary specification.

High Level ESR Development

- Process:
  - Initial list of ESR's developed by stakeholders and NPS inter-disciplinary team.
  - Stakeholders involved in iterative process to expand and refine ESR's.
- Results:
  - 17 Process ESR's –Focused on the process of choosing when to use which models and simulations.
  - 9 Acquisition ESR's –Focused on applying M&S in the acquisition lifecycle.
  - 5 Test and Evaluation ESR's –Focused on the role and use of M&S in test and evaluation.
  - 5 Operational ESR's –Focused on the use of operational and logistic M&S to support Acquisition/T&E activities.
  - 14 Engineering ESR's –Focused on the use of engineering models to support Acquisition/T&E activities.
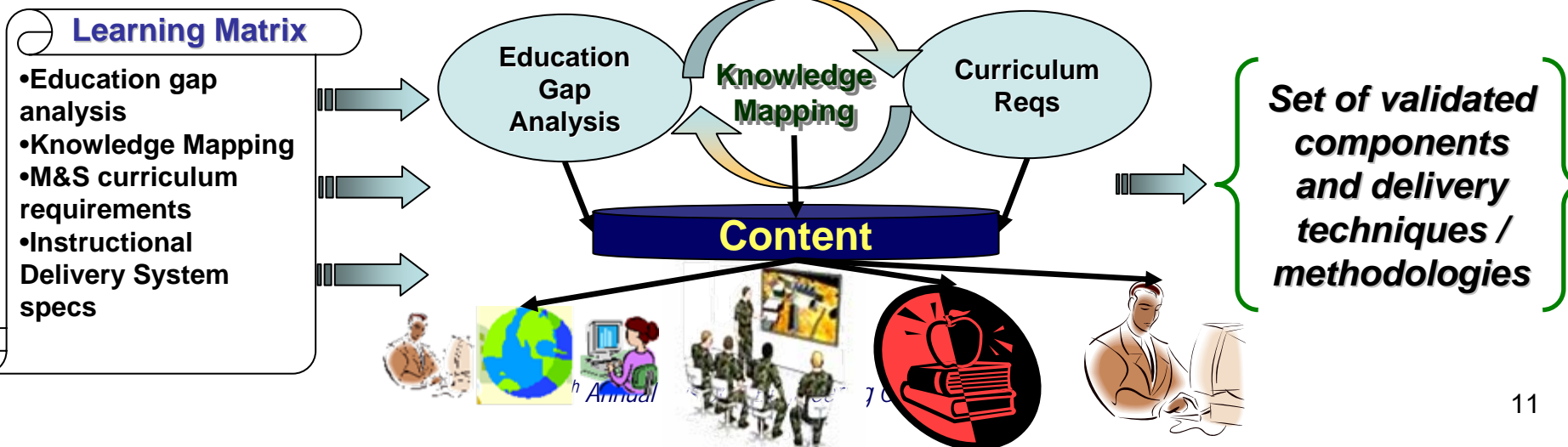
Sample ESRs of all Disciplines

P1) Understand the critical decisions in the acquisition lifecycle, the analysis plans to support them, and the information required.

A2) Understand the concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle, in order to reduce the time, resources, and risks associated with the acquisition process.

T2) Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent testing decision.

O4) Understand abstractions and lower levels of realism in operational and logistics models.

E2) Fluid Dynamics and Weapon System - Understand the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.

Spiral Two: Component Development

- <u>Emphasis:</u> Use the Learning Matrix to create necessary components for delivering training
  - Content
  - Instructional delivery technologies
  - Enable reuse and scalability
- <u>Methods will include:</u>
  - Blending SE with ISD
  - Design, Develop, Implement and Test components
- <u>Deliverables</u>:
  - Validated system components
    - Content
    - Delivery methods
  - Learning Architecture Framework to support integration

Learning Matrix

- Education gap analysis
- Knowledge Mapping
- M&S curriculum requirements
- Instructional Delivery System specs

Education Gap Analysis

Knowledge Mapping

Curriculum Reqs

Content

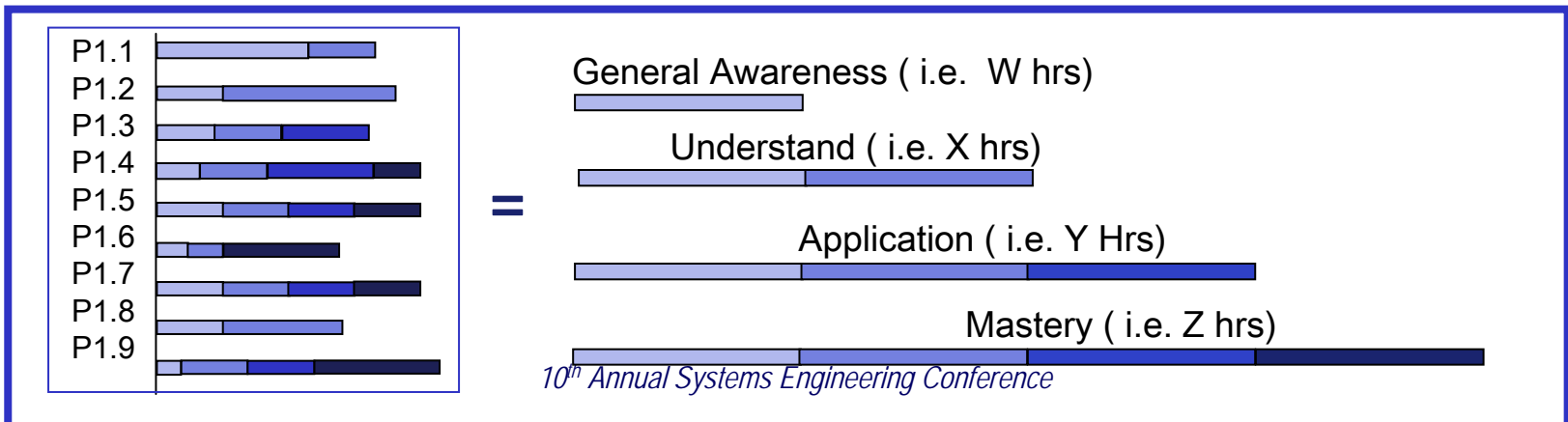*Set of validated components and delivery techniques / methodologies*

Academic Partners

- Air Force Institute of Technology
- Defense Acquisition University
- George Mason University
- Johns Hopkins University/ Applied Physics Lab

- Old Dominion University
- Stevens Institute
- Texas A&M
- University of California, San Diego
- University of Central Florida

Course/Module Concept

- Goal – Develop Course/Module "Syllabi"
  - Syllabi outline desired content of educational elements that will satisfy the needs identified in the Learning Matrix.
  - Syllabi combined into a consolidated and cohesive Learning Architecture.
- Each module developed to highest level of competency required for the subject matter (not always mastery)
- Modules constructed so that slices of the content can be extracted for lower required competency levels
- Courses built to target audience
  - Desired length of courses and competency levels required determine subset of modules combined into course structure
  - Human Capital Strategy survey feedback will help guide requirements.

P1.1
P1.2
P1.3
P1.4
P1.5
P1.6
P1.7
P1.8
P1.9

=

General Awareness (i.e. W hrs)

Understand (i.e. X hrs)

Application (i.e. Y Hrs)

Mastery (i.e. Z hrs)

Workforce Mapping

- Mapping of ESRs to workforce needs (Learning Matrix)

- Performed by Academic Partners, including GMU, JHU/APL, ODU, UAH, UCF, and UCSD

- Three pieces provided to complete mapping:
  - Workforce segmentation definitions
    - Career Fields - Project Managers, Systems Engineers, and T&E workforce
    - Career Levels - Basic/entry, intermediate/journeyman, and advanced/senior career levels
    - Follows DoD 5000.52M descriptions
  - Competence Levels
    - Four competence levels defined and mapped to Bloom's taxonomy – General Awareness, Understand, Application, and Mastery
  - Detailed ESR's – High level ESR's decomposed into "mappable" level of granularity

Program Management

- **Positions Held:**
  - All of functions of a PMO or PEO
  - Program integrators and analysts, program managers, PEOs, and deputies
  - Support and management positions throughout the workforce
- **Responsibilities:**
  - Balance the factors that influence cost, schedule, and performance
  - Interpret and tailor application of the DoD 5000 Series regulations
  - Ensure that high-quality, affordable, supportable, and effective defense systems are delivered to the warfighter as quickly as possible

PM Career Levels

- Basic/Entry
  - Member working in PM support role
  - Example jobs include R&D coordinator, test officer staff officer, integrator, analyst, etc.
- Intermediate/Journeyman
  - Managers of PEO/PMO office functions
  - Deputy PM or PM for small programs, PEO staff roles
- Advanced/Senior
  - ACAT 1 or 2 PM, PEO

Competence Levels

| Competence Level	Bloom's Taxonomy	Definition	Examples and Keywords
General Awareness	Knowledge	Recall or recognize data or information.	**Examples:** Recite a policy. Quote prices from memory to a customer. Knows the safety rules. **Keywords:** defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states.
Understand	Comprehension	Understand the meaning, translation, interpolation, and interpretation of instructions and problems. State a problem in one's own words.	**Examples:** Rewrites the principles of test writing. Explain in one's own words the steps for performing a complex task. Translates an equation into a computer spreadsheet. **Keywords:** comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives Examples, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates.
Application	Application	Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place. Put theory into practice, use knowledge in response to real circumstances	**Examples:** Use a manual to calculate an employee's vacation time. Apply laws of statistics to evaluate the reliability of a written test. **Keywords:** applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses.

Competence Levels

| Competence Level	Bloom's Taxonomy	Definition	Examples and Keywords
Mastery	Analysis	Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences.	**Examples:** Troubleshoot a piece of equipment by using logical deduction. Recognize logical fallacies in reasoning. Gathers information from a department and selects the required tasks for training. **Keywords:** analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates.
	Synthesis	Builds/develops new structures, systems, models, approaches, or patterns from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure.	**Examples:** Write a company operations or process manual. Design a machine to perform a specific task. Integrates training from several sources to solve a problem. Revises and process to improve the outcome. **Keywords:** categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes.
	Evaluation	Make judgments about the value of ideas or materials. Assess effectiveness of whole concepts in relation to values, outputs, efficacy, viability; critical thinking, strategic comparison and review.	**Examples:** Select the most effective solution. Hire the most qualified candidate. Explain and justify a new budget. **Keywords:** appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports.
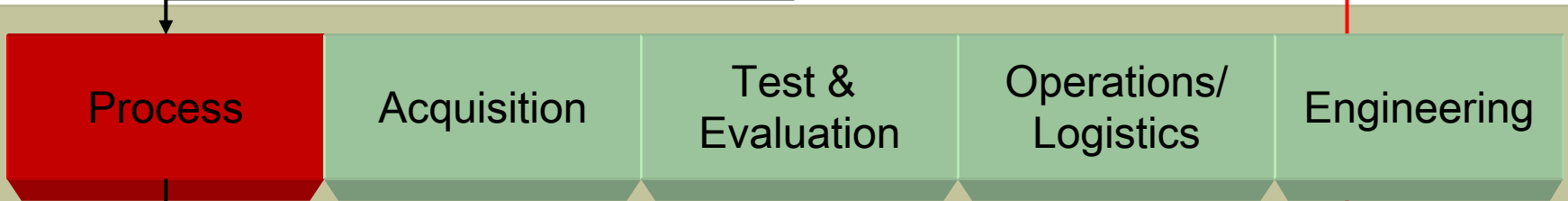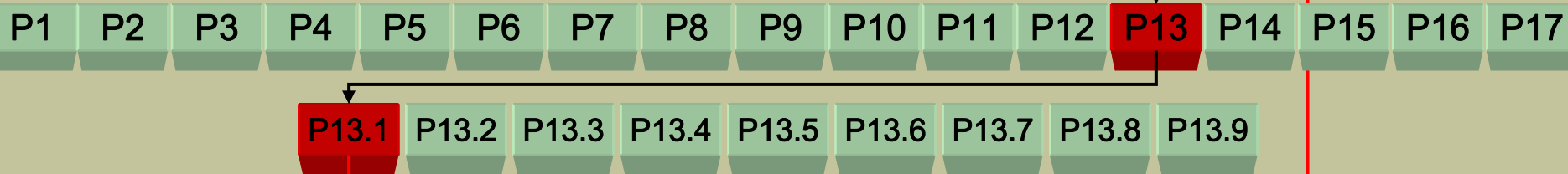
Workforce Mapping Example
Learning Matrix for one ESR (of 50)

	P13: Understand the trades between using a general model and a custom model, including the VV&A implications.								
	P13.1	P13.2	P13.3	P13.4	P13.5	P13.6	P13.7	P13.8	P13.9
PM									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Application	Mastery	Mastery
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
SE									
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	Application					
Advanced	Understand	Application	Application	Application					
T&E									
Basic	Understand	Understand	Understand	Understand					
Intermediate	Understand	Application	Application	Application					
Advanced	Understand	Application	Application	Application					

P13.1 Define general model and custom model
P13.2 State advantages of general model
P13.3 State disadvantages of general model
P13.4 State advantages of custom model
P13.5 State disadvantages of custom model
P13.6 State VVA requirements of general model
P13.7 State VVA requirements of custom model
P13.8 Describe situations where each type of model is more appropriate
P13.9 Given historical examples of each, describe and analyze which is more appropriate

Way Forward

- **Spiral Three – Course Development**
  - Capitalize on Academic Partner Experience & Assets
  - Continue to integrate Stakeholder feedback
  - Ensure flexibility in course design through modular concept (plug and play)

- **Spiral Four – Education Program Deployment**
  - Test Courses with student/sponsor feedback
  - Implementation of Continuous Assessment Tool
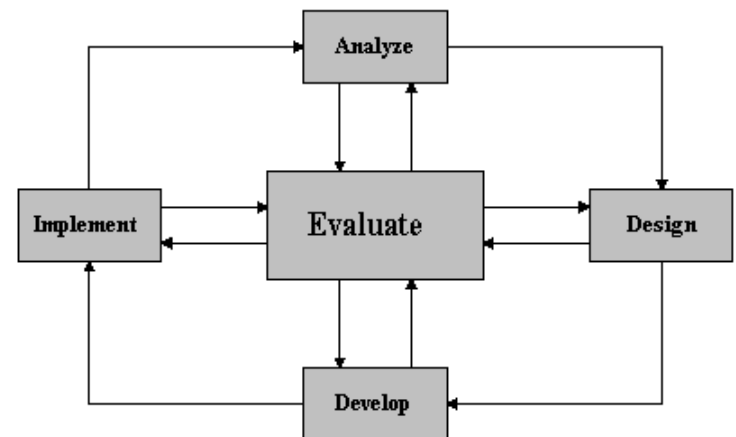
Questions?

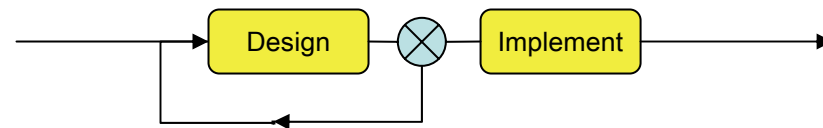# Backup Slides

Curriculum Design

- **Many choices exist**
  - Ad Hoc Approach

  - Linear Process

  - Feedback Loop Driven

    Design — Implement

  - Systems Engineering Approach

  - Instructional System Design
    - ADDIE phases

Analyze

Implement Evaluate Design

Develop
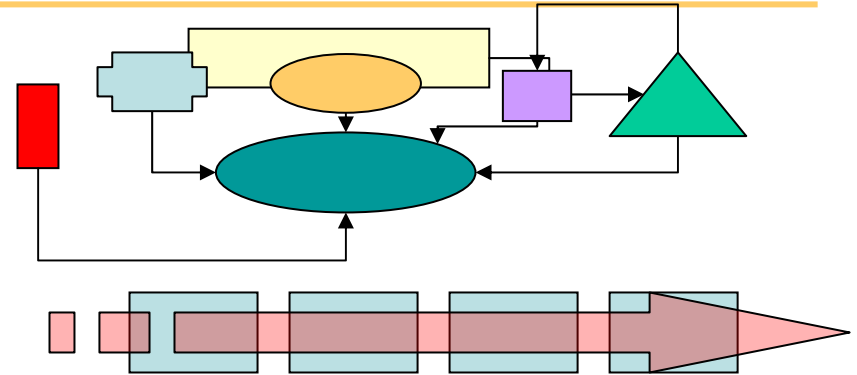
Systems Engineering

- Familiar SE Models
  - Vee
  - Waterfall
  - Spiral
- Five common items to all
  - Top-down view of entire system
  - Life-cycle approach
  - Ensure requirements are right
  - Iterate using feedback loop
  - Use interdisciplinary approach
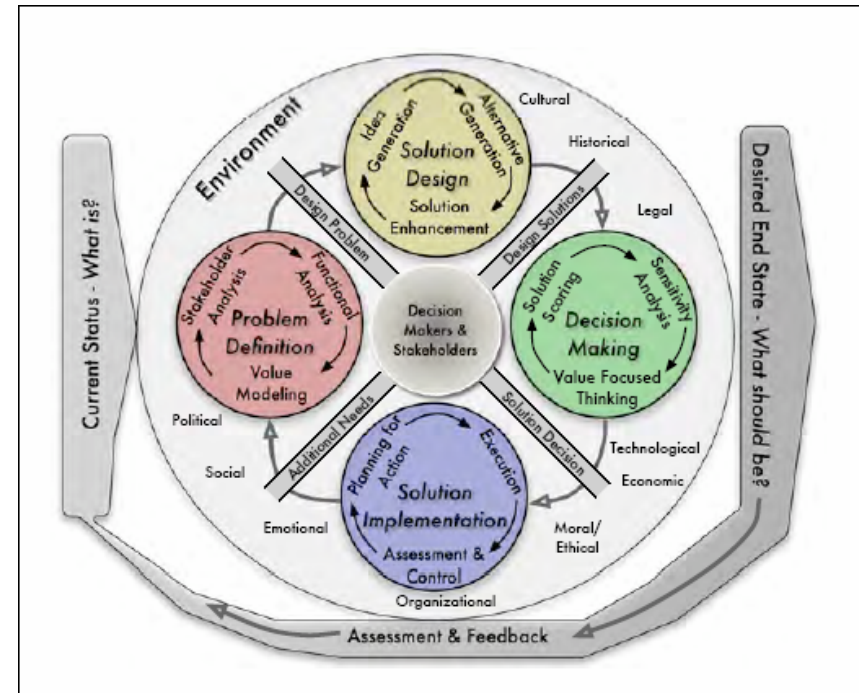
US Military Academy Approach

Project Overview

4 Spirals (Phases) make up the Project

1. Learning Matrix
   - Desired instructional content based on ESRs for Acquisition workforce
   - Integrates educational background, learning style, workforce role, and desired education end state
   - M&S Workforce Education Gap Analysis

2. Learning Architecture/Instructional Framework
   - Degree/certificate programs and continuous learning modules
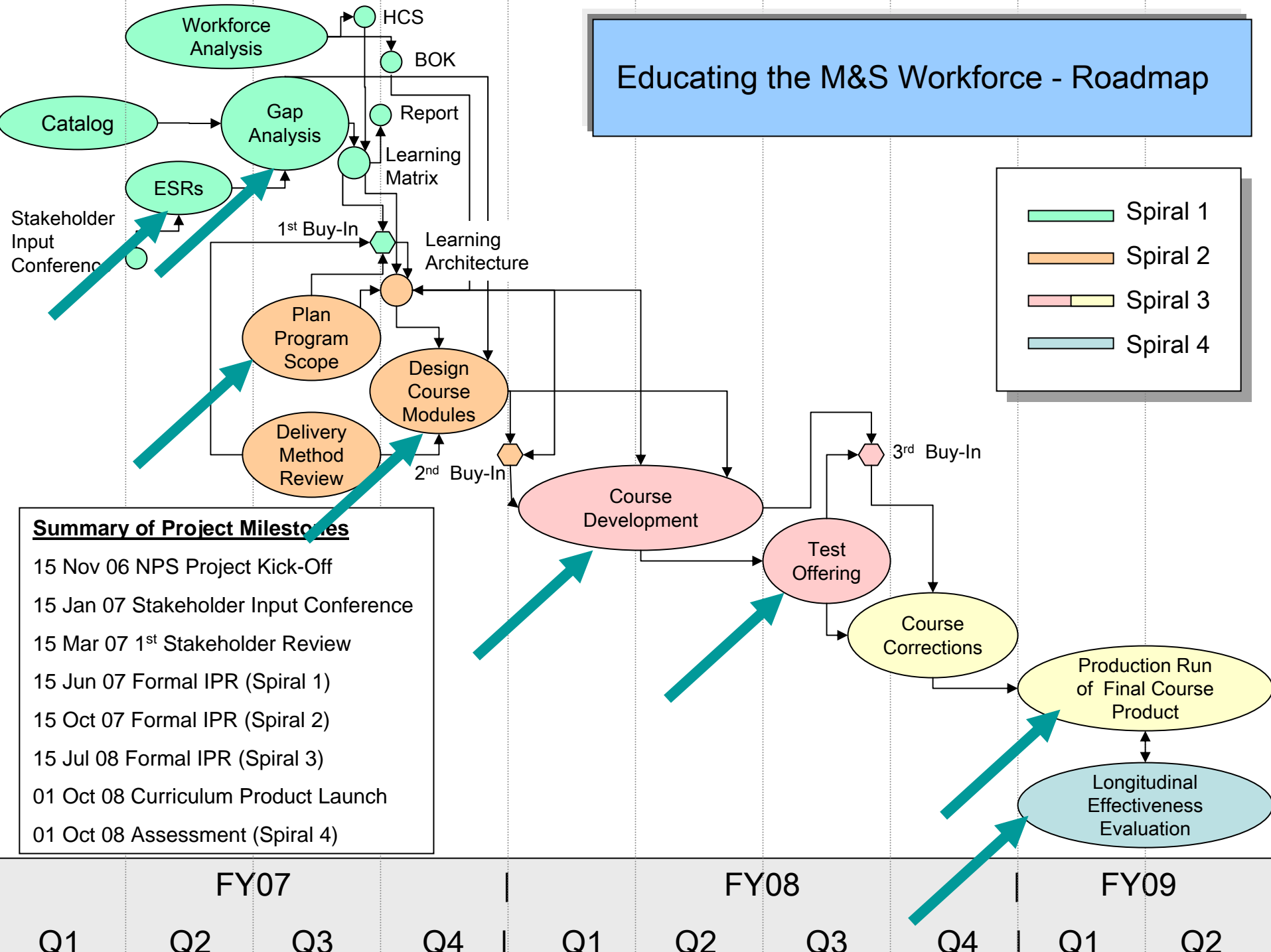   - Content modules (course syllabi)

3. Prototype Curriculum
   - Develop curriculum from content architecture
   - Deliver with endorsement/accreditation to DAU, NPS and services

4. Assessment
   - Longitudinal Curriculum Effectiveness Evaluation

Educating the M&S Workforce - Roadmap

Workforce Analysis

HCS

BOK

Gap Analysis

Catalog

Report

Learning Matrix

ESRs

Stakeholder Input Conference

1st Buy-In

Learning Architecture

Plan Program Scope

Design Course Modules

Delivery Method Review

2nd Buy-In

Course Development

3rd Buy-In

Test Offering

Course Corrections

Production Run of Final Course Product

Longitudinal Effectiveness Evaluation

Legend:
- Spiral 1
- Spiral 2
- Spiral 3
- Spiral 4

Summary of Project Milestones

15 Nov 06 NPS Project Kick-Off

15 Jan 07 Stakeholder Input Conference

15 Mar 07 1st Stakeholder Review

15 Jun 07 Formal IPR (Spiral 1)

15 Oct 07 Formal IPR (Spiral 2)

15 Jul 08 Formal IPR (Spiral 3)

01 Oct 08 Curriculum Product Launch

01 Oct 08 Assessment (Spiral 4)

FY07	FY08	FY09
Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2

Tying it all Together

Stakeholder Group

Army
Navy
Air Force
Marines
Acquisition
Training
Planning
Testing
Analysis
Experimentation

Workforce Survey

Review of Consolidated BOK

Learning Matrix/ Instructional Content

M&S Human Capitol Strategy

M&S Body of Knowledge

Learning Architecture/ Instructional Framework

Prototype Educational Elements for Acquisition

Application of Educational Elements to Other Communities and Services

10th Annual Systems Engineering Conference

Spiral Three: System Integration and Delivery

- <u>Emphasis:</u> Spiral three will create prototype curriculum
  - Modeled after other DAU courses like the Acquisition courses which have on line and schoolhouse components based on user's career needs
- <u>Methods:</u> The curriculum will
  - Provide tailorable learning modules
  - Support various accreditation approaches
  - Leverage distance learning and schoolhouse instructional paradigms.
- <u>Deliverable:</u> Instruction provided through existing DoD channels identified in conjunction with DAU

Spiral 3 will produce validated, reusable course content that can be accessed by individuals at various stages of career development

Education Gap Analysis — Knowledge Mapping — Curriculum Reqs

Content
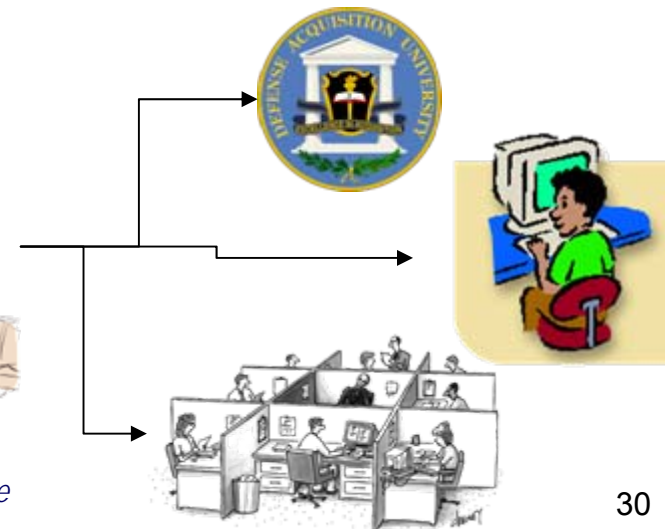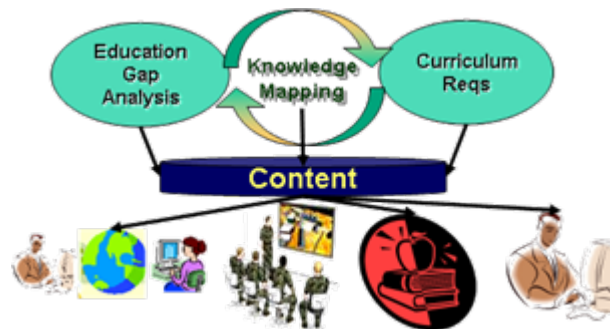
Spiral Four: Longitudinal Curriculum Effectiveness Evaluation

- <u>Emphasis:</u> Spiral four will provide assessment and validation of the long term impact of the curriculum

- <u>Methods:</u> Base evaluation on Kirkpatrick's 'four levels'

- <u>Deliverable:</u>
    - Measurement of the degree to which this approach enhances performance
    - Suggestions for enhancements and modifications

Using ISD, evaluation cuts across all Spirals, but in different ways

Kirkpatrick's 4
- **Reactions**
- **Learning**
- **Behavior**
- **Results**

Integrated Feasibility Assessment 1
- SME Review

Integrated Feasibility Assessment 2-3
- SME Review
- Iterative Usability

Results (impact on bottom line):
- **Increased productivity**
- **Improved quality**
- **Reduced costs**

Behavior:
- **Are KSAs being used in the work environment?**

Learning:
- **Were desired KSAs advanced and internalized?**
- **Use Pre/Post paradigm**

Reactions:
- **How did students like the program?**
- **Did it address perceived needs?**
- **How would they change it?**