Requirements-Driven and Partnership-Based Systems Engineering & Training Education

Jerrell Stracener
Stephen Szygenda
James Rodenkirch

October 24, 2007
Agenda

- Systems Engineering Education
  - SMU (Systems Engineering Program) Overview
  - Program Development
- Systems Engineering Aerospace & Defense Initiative
- Systems Engineering Training
- Summary
Definitions

• Education
  – “can be thought of as the process of acquiring knowledge and information, usually in a formal manner… [including] learning how to think”
  – “typically measured by testing comprehension and knowledge retention”

• Training
  – “the process of gaining proficiency in some skill or skill set”
  – “usually measured by the learner’s ability to demonstrate the learned skill by producing desired outcomes”

Definitions from the American Society of Quality, Certified Quality Manager Handbook
Agenda

• Systems Engineering Education
  - SMU (Systems Engineering Program) Overview
  - Program Development
• Systems Engineering Aerospace & Defense Initiative
• Systems Engineering Training
• Summary
Objective (of this section)

To present the highlights of a non-traditional university systems engineering program that was initiated and has been developed
—in response to aerospace & defense needs
—with extensive industry and government participation
—with DoD OSD / DAU / Military Services review & guidance
Systems Engineering Program (SEP) Overview
Mission

- Provide education relevant to the engineering of systems
- Foster and conduct research in selected areas of systems engineering
- Maintain a Systems Engineering Program in partnership with industry, government and associations that is responsive to current and emerging needs and requirements
Driven by Industry and Government needs

- Systems Engineering
  - Education
  - Research

- Engineers, Designers, Analysts
  - Systems Thinking Skills
  - Problem definition, solving, and presentation skills

- Systems Engineers
  - Entry level skills
  - Skills update
  - Career growth

- Team Leaders
  - Skills update
  - Systems Thinking Skills
  - Systems Engineering Skills

To help you become a better engineer and manager
Current Academic Program

Non-Degree Studies in SE

Certificate Series in SE

MS SE

PhD Applied Science (SE Major)
Academic Programs

• On-Campus and Distance Programs
  • MS SE
  • Fast Track Second Masters
  • Certificate Series in SE
  • Non-Degree Studies (for credit) in SE
  • PhD in Applied Science (Major in Systems Engineering)
• On-Site and Virtual On-Site Programs
  • MS SE
  • Fast Track Second Masters Program
MS SE Program Options

• “Live” on-campus and Distance Students via DVD
  – Very flexible structure
• On-Site and Virtual On-Site
  – Offered “live” only
  – Very little flexibility
MS SE Degree Requirements

- Thirty term-credit hours of graduate courses with a minimum GPA of 3.00 on a 4.00 scale.

- Satisfactory completion of the following five core courses:
  EMIS 7300 Systems Analysis Methods
  EMIS 7301 Systems Engineering Process
  EMIS 7303 Integrated Risk Management
  EMIS 7305 Systems Reliability, Supportability & Availability Analysis
  EMIS 7307 Systems Integration and Test
MS SE Degree Requirements

• Satisfactory completion of one of the following tracks:
  - Systems Engineering Technology Track
  - Systems Engineering and Design Track
  - Logistics and Supply Chain Management Track
  - Systems Engineering Application Track
  - On-site (Executive Format) Track
MS SE Degree Admission Requirements

• MS SE Admission Requirements
  • Bachelor of Science in engineering*, mathematics, or one of the quantitative sciences (*a Bachelor of Science in an appropriate engineering discipline is required for the Systems Engineering and Design track)
  • G.P.A. of at least 3.00 out of 4.00 scale in previous undergraduate and graduate study.
  • A minimum of two years of college-level mathematics, including at least one year of calculus.
## Current Systems Engineering Courses

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Title</th>
<th>Date Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMIS 7300</td>
<td>Systems Analysis Methods</td>
<td>April-2000</td>
</tr>
<tr>
<td>EMIS 7301</td>
<td>Systems Engineering Process</td>
<td>September-1994</td>
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<tr>
<td>EMIS 7303</td>
<td>Integrated Risk Management</td>
<td>September-1994</td>
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<tr>
<td>EMIS 7305</td>
<td>Systems Reliability, Supportability and Availability Analysis</td>
<td>Sept 1994/Rev Apr 2005</td>
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<tr>
<td>EMIS 7307</td>
<td>Systems Integration and Test</td>
<td>September-1994</td>
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<tr>
<td>EMIS 7310</td>
<td>Systems Engineering Design</td>
<td>April-2000</td>
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<tr>
<td>EMIS 7312</td>
<td>Software Systems Engineering</td>
<td>April-2000</td>
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<tr>
<td>EMIS 7315</td>
<td>Systems Architecture Development</td>
<td>April-2000</td>
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<tr>
<td>EMIS 7320</td>
<td>Systems Engineering Leadership</td>
<td>Apr 2000/Rev Apr 2005</td>
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<tr>
<td>EMIS 7330</td>
<td>Systems Reliability Engineering</td>
<td>April-2000</td>
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<tr>
<td>EMIS 7335</td>
<td>Human-Systems Integration</td>
<td>April-2005</td>
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<tr>
<td>EMIS 7340</td>
<td>Logistics Systems Engineering</td>
<td>April-2000</td>
</tr>
<tr>
<td>EMIS 7347</td>
<td>Critical Infrastructure Protection/Security Systems Engineering</td>
<td>April-2005</td>
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<tr>
<td>EMIS 8340</td>
<td>Systems Engineering Software Tools</td>
<td>April-2005</td>
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<tr>
<td>EMIS 8342</td>
<td>Six Sigma Systems Engineering</td>
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<tr>
<td>EMIS 8348</td>
<td>Supply Chain Systems Engineering</td>
<td>April-2005</td>
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## Current Systems Engineering Courses

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Title</th>
<th>Date Approved</th>
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<tbody>
<tr>
<td>EMIS 7318</td>
<td>Systems Engineering Planning and Management</td>
<td>March-2007</td>
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<tr>
<td>EMIS 8307</td>
<td>Systems Test and Evaluation</td>
<td>March-2007</td>
</tr>
<tr>
<td>EMIS 8310</td>
<td>Collective Systems Design</td>
<td>March-2007</td>
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<tr>
<td>EMIS 8315</td>
<td>Innovation Systems Design</td>
<td>March-2007</td>
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</tbody>
</table>
In-Development Courses

• Introduction to Systems Engineering (Undergraduate Course)
• Systems Requirements Engineering
• Acquisition Logistics Systems Engineering
• Sustainment Logistics Systems Engineering
Systems Engineering Course Development Process

SEP DT
Identify
Needs

Identify & Select
Industry Subject
Matter Expert

Subject Matter
Expert Develops
Course Proposal

Course Proposal
Reviewed by
DT Experts

Course Proposal
Reviewed by
EMIS Dept.
Faculty

Course Developed by
Subject Matter Expert
w/ Assistance by DT
Experts

Course Proposal
Submitted to SoE
Faculty for
Approval

Submit Course
Proposal to EMIS
Department Chair

Executive Review_10.10.07
SMU-EMIS
System Engineering Program
SMU Systems Engineering Research Focus

Program SE and Concept Development SE For Complex Systems

- SoN/Rqmts Development
- Concept Development
- SDD
- Production
- Sustainment
- Disposal

Rqmts Analysis and Refinement

Sustainment SE For Complex Systems
## Funded Research

<table>
<thead>
<tr>
<th>Funded by</th>
<th>Title</th>
<th>Dates</th>
<th>Amount</th>
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<tbody>
<tr>
<td>U.S. DoD DAU / NAVYS SPAWAR</td>
<td>System Engineering in Science and Technology</td>
<td>October 1, 2007 – September 31, 2008</td>
<td>$40,000</td>
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<tr>
<td>Lockheed Martin Missiles &amp; Fire Control</td>
<td>Potential Capability Maturity Model, Integrated(^\text{TM}) (CMMI) Generic, Practice (GP) and Specific Practice (SP) Tailoring Approaches</td>
<td>September 15, 2005– May 31, 2006</td>
<td>$50,000</td>
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<tr>
<td>U. S. Navy- SPAWAR</td>
<td>Phase II: CIP Systems Engineering for Critical Infrastructure Protection Center (CIPC)</td>
<td>November 16, 2004–February 28, 2005</td>
<td>$60,000</td>
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<tr>
<td>U. S. Navy- SPAWAR</td>
<td>Phase I: CIP Systems Engineering</td>
<td>April 13, 2004 – September 30, 2004</td>
<td>$60,000</td>
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</table>
PhD AS (SE) Student Focus

• Target Students
  – Primary – Full-time Aerospace/Defense Sector employees; industry and government
  – Secondary – Full-time students funded by government and industry research grants

• Target Students Profile
  – Engineering and other Technical degrees
  – Work experience in Aerospace/Defense sector
  – U.S. Citizens with active DoD Security Clearances
Resident SE Faculty

- Jerrell Stracener, Ph.D. Scholar in Residence & Founding Director (Vought/Northrop Grumman)
- Steve Szygenda, Ph.D.* Professor, Cecil H. Green Chair (AT&T Bell Labs)
- Junfang Yu, Ph.D. * Assistant Professor (I2)
- Eli Olinick, Ph.D.* Associate Professor
- Mitch Thornton, Ph.D.* Professor (E-Systems Greenville)

* = Part time SE Program
SE Adjunct Faculty

- Arunski, Karl P.E. Raytheon Intelligence and Info. Sys.
- Bell, Bob Lockheed Martin Aeronautics Company
- Bell, Dave, DE Mitre
- Broihier, Ann Raytheon Network Centric Systems
- Chollar, Jr. George, PhD Statistical Design Institute, LLC
- Cluff, Kevin PhD, P.E. Abbott Laboratories
- Cowin, Howard Lockheed Martin Missiles & Fire Control
- Daley, Gunter Siemens Government Services
- Delzer, Dennis, PhD Raytheon Space and Airborne Systems
- Durchholz, Matt, PhD Lockheed Martin Missiles & Fire Control
- Hinderer, Jim, PhD Raytheon Space and Airborne Systems
- Hopper, Mike, DE L-3 Communications Integrated Systems
- Ibarra, Gerard, PhD Ibarra & Associates
- Lipp, John, PhD Lockheed Martin Missiles & Fire Control
SE Adjunct Faculty  continued

- Lyons, Jan, PhD  Lockheed Martin Missiles & Fire Control (Ret.)
- Muto, William, PhD  GE Medical Systems
- Oshana, Rob  Freescale Semiconductor
- Rynas, Chris  Raytheon Space and Airborne Systems
- Sampson, Mark  Siemens Automation
- Skinner, Steve  Bell Helicopter
- Vacante, Russell  US DoD defense Acquisition University
### Cumulative Admissions and Graduates

<table>
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<tr>
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<td>Admissions</td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>14</td>
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<td>30</td>
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<td>Graduated</td>
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<td>1</td>
<td>5</td>
<td>8</td>
<td>22</td>
<td>13</td>
<td>10</td>
<td>15</td>
<td>12</td>
<td>55</td>
<td>116</td>
<td>91</td>
<td>63</td>
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</table>

Cumulative admitted as of September 14, 2007: **731**
Cumulative graduated as of August 15, 2007: **411**

Note: Does not include NTU Students
SEP Development
Development Model
Industry-Government-Student Partnership

Industry & Government Organizations

Students, Engineers Managers

SEP Development Team

Development Projects

Review & Evaluation

Education Research

SEP

needs

Northrop Grumman
U.S. Marines
L-3 Communications
Southwest Research Institute
Defense Acquisition University
U.S. DoD
Boeing
Sandia Labs
S

UGS
General Dynamics
Raytheon
U.S. Air Force
U.S. Army
NASA

SMU-EMIS
System Engineering Program
Development Highlights

- Initiated Feasibility Study..........................September 1991
- Established ad hoc SE Advisory Council..........January 1992
- Initiated Proposal......................................February 1992
- Investigated Launching SEP at.....................April 1993
  - UT Arlington
  - UT Dallas
  - SMU
  (estimated 400 to 500 admissions in first 10 years)
- Selected SMU..............................................June 1993
- Delivered Proposal to SMU SoE......................July 1993
- SMU Board of Trustees Approved Proposal......December 1994
- MS SE Degree Program Launched....................Jan. 1995
# ad hoc Systems Engineering Advisory Council 1991-1995

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arunski, Karl, P.E.**</td>
<td>Texas Instruments, Inc.</td>
<td>Dallas, TX</td>
</tr>
<tr>
<td>Coyne, Bill</td>
<td>American Airlines</td>
<td>Fort Worth, TX</td>
</tr>
<tr>
<td>Davis, Joe, P.E.</td>
<td>Loral Vought Systems</td>
<td>Grand Prairie, TX</td>
</tr>
<tr>
<td>Dean, Joe, Ph.D.</td>
<td>Lockheed Martin Tactical Aircraft Systems</td>
<td>Fort Worth, TX</td>
</tr>
<tr>
<td>Halligan, Charles</td>
<td>General Electric Transportation Systems</td>
<td>Erie, PA</td>
</tr>
<tr>
<td>Hanson, Harold</td>
<td>EDS</td>
<td>Plano, TX</td>
</tr>
<tr>
<td>Harris, Doug, DE</td>
<td>Southern Methodist University</td>
<td>Dallas, TX</td>
</tr>
<tr>
<td>Jain, Anant, Ph.D.</td>
<td>Rockwell International</td>
<td>Richardson, TX</td>
</tr>
<tr>
<td>Kolson, Joanna</td>
<td>Federal Reserve Bank</td>
<td>Dallas, TX</td>
</tr>
<tr>
<td>Luhks, Ronald, Ph.D.</td>
<td>Loral Aerospace</td>
<td>Houston, TX</td>
</tr>
<tr>
<td>Martin, Kim</td>
<td>Abbott Labs</td>
<td>Irving, TX</td>
</tr>
<tr>
<td>Pearse, Derek</td>
<td>Hughes Training, Inc.</td>
<td>Arlington, TX</td>
</tr>
<tr>
<td>Ransom, C. J., Ph.D.</td>
<td>Bell Helicopter Textron</td>
<td>Arlington, TX</td>
</tr>
<tr>
<td>Stracener, Jerrell, Ph.D.*</td>
<td>Vought/Northrop Grumman Corp.</td>
<td>Grand Prairie, TX</td>
</tr>
<tr>
<td>Shaw, Terry, Ph.D.</td>
<td>E-Systems</td>
<td>Greenville, TX</td>
</tr>
<tr>
<td>Steinheimer, Steven L.</td>
<td>E-Systems</td>
<td>Garland, TX</td>
</tr>
<tr>
<td>Tucker, Scott</td>
<td>Hughes Training, Inc.</td>
<td>Arlington, TX</td>
</tr>
<tr>
<td>Vacante, Russell, Ph.D.</td>
<td>Army Management Staff College</td>
<td>Fort Belvoir, VA</td>
</tr>
<tr>
<td>Zsak, Mike</td>
<td>U.S. DoD OSD</td>
<td>Washington, DC</td>
</tr>
</tbody>
</table>

*Chairman

**Vice Chairman
SEP Business Structure

- Multidisciplinary Program – Department Independent
- Build on Aerospace & Defense (A&D) Base & Needs
- Focus on part-time students employed full-time by the A&D sector – Industry & Government
- Utilize SE subject matter experts employed by A&D for Adjunct Faculty for teaching most courses - Scalable
- Grow number of resident faculty to develop SE research & PhD SE programs and teach specialized advanced SE courses

ad hoc SE Council recommendations
Development Highlights

• Phase II - Start-Up and Development (Jan 1995 – Dec 1999)
• Phase III - Rqmts. Driven Development (Jan 2000 – Dec 2006)
• Phase IV - Focused Development (Jan 2007 – Dec 2011)
Executive Reviews

- U.S. DoD Defense Acquisition University
  - Dr. Russell Vacante, Director

- Lockheed Martin Aeronautics
  - Tom Blakely, VP Engineering
  - Bob Manny, VP Enterprise Integration
  - Jim Engelland, VP Systems Engineering & Chief Engineer F-35
  - Frank Cappuccio, VP Advanced Development Programs
  - Bill Anderson, VP Engineering

- Lockheed Martin Missiles & Fire Control
  - Glenn Miller, VP Technical Operations
  - Bill Cannon, VP Engineering

- Raytheon Information and Intelligence Systems
  - John Grimm, VP Engineering
Executive Reviews

- U.S. DoD OSD
  - Bob Skalamera, Deputy Director, Systems and Software Engineering
  - Mark Schaeffer, Deputy Director, Defense Systems, and Director, Systems Engineering, OUSD (AT&L)
  - Dr. James Roche, Secretary of the Air Force
  - Mike Zsak, Director, Systems Engineering
  - Mike McGrath, Director CALS

- Raytheon Space & Airborne Systems
  - Bob Kern, VP Engineering
  - Janne Ackerman, Director North Texas Engineering
  - Bob Rassa, Director Systems Supportability

- Vought Aircraft Company
  - Eric Smith, Senior VP Programs
  - Joe Ayers, VP Engineering

- L-3 Communications Integrated Systems
  - Dr. Val Gavito, VP Engineering & Strategic Initiatives
DAU – SMU SEP Partnerships

- U.S. DoD Defense Acquisition University (DAU) and SMU Systems Engineering Program (SEP) MoU

  1. Provide members of U.S. DoD Acquisition, Technology, and Logistics (AT&L) workforce the opportunity to apply courses provided by DAU towards a SMU graduate degree in systems engineering.

  2. Provide SMU SEP students access to DAU courses, and

  3. Collaboratively develop research topics and projects in systems engineering.

- U.S. Navy SPAWAR Charleston and SMU SEP Cooperative Research and Development Agreement (CRADA) in work
Plans
Baseline Academic Programs

Non-Degree Studies in SE

Certificate Series in SE

MS SE

Leaders MS SE

PhD SE

Advances in SE Certificate Series

MS Macro SE

Systems Engineering Education is a Journey – Not a Destination

= Entry Point
Summary
Summary

• A SE Education & Research program with focus on:
  – aerospace & defense
  – development of complex Systems (as opposed to acquisition)

• Track record of success in responding to Customer needs
  – SEP Established in 1994
  – Growing Enrollment and expanding scope
  – Extensive & growing industry and government network

• SE is currently a HOT topic (but lacks branding)
  – Emphasis on SE by U.S. DoD and defense contractors
  – High and increasing Student interest in SE (not in becoming a SE, but rather in utilizing SE education to become a “letter” engineer or for career advancement)
  – Increasing number of University SE Programs (but many are commingled with other programs)

• The SEP is severally resource constrained for PhD SE generation and research
Agenda

• Systems Engineering Education
  - SMU (Systems Engineering Program) Overview
  - Program Development
• Systems Engineering Aerospace & Defense Initiative
• Systems Engineering Training
• Summary
Description

• Research based exploration and definition of a framework for effective response to regional industry and government systems engineering-education, research and training & consulting needs.
• Initial focus on the aerospace/ defense/security sectors.
• Expansion to other sectors will be guided by regional needs.
Statement of Work

• Specific tasks necessary to evolve the preferred response framework include the following:
  – Industry and government needs captured and assessed
  – Identification and analysis of regional capabilities and resources, both current and planned
  – Analysis to determine gaps and overlaps with respect to needs
  – Explore and define alternatives for responding to needs, including benchmarking the nations best.
  – Evaluate and refine alternates to evolve the preferred concept, a regional framework.
  – Strawman regional framework development plan

• To ensure a structured technical approach and balanced solution, the systems engineering process will be utilized in the planning and conduct of this research project.
Regional Focus

Serving Universities and Industry

Leveraging Regional Capabilities to Meet Regional Needs
National Connectivity

- Fort Leavenworth, KS
  - War College
- Colorado Springs
  - Air Force Academy
- Monterey, CA
  - NPS
- San Diego, CA
  - SPAWAR
- El Paso
  - UTEP
- San Antonio
  - UTSA
- D/FW
  - SMU
  - UNT
  - UTD
  - UTA
  - TCU
  - TAMU
- Dayton, OH
  - AFIT
- West Point, NY
  - USMA
- Washington D.C.
  - DAU
  - USNA
- Charleston, S.C.
  - SPAWAR

Regional Center with National Ties
Mobilize Resources and Build on Experience

- Initiate SE Tiger Team of members Industry, Government and University Affiliations

- Utilize Previous Start-Ups as Guides
  - SAE RMSL Division (G-11): 1985 - 2000
  - CALS Connectivity Center (CCC) / UTA ARRI: 1989 - 1999
  - SMU Systems Engineering Program: 1991 - Present
Regional SE Center Concept Exploration & Definition using the SE Process

- Goal
- Objectives
- Vision
- Plan

Requirements, Boundaries & Constraints

Ground rules and Assumptions

Requirements-Driven Solution

Report

Proposal

August 10, 2007

December 7, 2007
Vision

Advancing SE Technology

SE Think Tank

Center for Systems Engineering

Texas Engineering Work Force Advancement

An Industry-Government-University Partnership to Improve Development of Complex A&D Systems

A National Center With Regional Focus
Center for SE – Functional Concept – Overview

- Needs
  - Vision & Leadership
  - Resources
  - Center for Systems Engineering
  - Products
  - A&D Customers

PRIVATE
Agenda

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Training Goal

to provide System Engineering training that is

– Tailored to customer needs and work place
– Delivered by industry, government and academia subject matter experts
– Relevant
– Conducted in an interactive workshop format
Training Objective

• to increase Systems Engineering awareness
• to increase organizations Systems Engineering capability
• to increase individual engineers SE expertise
Training Scope & Delivery

System Engineering training Scope

– Integrated program
– Stand-alone modules
– Special aligned systems engineering topics

• Delivery
– JGR Systems Engineering, LLC
Linkage to SE Graduate Courses

Systems Engineering Training

Linkage to SE Research

Linkage to SEP DT for Requirements Capture

Leveraged and Work-Place Relevant Training
Organizational Level, Training “Depth” and Value

Division or Department level
- Strategic or tactical business importance
- Overall value to a group, division, or department.

@ the Immediate Supervisor, Branch head or Project Lead level
- Impact on projects/programs
- Impact on employee competence

@ the individual engineer’s level
- Impact on the individual’s specific competency; e.g., ability, capabilities, skills
- Value of those competencies to the company
Systems Engineering Courses

Customer Tailored training from 1 – 5 days, in increments of one day

- Systems Analysis Methods
- Systems Engineering Process
- Integrated Risk Management
- Systems Reliability, Supportability and Availability Analysis
- Systems Integration and Test
- Systems Engineering Design
- Software Systems Engineering
- Systems Architecture Development
- Systems Engineering Leadership
- Systems Reliability Engineering
- Human-Systems Integration
- Logistics Systems Engineering
Systems Engineering Courses

- Critical Infrastructure Protection/Security Systems Engineering
- Systems Engineering Software Tools
- Six Sigma Systems Engineering
- Supply Chain Systems Engineering
- Systems Test and Evaluation
- Systems Engineering Planning and Management
- Systems Cost Engineering
- Systems Life Cycle Logistics
- Innovative Systems Design
- Systems Modeling and Simulation
- Systems Prognostic and Health Management
- Systems Development Program Engineering and Management
Summary

• Work-place Relevant Systems Engineering Training
  – By Subject Matter Practioners
  – Tailored to Customer Needs
• Linkage to Graduate Systems Engineering Courses
• Aerospace & Defense focused
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