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Innovative Strategies for Effective System Engineering Training

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Background

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- The need for trained systems engineers is steadily increasing
- Wide variations exist in the style and content of systems engineering training
- This presentation will highlight these differences, and offer innovative strategies for ensuring systems engineering training is effective
  - Target audience
  - Body of knowledge
  - Delivery format
  - Student-centered learning
  - Case studies

Key Questions in Establishing SE Training

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- What topics should be addressed?
  - Technical, process, organizational, contextual?
- Should training be developed in-house or bought from a vendor or university?
- Are alternatives to classroom training effective? Under what conditions?
  - Mentoring, on-line, guided self-study, on-the-job?
- How should training be paid for?
- How do you determine whether training is effective?
- How much SE training is enough?

Who is the Target Audience?

Junior SEs and component engineers

- Seeking to broaden their understanding of SE, as it applies to their tasks

Support personnel

- Seeking to understand SE, to support more effectively

Senior SEs

- Seeking to effectively manage the SE process

- Student background and experience
- Student expectations
- Overhead vs. student time

Is the Staff Qualified to Do Their Work?

An organizational responsibility!

- What are the minimum skills and knowledge needed to perform their job function?
- Does each individual possess these skills?
  - If not, training should address the gaps

How does the organization maintain a skilled and knowledgeable workforce?

Competency Model

- A competency is a set of behaviors encompassing skills, knowledge, abilities, and personal attributes critical to successful performance at a particular job
  - Should be observable and measurable through behaviors
  - These behaviors provide a model for superior job performance
- Can provide a powerful mechanism for identifying gaps in individual and workforce-wide skills sets, identify appropriate training
- Must be integrated with an organization's strategic goals and individual performance plans

Strategies for Organizational Training - 1

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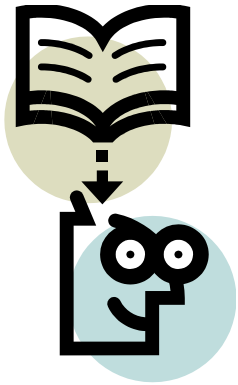
- Start by defining the key job functions in the organization
  - E.g., project manager, software engineer, quality assurance specialist



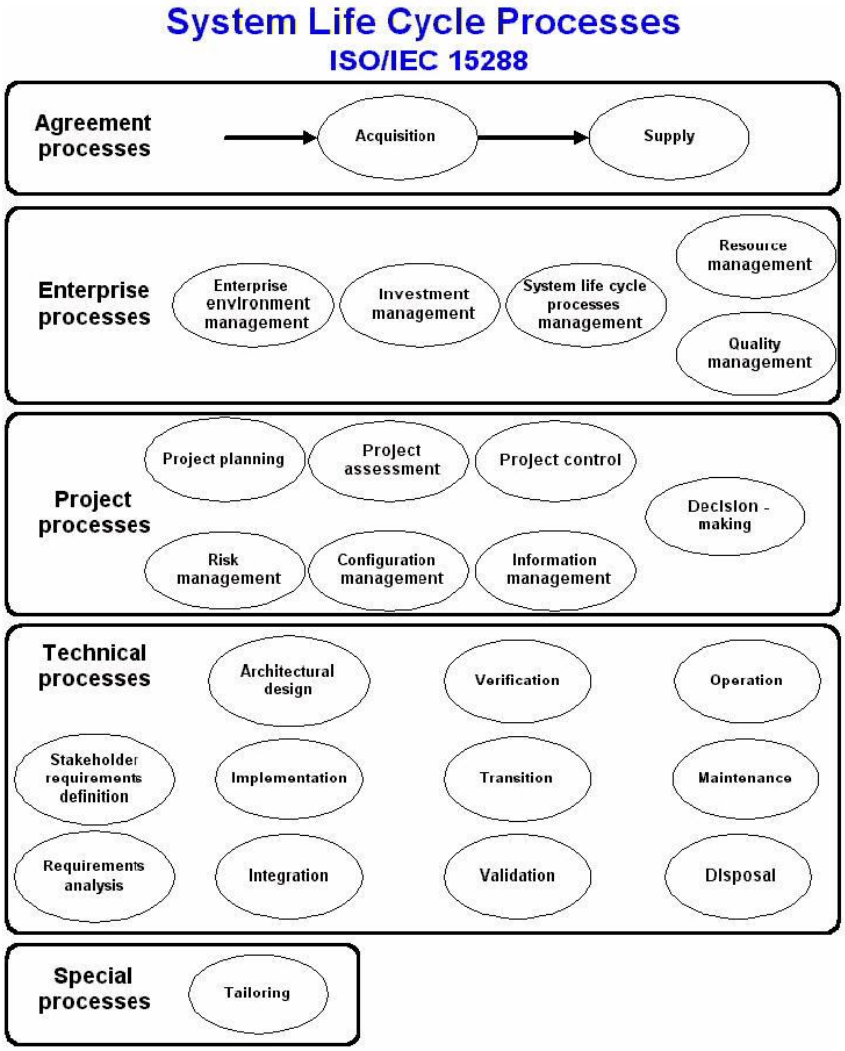
- Identify the requisite knowledge associated with each function
- Define a set of course modules that impart this knowledge
  - Map modules to job functions
  - Some modules will be common to multiple job functions

- Acquire training materials and trainers
  - Should reflect the organization's policies and processes
  - Unlikely that standard vendor/university courses will fit

Strategies for Organizational Training - 2

- Identify each employee by their job function(s), map to required courses
  - If the employee already has the identified minimum knowledge, they do not need to take the course
- Establish student records
  - Who has completed what course, waivers
- Review required training with employees
  - Career-planning, promotions, new hires
- Add project-specific training (e.g., tools, methods), where needed

Body of Knowledge



Government/commercial standards (e.g., MIL-STD-499C, INCOSE SE Handbook, SEBoK, …)

System engineering discipline vs. engineering a system

Organizational-specific topics

- Processes and procedures
- Tools and methods
- Customer acquisition practices
- Domain-specific technologies

Andragogy - Learning strategies focused on adults

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- Need to Know - Adults need to know the reason for learning something
- Foundation - Experience (including error) provides the basis for learning activities
- Self-concept - Adults need to be responsible for their decisions on education; involvement in the planning and evaluation of their instruction
- Readiness - Adults are most interested in learning subjects having immediate relevance to their work and/or personal lives
- Orientation - Adult learning is problem-centered rather than content-oriented
- Motivation - Adults respond better to internal versus external motivators

Knowles, Malcolm; Holton, E. F., III; Swanson, R. A. (2005). *The adult learner: The definitive classic in adult education and human resource development* (6th ed.)

Student-Centered Learning

Traditional Instructor-Led

- Instructor as recognized authority, constant lecturer, and master of the classroom
  - Student as passive receptor
- Instructor presents course content primarily through lecture
- Assessment verifies that course content was memorized

Student-Centered Learning

- Student is responsible for their own learning, proactively identifies gaps in knowledge, how best to learn
  - Teacher as guide
- Goal is for the student to develop the skills needed to explore and use the information
- The student explores and applies content, with instructor and fellow students providing feedback

Student-Centered Teaching Styles

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- Read-ahead material
- References for further study
- Students help identify topics, depth of instruction
- Students review material and teach others
- Class projects
- Case studies

Case Studies

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- Case studies provide an opportunity for students to see the real-life application of SE principles and tools
  - Bad examples often just as instructive as good examples
- Require participation and integration of a broad set of skills

USAF SE Case Studies

http://www.afit.edu

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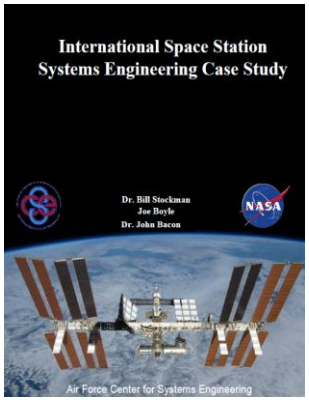
- A-10 Thunderbolt
- B-2 stealth bomber
- C-5 military transport
- E-10A MC2A aircraft
- F-111 aircraft
- Global Hawk drone
- Global Positioning System (GPS)
- Hubble Space Telescope
- International Space Station
- KC-135 simulator
- Large Aircraft Infrared Countermeasures
- MH-53J/M PAVE helicopter
- T-6A Texan II aircraft
- Theater Battle Management Core System (system-of-system command and control)



	Responsibilities		
	Contractor	Shared	Govt.
Requirements Definition and Mgmt			
Systems Architecture Development			
System, Subsystem Design			
Validation and Verification			
Risk Management			
Systems Integration & Interfaces			
Life Cycle Support			
Deployment and Post Deployment			
System and Program Mgmt			

Lessons Learned

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- Student individual motivations greatly effect the degree of learning
- The classroom setting provides a low risk environment conducive to learning
- Students value an understanding of the overall SE process and an SE perspective
- Class projects provide practical feedback on implementation details, team dynamics
- SE training can encourage further study and connections with other functional areas on the students' current project

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