Study

Competency-based Space System Engineering Education

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Overview

- Introduction
- Purpose of the Study
- Study Team
- Space System Engineering Capabilities
- Summary and Discussions

Competency-based Space System Engineering Education

- **Proposer(s): W. Larson, P. and C. Swan, E. Ashford, R. Malina, C. Stavrinidis**
- **Primary IAA Commission Preference: Commission 6--Education**
  - **Secondary IAA Commission Interests: Commission 3—System Engineering Development (possibly)**
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Competency-based Space System Engineering Education

- Study Committee Members
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Competency-based Space System Engineering Education—Overall Goal

- **Currently, space system engineering practitioners are needed by most space agencies and industry, in order to meet upcoming challenges. Many companies and Government agencies have large numbers of unfilled positions.**

- **The study team will develop an international list of required space system engineer competencies (capabilities) with performance levels necessary to perform required tasks. The study team will use the vetted and approved capability list to review system engineer education programs and identify which capabilities they develop in participants.**

- **The study team will make recommendations pertaining to the system engineer capability content of, and potentially missing components in, existing and proposed system engineering education programs.**

Competency-based Space System Engineering Education—Steps

1. Develop a baseline list of space system engineer capabilities with performance levels
2. Identify system engineering educational programs globally
3. Measure educational programs against needed capabilities
4. Make recommendations for potential improvement
5. Generate and update the space system engineering report

Competency-based Space System Engineering Education--Method

1. Form the study group
2. Establish and implement the process for gathering required capabilities from industry and Governments
3. Organize and vet capabilities and performance levels
4. Assess educational programs against competencies
5. Complete the report

Time Line: Dates by items 1-5 above. 1- December 2006, 2- March 2007, 3-September 2008, 4- March 2009, and 5- November 2009.

Target Community: Space agencies, industry and educational institutions that must perform system engineering in order to succeed in their tasks.

System Engineering Capabilities

SpaceTech's Masters of Space System Engineering--System Engineer Capabilities*	
1.0 Concepts and Architecture	**6.0 Internal and External Environments**
1.1 Mission Needs Statement	6.1 Organization Structure, Mission, and Internal Goals
1.2 System Environments	6.2 PM/SE Procedures and Guidelines
1.3 Trade Studies	6.3 External Relationships
1.4 System Architecture	
2.0 System Design	**7.0 Human Capital Management**
2.1 Stakeholder Expectation Definition & Management	7.1 Technical Staffing and Performance
2.2 Technical Requirements Definition	7.2 Team Dynamics and Management
2.3 Logical Decomposition	
2.4 Design Solution Definition	
3.0 Production, Product Transition, Operations	**8.0 Security, Safety and Mission Assurance**
3.1 Product Implementation	8.1 Security
3.2 Product Integration	8.2 Safety and Mission Assurance
3.3 Product Verification	
3.4 Product Validation	
3.5 Product Transition	
3.6 Operations	
4.0 Technical Management	**9.0 Professional and Leadership Development**
4.1 Technical Planning	9.1 Mentoring and Coaching
4.2 Requirements Management	9.2 Communication
4.3 Interface Management	9.3 Leadership
4.4 Technical Risk Management	
4.5 Configuration Management	Numbered Items: 1.1 – 10.1 = Desired System Engineer Capabilities
4.6 Technical Data Management	* = Documented SE Process
4.7 Technical Assessment	Numbered Items = SE Capabilities Provided by SpaceTech
4.8 Technical Decision Analysis	
5.0 Project Management and Control	**10.0 Knowledge Management**
5.1 Acquisition Strategies and Procurement	10.1 Knowledge Capture and Transfer
5.2 Resource Management	
5.3 Contract Management	
5.4 Systems Engineering Management	

* Compiled via aligning of SE Competencies/ Processes/ Functions/ Task from NASA Centers (MSFC, GSFC, JSC, KSC, ARC,) Agency (SE DACUM; ES NPR – DRAFT; APPL's PMDP Competency Model NESC;) and other SE Sources (DoD, INCOSE, Industry Partners, SpaceTech)

Capability Descriptions and Performance Levels

	SE Proficiency Level I	SE Proficiency Level II	SE Proficiency Level III	SE Proficiency Level IV
Engineering Leadership	Technical Engineer / Project Team Member	Subsystem Lead	Project Systems Engineer	Program Systems Engineer or Organization *Chief Engineer*
Description of Role/ Responsibility	Performs fundamental and routine SE activities while supporting a Level II-IV systems engineer as a member of a project team	Performs SE activities for a subsystem or simple project (e.g. no more than two simple internal/external interfaces, simpler contracting processes, smaller team/budget, shorter duration)	Performs as a systems engineer for a complex project (e.g. several distinct subsystems or other defined services, capabilities, or products and their associated interfaces)	Oversees SE activities for a program with several systems and/or establishes SE policies at top organizational level.
Level of Expertise (LEO)/ Capability to Attain Proficiency Level	Practitioners have obtained a working knowledge of technical integration, systems engineering (SE) concepts and tools and performed tasks and activities to support and contribute to a project. They demonstrated an awareness and understanding of the organization's SE tools, techniques, and lexicon. They have sufficient experience and responsibility and are prepared to contribute to fundamental and routine SE activities.	Practitioners participated in or led SE activities (e.g. requirements development, concept and architecture development, risk management). They demonstrated the application of SE tools, techniques, and lexicon at the project subsystem level, including use of SE best practices. They have sufficient experience and responsibility and are prepared to lead SE and technical integration activities for a subsystem or simple project.	Practitioners have taken a significant leadership role in multiple phases of a project life cycle managing both programmatic and technical aspects and/or managing all technical integration and SE functions for a subsystem or small project. They demonstrated the integration of SEtools, techniques, and best practices across subsystems at the project level. They have sufficient experience and responsibility and are prepared for a technical leadership role in support of a major system or project	Practitioners will have contributed to organizational goals and be effective in managing programmatic, technical, and strategic interfaces both internal and external to the organization. They demonstrated superior capabilities in all Systems Engineering formulation and implementation activities. They have sufficient experience and responsibility and are prepared for a technical leadership role at the program, top organizational or HQ level.
Validation of Levels	Practitioner's immediate supervisor	Division Peer Group and Senior Panel	Division Peer Group and Senior Panel	Division Peer Group, Senior and organization-wide panels
Learning and Development emphasis	The emphasis at Level I is knowledge and understanding of technical integration, SE and basic project management.	The emphasis at Level II is leadership application and participation in SE.	The emphasis at Level III is the directing, structuring, and integration activities of SE.	The emphasis at Level IV is on the strategy for SE of large complex initiatives and the strategy and management of organizational initiatives.

Capability Descriptions and Performance Levels

Capability Area: 1.0 Concepts and Architecture				
Capability: 1.2 System Environments				
Capability Elements and Descriptions	**Proficiency Level Descriptions**			
	Level 1	Level 2	Level 3	Level 4
1.2.1 System Environment Identification a. Identify constraints b. Identify expected system environment c. Analyze/quantify expected environment	**Involved in** identifying constraints and the expected system environment **Able to** analyze/quantify expected environment	**Able to** (for a subsystem or simple project): • Identify constraints • Identify expected system environment • Analyze/quantify expected environment	**Direct** (for a system): • Identification of constraints • Identification of expected system environment • Analysis/quantification of expected environment	**Direct**(for a program): • Identification of constraints • Identification of expected system environment • Analysis/quantification of expected environment
1.2.2 Design Guidance a. Establish margin philosophy against the expected environment b. Establish design guidance for the expected environment	**Understand** the purpose of having a margin philosophy against the expected environment and how that leads to design guidance **Apply** provided design guidance	**Apply** (for a subsystem or simple project): • Margin philosophy against the expected environment • Design guidance	**Establish** (for a system): • Margin philosophy against the expected environment • Design guidance	**Establish** (for a program): • Margin philosophy against the expected environment • Design guidance **Define** Organizational design guidance policies
Courses				
OJL activities				
Other learning activities				
Assessment				

Capability Descriptions and Performance Levels

Capability Area: 1.0 Concepts and Architecture

Capability: 1.3 Trade Studies

Capability Elements and Descriptions	Proficiency Level Descriptions			
	Level 1	Level 2	Level 3	Level 4
1.3.1 Concept Definition a. Define scope options b. Define operations concept c. Define technical solution options	**Contribute to** definition of scope options **Understand** the need for an operations concept early in the project	**Able to** define (for a subsystem or simple project): • Scope options • Technical solution options **Contribute to** (for a subsystem or simple project) development of the operations concept	**Direct** (for a system): • Definition of scope options • Definition of technical solution options • Development of the operations concept	**Direct** (for a program): • Definition of scope options • Definition of technical solution options • Development of the operations concept
1.3.2 System Model a. Create system model b. Validate system model c. Operate system model d. Correlate system model with operational data	**Contribute to:** • Creation of system model • Validation of system model • Correlation of system model with operational data **Able to** operate a system model	**Able to** (for a subsystem or simple project): • Create, validate, and operate a system model • Correlate a system model with operational data	**Direct** (for a system): • Creation, validation, and operation a system model • Correlation of system model with operational data	**Direct** (for a program): • Creation, validation, and operation a system model • Correlation of system model with operational data
1.3.3 System Performance a. Evaluate possible concepts b. Select technical solution	**Contribute to:** • Evaluation of possible concepts • Recommendation of a technical solution that balances technical and non technical features of the system	**Able to** (for a subsystem or simple project): • Evaluate possible concepts • Recommend a technical solution that balances technical and non technical features of the system	**Direct** (for a system): • Evaluation of possible concepts • Selection of a technical solution that balances technical and non technical features of the system	**Direct** (for a program): • Evaluation of possible concepts • Selection of a technical solution that balances technical and non technical features of the system
Courses				
OJL activities				
Other learning activities				
Assessment				

System Engineering Assessments

System Engineer Capabilities—WL Example	Performance Levels I - IV			
	I	II	III	IV
1.0 Concepts and Architecture				+
1.1 Mission Needs Statement			+	
1.2 System Environments				+
1.3 Trade Studies				+
1.4 System Architecture				
2.0 System Design				
2.1 Stakeholder Expectation Definition & Management				+
2.2 Technical Requirements Definition				+
2.3 Logical Decomposition			+	
2.4 Design Solution Definition				+
3.0 Production, Product Transition and Operations				
3.1 Product Implementation			+	
3.2 Product Integration			+	
3.3 Product Verification			+	
3.4 Product Validation		+		
3.5 Product Transition			+	
3.6 Operations			+	
4.0 Technical Management				
4.1 Technical Planning				+
4.2 Requirements Management			+	
4.3 Interface Management			+	
4.4 Technical Risk Management			+	
4.5 Configuration Management			+	
4.6 Technical Data Management			+	
4.7 Technical Assessment			+	
4.8 Technical Decision Analysis			+	
5.0 Project Management and Control				
5.1 Acquisition Strategies and Procurement				+
5.2 Resource Management				+

System Engineering Assessments—Organization Needs, Education

System Engineer Capabilities	Performance Levels I - IV			
SpaceTech Target Performance	I	II	III	IV
1.0 Concepts and Architecture				
1.1 Mission Needs Statement		X		
1.2 System Environments		X		
1.3 Trade Studies		X		
1.4 System Architecture		X		
2.0 System Design				
2.1 Stakeholder Expectation Definition & Management		X		
2.2 Technical Requirements Definition		X		
2.3 Logical Decomposition		X		
2.4 Design Solution Definition		X		
3.0 Production, Product Transition and Operations				
3.1 Product Implementation		X		
3.2 Product Integration		X		
3.3 Product Verification		X		
3.4 Product Validation				
3.5 Product Transition				
3.6 Operations		X		
4.0 Technical Management				
4.1 Technical Planning			X	
4.2 Requirements Management			X	
4.3 Interface Management				
4.4 Technical Risk Management		X		
4.5 Configuration Management	X			
4.6 Technical Data Management	X			
4.7 Technical Assessment		X		
4.8 Technical Decision Analysis			X	
5.0 Project Management and Control				
5.1 Acquisition Strategies and Procurement		X		
5.2 Resource Management		X		
5.3 Contract Management				
5.4 Systems Engineering Management			X	
6.0 Internal and External Environments				
6.1 Organization Structure, Mission, and Internal Goals				
6.2 PM/SE Procedures and Guidelines				
6.3 External Relationships				
7.0 Human Capital Management				
7.1 Technical Staffing and Performance				
7.2 Team Dynamics and Management			X	
8.0 Security, Safety and Mission Assurance				
8.1 Security				
8.2 Safety and Mission Assurance		X		
9.0 Professional and Leadership Development				
9.1 Mentoring and Coaching				
9.2 Communication			X	
9.3 Leadership			X	
10.0 Knowledge Management				
10.1 Knowledge Capture and Management				

Note: Performance Levels—I = knowledge of, II = application, III = manage, IV = provide strategy and guidance. [illegible]—FILL IN YOUR ASSESSMENT

System Engineer Capabilities	Performance Levels I - IV			
[illegible]SE Capability Assessment	I	II	III	IV
1.0 Concepts and Architecture	Aware	Apply	Manage	Strategy
1.1 Mission Needs Statement		C-N		
1.2 System Environments		C		
1.3 Trade Studies		C		
1.4 System Architecture		C		
2.0 System Design				
2.1 Stakeholder Expectation Definition & Management		C		
2.2 Technical Requirements Definition		C		
2.3 Logical Decomposition		C		
2.4 Design Solution Definition		C		
3.0 Production, Product Transition and Operations				
3.1 Product Implementation		O		
3.2 Product Integration		C		
3.3 Product Verification		C		
3.4 Product Validation		N		
3.5 Product Transition		O		
3.6 Operations		N		
4.0 Technical Management				
4.1 Technical Planning		C		
4.2 Requirements Management		C		
4.3 Interface Management		C		
4.4 Technical Risk Management		C		
4.5 Configuration Management		N		
4.6 Technical Data Management		O		
4.7 Technical Assessment		C		
4.8 Technical Decision Analysis		C		
5.0 Project Management and Control				
5.1 Acquisition Strategies and Procurement		O		
5.2 Resource Management		O		
5.3 Contract Management		O		
5.4 Systems Engineering Management		N		
6.0 Internal and External Environments				
6.1 Organization Structure, Mission, and Internal Goals		O		
6.2 PM/SE Procedures and Guidelines		O		
6.3 External Relationships		O		
7.0 Human Capital Management				
7.1 Technical Staffing and Performance		O		
7.2 Team Dynamics and Management		C		
8.0 Security, Safety and Mission Assurance				
8.1 Security		O		
8.2 Safety and Mission Assurance		N		
9.0 Professional and Leadership Development				
9.1 Mentoring and Coaching		O		
9.2 Communication		C		
9.3 Leadership		N		
10.0 Knowledge Management				
10.1 Knowledge Capture and Management		O		

Note: Performance Levels—I = knowledge of, II = application, III = manage, IV = provide strategy and guidance. RATINGS: C = CRITICAL, N = NECESSARY, O = Optional

Results of System Engineering Assessments

- Study Group is able to assess ORGANIZATIONAL approaches to system engineering development
- Study Group is able to assess INDIVIDUAL capabilities relative to the desired list of SE capabilities
- This approach provides a strong, organized approach to help industry, educational and training organizations develop necessary space system engineers