

# Global Systems Engineering Competencies: A Business Advantage

Eileen Arnold  
BAE Systems  
4800 East River Road Fridley, MN United States

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**Abstract.** As market boundaries change, diversified corporations can no longer focus on end product markets. A competency system, flowed-down from enterprise and business objectives and strategy to a workforce comprised of an individual's competencies with a global Systems Engineering focus, is proposed as a business advantage. Unexpected results, capitalizing on the synergies and combinations of competencies; the "whole is more than the sum of its parts" concept illustrates a newly introduced term, *Emergent Competency* behavior. A multi-dimensional Systems Engineering Competency Model example, based on individual competencies with global and layer dimensions, is provided as a way to leverage the knowledge, skills, abilities, and attitudes of a workforce to achieve business success. Six categories of competencies are proposed to include Enterprise, Domain, Discipline, Cognitive, Environmental Sustainability, and Behavioral.

## 1. Introduction and Definitions

**Introduction.** Identification of Global Systems Engineering Competencies, as pertains to individual and business competencies is proposed as a way to leverage the knowledge, skills, abilities, and attitudes of a workforce to achieve business success. Global Systems Engineering Competencies are well suited to enhance a company's competency portfolio in pursuit of business and employee personal success.

Criteria for what constitutes success in business and industry is cycling at a greater frequency than ever before as global technology capabilities encourage broader networks of global communication, instantaneously; via internet, cell phones, video conferencing, and inventions not yet available. According to (Pralhad et al. 2006), "As market boundaries change, diversified corporations can no longer focus on end product markets. The targeted markets are elusive and their capture is at best, temporary." The invention of new markets, the technique currently in vogue, and which has been working the past few years, may not be what works in the future. A competency view may help drive heightened success if coupled with targeted markets.

Grovewell, <http://www.grovewell.com/Consult/Global.pdf>, maintains that competencies, if understood and fostered, result in the, "... attainment of excellent performance in a role, function, or specific business." Systems Engineers have the skills and abilities to be the go-to-personnel; piecing customer, product, capabilities, and services together into a solution for a complex, global, environment. He proposes that "Competencies are the knowledge, behavioral skills, and personal attributes required for attainment of excellent performance in a role, function, or specific business." He suggests that competencies become *global competencies* when the roles, functions, or business is operating outside of the company's home culture, or when the competencies involve

sustained contact with people from one or more unfamiliar cultures. Global competence is the ability, "... not only to contribute to knowledge, but also to comprehend, analyze, and evaluate its meaning in the context of an increasingly globalized world" according to the (NASULGC Task Force 2007).

Competencies, as applied in this paper, refer to the knowledge and experience, skills, abilities, and attributes of a workforce, made up of individuals' personal competencies. A competency system, flowed-down from enterprise and business objectives and strategy to a workforce comprised of an individual's competencies with a global Systems Engineering focus, is proposed as a business advantage.

Capabilities will be considered to be the physical manifestations of technology, both the end products and systems and the physical infrastructure required to design, develop, manufacture, produce, verify and validate the technology or service. The breakdown into physical tiers of a Systems Integration Facility (SIF) capability comprised of a Modeling and Simulation (M&S) capability, and further decomposed into hardware and software capabilities illustrates the multi-level concept of capabilities. The detailed knowledge and experience of the individuals developing the SIF or the users of the facility with expertise in a functional area such as 3-D Modeling, applied to the M&S capability, would contribute to a 3-D modeling competency for the individuals, and may translate to the workforce and business level.

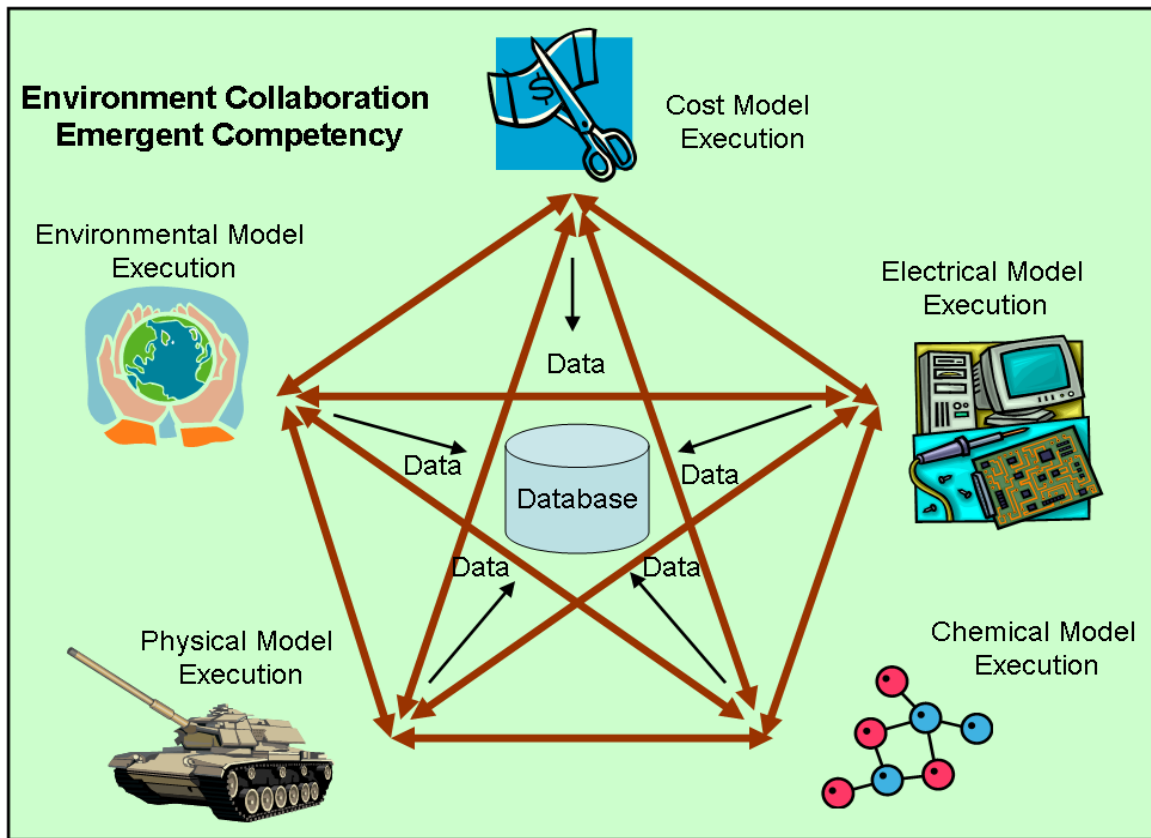
**Emergent Competencies.** If emergent properties can be identified as characteristic of the merger of capabilities then it follows that behaviors associated with the competencies employed to create the capabilities, also result in emergent behavior, which may translate to what this author has identified as *emergent competencies*. Unexpected results, capitalizing on the synergies and combinations of individual behaviors and workforce competencies; the "whole is more than the sum of its parts" concept illustrates emergent competency behavior.

To borrow activities from (Kalawsky et al. 2007) to use in our M&S environment example, two individuals may possess M&S competencies:

Individual 1: Data Management competency – linking simulation models to remote databases which store data

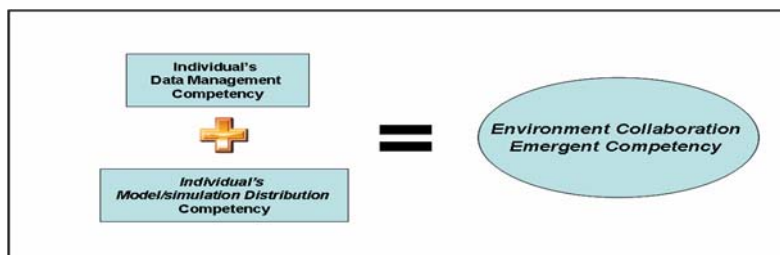
Individual 2: Model/Simulation Distribution competency – execution of many separate simulation models across different computers

Figure 1 illustrates the two competencies possessed by the individuals, whereby the Data Management competency of Individual 1 is represented by the black arrows pointing to the Database. The Model/Simulation Distribution competency of Individual 2 is represented by the brown bi-directional arrows showing interaction across all the various models comprising the System.



**Figure 1. Environmental Collaboration Emergent Competency**

The merger of the two competencies result in an emergent competency, *environmental collaboration*, whereby simulations that can be interactively steered by many users can also include models that can be shared, linking remote databases (Figure 2). Emergent competencies have the effect of adding a “phantom person” with knowledge and experience not possessed by other individuals until they are brought together to uncover the hidden competency. The emerging competencies generated by Environmental Collaboration in Figure 1 might include manufacturing and chemical waste handling and waste reuse, driven by access to data for the entire System and the knowledge that results from all data, not just isolated discipline-based data. This can easily be extrapolated to global competency when the internet and additional global competencies are added to the system of interest.



**Figure 2. Individual Competencies becoming an Emergent Competency**

## 2. Competency Dimensions - Global Systems Engineering Competency Model.

The Hitchins-Kasser-Massie Framework introduced by (Kasser 2007) is a three dimensional framework for Systems Engineering. The 3-Dimensional model serves as a basis for our Competency System, a Global Systems Engineering Competency Model. Kasser outlines vertical and horizontal dimensions, and proposes an added third dimension.

**Pictorial Third Dimension.** Although our layers can be seen as vertical layers based on the Hitchins <http://www.hitchins.net/5layer.html> vertical dimension consisting of a five-layer model, we will apply the layers to our pictorial third dimension. Hitchins states that the, “ Five Layers form a "nesting" model, i.e. many products make a project, many projects make a business, many businesses make an industry and many industries make a socio-economic system.” Kasser indicates that, “these statements are only approximate since- many industries make a socio-economic system”. Competencies have a similar hierarchy as proposed in Table 1, although to ensure applicability across all organizations, such as academic institutions, “Industry” is replaced by “Enterprise”.

**Table 1. Competency Layers**

Layer Number	Layer Name	Competency Layer Description
Layer 5	Enterprise Layer	Many enterprise competencies make up global socioeconomic competencies.
Layer 4	Business Layer	Many business competencies make up enterprise competencies.
Layer 3	Workforce Layer	Many workforce competencies make up Business Competencies.
Layer 2	Individual Layer	Many individual competencies make up Workforce Competencies.
Layer 1	Root Layer	Many personal competencies make up an Individual’s Competencies.

**Pictorial Vertical Dimension.** The horizontal dimension of the 2-dimensional Kasser - Massie (Kasser et al, 2001) framework was used to conceptualize a Systems Engineering body of knowledge based on the roles of Systems Engineers to explicitly cover the phases of the Systems Engineering Lifecycle. The SE Competencies are the vertical pictorial dimension in our model. Each one of the competency categories has embedded global competencies suggested.

The vertical pictorial dimension of the proposed Competency Model includes the following multi-dimensional Global Systems Engineering Competency Model set of competencies:

- 1) **Enterprise** – A set of competencies expected of all employees throughout an organization. These competencies are not limited to Systems Engineers, or even

engineers. For example, all employees may be expected to have knowledge and experience in ethical behavior, security, workplace safety, and a working knowledge of time charging or other business requirements. Global enterprise competencies, extracted from the Enterprise and other Competency Layers, would extend the knowledge and experience available and desired to the cultural differences of countries or regions, either within the workforce or across the businesses.

- 2) **Discipline** – A set of competencies attributed to individuals associated with the various disciplines such as Systems Engineering (SE), Electrical Engineering, or Finance. Systems Engineering discipline competencies could be derived from (EIA 632 1999), (Kasser 2007), the (INCOSE Systems Engineering Handbook 2007) or other source of the special knowledge and experience associated with product or system conceptualization. INCOSE’s SE Certification Professional (CSEP) “Experience Applicable to Systems Engineering Certification” will be used in our sample Global Systems Engineering Competency Model <http://www.incose.org/educationcareers/certification/experience.aspx> as illustrated in Table 2. Extending this SE Model to layers beyond engineering would include additional competencies such as Marketing, Accounting, Program Management, Health Services, and a host of others. Global discipline competencies would require the knowledge and experience to apply discipline competencies across cultures.
- 3) **Domain** – A set of competencies specific to the capabilities of a Business. A Government Contractor may include a workforce knowledgeable and experienced with avionics, artillery, or M&S. Other industries may focus on competencies associated with washing machines or travel services. A language competency would fall in this category, if a second language was desirable, and is considered to be a global competency. An Avionics competency example is listed in Table 2. Knowledge of the ARINC Standards would constitute a global competency.
- 4) **Cognitive** – Systems Engineering requires a different set of cognitive competencies (the mental processes of perception, memory, judgment, and reasoning) than a Software Engineer might possess, although there may be some areas in common. (Frank 2006) proposed ten cognitive characteristics that could be used to assess competency, and may also provide insight into global competency.
- 5) **Environmental Sustainability** – Sustainability focuses on achieving balanced solutions that account for the social, technological, economic, environmental, and political constraints. In this example, *environmental sustainability* was chosen as the concept focus. Environmentally safe electronics and electronics manufacturing processes (filtering), equipment, materials (replacement of lead-based solder and other hazardous materials) and practices such as disposal are all considerations in achieving sustainability. Environmental impact goes beyond the selection of “green” materials to include the environmental costs to manufacture and transport the materials. It could also include the impact to the environment due to the cutting of trees to make paper that engineers use as they print

specifications and other documentation during product development, and the light sources they use during product and system development.

- 6) **Behavioral** – A set of attributes and soft skills, such as “employee dedication”. Michigan State University administered a survey to capture what behaviors organizations desire globally-competent graduates to possess. The results of the survey are captured in Table 2 under the Behavioral competency category.

In the Table 2 example, we have illustrated a set of global Avionics Systems Engineering competencies. Not all Avionics Systems Engineers would be expected to possess all of these competencies, although several would attest to a stronger SE background. (Arnold 2006) maintains, “Flexibility of a Systems Engineer to use multiple skills as the Life Cycle phases evolve, allows for a more stable work force pool since a Systems Engineer could evolve from requirements to design to verification focus, dependent upon the emphasized need of the program phase”. A Systems Engineer and their Manager should first determine what is needed for the group as part of the workforce as flowed down from business needs. The Manager would then identify competency targets the individual would and should meet in a specific time frame to complement competencies of other individuals, extrapolated to whatever unique business or enterprise is applicable.

**Table 2. Global Avionics Systems Engineering Competency**

<b>Enterprise</b> (Applies to All Employees) <b>Examples:</b> <ul style="list-style-type: none"> <li>▪ Ethics</li> <li>▪ Security</li> <li>▪ Time</li> <li>▪ Charging</li> <li>▪ Safety</li> </ul>	<b>Discipline</b> (Applies to SE Discipline) <b>Examples:</b> <ul style="list-style-type: none"> <li>▪ Requirements Engineering</li> <li>▪ Risk and Opportunity Management</li> <li>▪ Baseline Control</li> <li>▪ Technical Planning</li> <li>▪ Technical Effort Assessment</li> <li>▪ Architecture/Design Development</li> <li>▪ Qualification</li> <li>▪ Verification</li> <li>▪ Validation</li> <li>▪ Process Definition</li> <li>▪ Tool Support</li> <li>▪ Training</li> <li>▪ Systems Integration</li> <li>▪ Quality Assurance</li> <li>▪ Specialty Engineering</li> <li>▪ Other</li> </ul>	<b>Domain</b> (Applies to Capabilities) <b>Avionics</b> <b>Examples:</b> <ul style="list-style-type: none"> <li>▪ A615a</li> <li>▪ DO178B</li> </ul> <b>Avionic Units</b> <ul style="list-style-type: none"> <li>▪ Primary Flight Display</li> <li>▪ Multi-Function Display</li> </ul> <b>Signals</b> <ul style="list-style-type: none"> <li>▪ ARINC 429</li> <li>▪ Ethernet</li> </ul> <b>Implementation</b> <ul style="list-style-type: none"> <li>▪ COTS HW Configuration</li> <li>▪ Networking</li> <li>▪ Reusable Avionics Architecture</li> </ul> <b>Flight</b> <ul style="list-style-type: none"> <li>▪ Pilot</li> <li>▪ Simulator</li> </ul>	<b>Cognitive</b> (Applies to SE Thinking) <b>Examples:</b> <ul style="list-style-type: none"> <li>▪ System-Level Interconnections and Closed-loop Thinking</li> <li>▪ System Synergy</li> <li>▪ Multiple Perspectives</li> <li>▪ Creative Thinking</li> <li>▪ Tolerance for Ambiguity and Uncertainty</li> <li>▪ Implications of Proposed Changes</li> <li>▪ Immediate System Understanding</li> <li>▪ Analogies and Parallelisms Between Systems and Disciplines</li> <li>▪ Limits to Growth</li> </ul>	<b>Environmental Sustainability</b> (Applies to Specific Business Need) <b>Examples:</b> <ul style="list-style-type: none"> <li>▪ Atmospheric Radiation</li> <li>▪ Materials Hazards</li> <li>▪ Disposal</li> <li>▪ Composites</li> <li>▪ Power Consumption</li> <li>▪ Sustainability</li> </ul>	<b>Behavioral</b> (Applies to Individuals) <b>Examples:</b> <ul style="list-style-type: none"> <li>▪ Initiative</li> <li>▪ Enthusiasm</li> <li>▪ Inquisitiveness</li> <li>▪ Self-reliance</li> <li>▪ Self-confidence</li> <li>▪ Self-control</li> <li>▪ Self-knowledge</li> <li>▪ Positive outlook</li> <li>▪ Independence</li> <li>▪ Appreciation of Diversity</li> <li>▪ Perseverance</li> <li>▪ Creativity</li> <li>▪ Flexibility</li> <li>▪ Comfort with uncertainty</li> <li>▪ Open-mindedness</li> <li>▪ Language and communication skills</li> <li>▪ Assertiveness</li> </ul>
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Each of the competencies identified should include a skills description of what is meant, to help diffuse ambiguity. For example, the SE discipline competency of System-Level Understanding would include the following description (Frank 2006),

“System-Level Understanding – Understand the whole system beyond its elements/subsystems/assemblies/components functions as part of the entire system. Understand how subsystems integrate into a whole system, aimed at fulfilling predetermined requirements and specifications.

Understand the system and the environment in which it performs. Understand mutual relationships and interconnections, discerning change patterns, understand that problems are not solved by breaking it down into constituent elements, finding a separate solution for each of its elements”.

**Pictorial Horizontal Dimension.** The pictorial horizontal dimension of our Competency System would be Knowledge Source (KS) levels instead of the (Kasser 2007) third dimension of, “the types of problems posed in each area of the network”. Knowledge Source levels address the extent of knowledge and where the knowledge came from, i.e. experience, education, etc. The Rote Learning Knowledge Source (RLKS) is comprised of the extent of knowledge gained from learning through courses or self-study. The Experiential Learning Knowledge Source (ELKS) is gained through experience; on-the-job-training and mentoring.

It is recommended that only four pairs of KS levels be assessed. An odd number, such as five levels result in most individuals selecting the middle bracket, a high-peak normal distribution curve. A distribution with most falling in the middle does not provide much insight into whether the competency does or does not exist. Four levels enforce a more binary result whereby an individual either has the knowledge and experience or not.

KS levels are enhanced with a top level description and skills applicable to each level defined. Table 3 integrates the KS view. The skills specified are a derivative of Bloom’s Taxonomy of Cognitive Skills (Bloom 1956). Although they more effectively address the needs of individuals in an academic learning environment, many were applicable to this model.

**Table 3. Knowledge Source Definition**

KS Level	KS Level Description	KS Level Skills
RLKS 0	Awareness	define, label, list, memorize, name, order, recognize, relate, recall
ELKS 0		
RLKS 1	Comprehension	classify, describe, discuss, explain, express, identify, indicate, locate, recognize, restate, translate
ELKS 1		
RLKS 2	Synthesis	arrange, assemble, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, integrate
ELKS 2		
RLKS 3	Mastery	apply, perform trades, demonstrate, dramatize, employ, illustrate, interpret, practice, schedule, solve, author, teach, analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, experiment, question, test, evaluate, appraise, assess, defend estimate, judge, predict, rate
ELKS 3		

It is recommended that a set of competencies be derived from a top-down flow of the organization’s strategy and objectives to the individual’s objectives. During strategy and objective development, it would be best if the organization knew how the strategy and objectives would be used. Competencies assessed at an individual level would be aggregated to form a multi-dimensional basis for Workforce Competency, with an

emphasis on global attributes. Ideally, an organization would develop a concept of what they would like the competency distribution to be in say, five years. The concept and Global Competency Model results would be compared, and a roadmap developed indicating where further education, training, experience would be need to be acquired through hiring, organizational restructuring, and career enhancements. The Global Competency Model would consist of a current state view and a targeted future view.

**Global Systems Engineering Competency Model.** Combining the pictorial dimensions, our Competency Model might look something like Table 4. Note that the third pictorial dimension, Competency Layers (Table 1) is not visible in this two dimensional view, although it could be applied from the Enterprise Layer through the Root Layer. This Competency Model might be administered via a tool as simple as Microsoft Excel, or implemented in tools designed for performance assessment and development.

**Table 4. Multi-Dimensional Competency Model**

Competency	Competency Description	Awareness		Comprehension		Synthesis		Mastery	
		RLKS 0	ELKS 0	RLKS 1	ELKS 1	RLKS 2	ELKS 2	RLKS 3	ELKS 3
<b>Enterprise</b> Competency 1	Competency 1 Description								
<b>Enterprise</b> Competency n	Competency n Description								
<b>Discipline</b> Competency 1	Competency 1 Description								
<b>Discipline</b> Competency n	Competency n Description								
<b>Domain</b> Competency 1	Competency 1 Description								
<b>Domain</b> Competency n	Competency n Description								
<b>Cognitive</b> Competency 1	Competency 1 Description								
<b>Cognitive</b> Competency n	Competency n Description								
<b>Environmental Sustainability</b> Competency 1	Competency 1 Description								
<b>Environmental Sustainability</b> Competency n	Competency n Description								
<b>Behavioral</b> Competency 1	Competency 1 Description								
<b>Behavioral</b> Competency n	Competency n Description								

A limited set of competencies, those that are the most critical to the business, is preferable to an extensive list. Understanding business core competencies and the need to build upon them is a vision in stark contrast to seeing the company as a collection of discrete businesses. As a goal, it is recommended that a limit of 25, four to five from each of the six competency categories above, be the upper limit in quantity of competencies in order to capture maximum value of what is important to your business. This forces the developer of the competency model to focus on business strategy. If strategic planning determines that Environmental Sustainability competencies are more critical than Behavioral competencies, then increase the number and depth of Environmental Sustainability competencies, and reapportion others across the categories, or limit the

competency categories. The goal is to identify where a business is and needs to be, in order to compete in a global market.

**Competency Development.** The (G2SEBOK 2003) emphasizes the need for Competency Development, “Competency development is the means by which a person gains levels of proficiency in current competencies and broadens their span of competencies. To be proficient at both the art and science of SE, a practitioner must develop their competencies by combining work experience, training and education. Most systems engineers do begin their careers in other engineering or related technical disciplines. Initial work assignments in design and design related areas expand to include increased responsibilities in other aspects of product development”.

Individual competency assessment and follow-on gap analysis from the desired and resultant improvement roadmap will help an organization in a number of ways. The (World International Competency University) <http://www.worldicu.ca/> advertises that an assessment will:

- Define where the employee is in alignment with the desirable skills of the organization
- Provide a common language the organization employs to describe their desires
- Connect the mission, vision, and values of the organization with goals and objectives of the individual
- Facilitate employee development (personal and professional)
- Provide a Portfolio of Competence™ for the individual that documents a transcript or list of competencies the employee has achieved
- Bridge the divide between theory and practice
- Foster confidence in employees as they succeed in mastering specific competencies
- Provide connections and outcomes identified within a set of similar job profiles and or across different job profiles
- Evaluate each participant's ability to perform essential job skills in real time
- Support multiple learning approaches with multiple acceptable outcomes
- Weave personal and cultural practices of organizations together in concert with the marketplace of activities and societal requirements
- Satisfy employers' needs for a knowledgeable and skilled workforce

(Davidz et al. 2007) recommend in step 4 of 5 *Steps to Develop Systems Engineering Capability* to, “Build quality control mechanisms into the systems development program to show if the development program is working effectively”. Quality control mechanisms would also be an advantage in competency assessments. Assess Systems Engineering competency at the individual, business and enterprise levels, watching for opportunities to incorporate global competencies where it makes business sense.

### **3. Global Business Competency Challenges**

Along with the rapidly changing technologies, the emergence of new, fast-growth economies, and changing awareness and concerns for our planet, come the need to ensure the workforce and organization is competent to meet the changes and challenges. These factors are valid reasons why companies should consider competency assessment and

competency development, as they translate into business opportunities. Competency development is particularly important in the area of Systems Engineering. Competency assessment and development transcends commercial, government/military, and education and research applications. As with any business initiative, challenges are in abundance.

**Competency Adoption Challenge.** Competency challenges begin with the need for recognition by organizations that identification of competencies are of value and critical to understanding their workforce, leveraging the knowledge to enhance competitiveness in the marketplace. The organization and the individual employee benefit from the identification of competencies, as strengths and weaknesses are identified to help chart a purposeful course for the future. Competency identification has a strong link to employee development. It also has a strong link to organization strategy and objectives per the organization's vision.

**Management and Leadership Challenge.** The identification of competencies themselves, pose additional challenge and is not as easy as it first appears. There are trade-offs to choosing the competencies desired. Are the competencies chosen to measure the current organizations competencies realistic? Are they detailed enough to be discerning at the Competency Levels applied? Are they too detailed? Are they the "right" competencies? A well-defined common understanding of each competency across all the organizations and levels applicable to your particular culture and situation is ideal. The answers to these questions won't be known until a competency program is implemented and measured, with adjustments made accordingly.

(Roe 1995) indicates that "the knowledge and skills of Systems Engineers are the same as those of project management in the areas of management expertise, technical breadth and technical depth". Roe adds that the difference in application is that the System Engineer has more technical breadth, while the Project Manager has more management expertise. (Bottomly et al, 1998) studied the roles of the Systems Engineer and the Project Manager and identified 185 activities and their competencies (experience and knowledge). Their findings concluded that:

- No competency was assessed as being purely the province of systems engineering.
- There is no sharp division between the two disciplines (Systems Engineer and the Project Manager

(Johnson 1997) supports the overlap in his statement, "Today's organizational paradigm contains three overlapping evolving disciplines (project management, systems engineering and operations research) attempting to solve the same problems from three different perspectives.

The World Health Organization (WHO) has identified six challenges for competency management. <http://www.who.int/employment/competencies/en/> (WHO) suggests we create an organization capable and competent in developing the:

- 1) Products or services customers need
- 2) Perception of products or services a customer can't live without

- 3) Product or service functionality based upon solutions driven by the need to simplify, save time, are safe, that integrate with other products and services, and are environmentally friendly, inducing “green”, environmentally safe and economically sound, concepts during their development, production, deployment and disposal.
- 4) Organizational environment into an empowering, and motivating environment to guide and motivate the workforce towards meeting challenges and achieving objectives to promotes ownership and responsibility for desired outcomes at all level.
- 5) Plan for the use of resources by identifying priorities in accordance with the Business strategic directions in the form of action plans and monitoring the outcomes.
- 6) Partnerships across organizations and cultures to provide information, assistance and support to the Organization using Systems concepts and synergies.”

In addition to the above, WHO developed three additional behavior-based competencies for Leadership, recognizing that Managers and Leaders are often seen as two distinct functions. (Bennis 1961) was one of the first to point out the two are not one and the same. He identified 12 differences between managers and leaders. Key is his concept that managers focus on systems while leaders focus on people. He also indicates that managers do things right, while leaders do the right things.

The WHO challenges for Leaders include:

- 1) Driving the Organization to a successful future through demonstration of a broad-based understanding of the growing complexities of the organizational issues and activities, by creating a compelling vision of shared goals, and developing a roadmap for successfully achieving real progress in improving the Organization’s growth and profitability.
- 2) Promoting innovation and organizational learning to invigorate the Organization by building a culture that encourages learning and development.
- 3) Promoting the Organization’s position in global leadership by coordinating, planning and communicating in a way that attracts support from intended audiences.

Who would be better trained and positioned to demonstrate a broad-based understanding of growing complexities of organizational issues and activities than Systems Engineering leaders? Systems Engineering leaders, particularly those with cross-cultural and global competencies, are certainly at the forefront of those leading in the quest for business success. Opportunities for management and leadership aimed at defining new solutions to old and new problems arise daily.

**Diversity Challenge.** Global competency is more than identifying global knowledge and skills. (Grovesell 1998) believes experience reveals that “the key to opportunities for global growth is to *proactively*, view diversity in terms of *differences in the human values and behaviors* of employees, partners, consumers, and other stakeholders worldwide.”

(Groveswell, 2004) indicates that diversity research has been collected for decades. This research indicates that, in business organizations:

- Human differences can contribute to enhanced unit performance: heterogeneity of ideas and perspectives leads to greater creativity and much broader applicability of solutions.
- Human differences also can create barriers, so they need to be skillfully leveraged; building performance synergy in a culturally diverse, far-flung unit is as complex as it is urgent.”

Groveswell, <http://www.groveswell.com/Consult/Global.pdf>, further indicates that, “Value and behavior differences need to be leveraged for an informed, systemic approach to globalization that:

- embraces new patterns of thinking and behavior grounded in business-oriented anthropological and intercultural research
- generates infrastructures, systems, and processes that support the leveraging of human value differences for global revenue growth.”

In order to achieve global diversity, domestic enterprises must convert to global diversity by changing the behavior of their workforce. Table 5 is indicative of the conversion.

**Table 5. Workforce Conversion to Global Business Competency**

<b>Workforce Competency</b>	<b>Business Competency</b>
Change people-related behaviors Transform hiring & promotion practices	Change business-related behaviors Transform infrastructures & systems
Demographic inclusion in the workplace Fairness & equal opportunity in promotions Broader appeal to customers at home	Adaptability across borders & cultures High performance with international partners Broader appeal to customers worldwide

**Environmental Challenge.** The INCOSE International Symposium has designated the 2008 theme to be, “Systems Engineering for the Planet”. They maintain that, “Systems Engineering principles and perspectives can improve the sustainability of our planet. Sustainability is concerned with achieving balanced solutions that account for the social, technological, economic, environmental, and political constraints” (INCOSE 2008).

(Haskins 2007) believes that “Sustainable development measures the degree to which a firm focuses on environmental-economic and socio-economic performance. The hypothesis is that waste is a symptom of poor use of resources with the resulting negative economic impact; therefore, cleaner production, green energy, and use of renewable raw materials are both more sustainable and good business. Similar analogies exist in attention to the health, safety and welfare of employees. Companies that band together in industrial parks have special opportunities to cooperate and share the costs of recycling services, child care facilities, and canteens, to name a few examples.” Sustainability is big business these days, resulting in changed business objectives driving the need for additional competencies to accommodate sustainability.

Green awareness contributes to enterprise profitability beyond technology and capability enhancements. It also may lead to competencies in using fewer physical resources in the day-to-day operations such as less reliance on paper, reduced lighting usage when personnel are not in their offices and conference rooms, usage of public transportation, and smarter usage of heating and cooling.

**Risk Sharing and Global Business Challenge.** Those companies that are competent in managing complexity, using Systems Engineering principles, seem to be the winners in our global competency race. The challenge is to leverage alliances with other enterprises, capitalizing on global opportunities and monetary risk sharing. Examples of success are becoming more prevalent.

The Boeing 787 Dreamliner is the newest and latest aircraft within the Boeing Commercial Airplanes (BCA) family currently being developed. Boeing is one of the first large corporations to venture into global risk sharing. With the 787 program, they retain only about 35% of the total Boeing 787 work share. Boeing is certainly known for its commercial aircraft assembly capability. Historically, they have also been known for their Systems Engineering integration competency. Boeing is now leveraging their suppliers to take on more of a systems integrator role, providing more integrated components and managing their own sub-tier suppliers. This is the first time Boeing has outsourced the entire wing design and manufacturing to external suppliers (e.g., to risk-sharing partners Fuji Heavy Industries, Ltd. - the center wing box; Kawasaki Heavy Industries, Ltd. – the main wing fixed trailing edge; Mitsubishi Heavy Industries, Ltd. the wing box). Boeing's competencies have shifted as a result.

In return for asking suppliers to carry all of the non-recurring costs, they give back to their risk-sharing partner suppliers the intellectual rights on the components or systems they provide. The alliance is designed such that if the aircraft does well in the marketplace, their risk-sharing partners derive direct benefits in the form of revenues above amortized non-recurring investments based on initially-agreed-on expected volume. The first-tier (major suppliers) is responsible for the detailed interface definitions work and Boeing acts as referee in case of conflicts, a separate set of competencies.

Not only is an awareness of shifting competencies within your own organization beneficial, the knowledge of your competitors and where their dynamic competencies lie adds further complexity to mapping your organizations future target competencies. Competencies should be adjusted as your organization changes strategically.

**Erosions of Core Competencies.** (Prahalad et al 1990) warn that “Few companies are likely to build world leadership on more than five or six fundamental competencies”. The intent is that the five or six, would flow down through business strategy alignment to the 25 or so proposed at the Individual Layer. (Prahalad et al 1990) continue their guidance that, “Companies that judge competitiveness, their own and their competitors, primarily in terms of price or performance of end products are courting the erosion of core competencies or making too little effort to enhance them. Watch for erosions of core competencies due to cost cutting measures and the exit of an aging workforce with the knowledge, not passed on to younger generations”. This is a global issue, but is not present in all organizations or cultures.

**Summary.** As market boundaries change, diversified enterprises can no longer focus on end product markets. A competency system, flowed-down from enterprise and business objectives and strategy to a workforce comprised of an individual's competencies with a global Systems Engineering focus, was proposed as a business advantage. These individual competencies will result in *emergent competencies*. In order to gain a cross-sectional and multi-dimensional view of a competitive, global strategy, a five-tier, multi-dimensional Global Systems Engineering Competency Model example, is proposed as a basis for development of a competency system unique to your own business.

Competency challenges, including competency adoption, diversity, environmental, risk sharing, and global challenges can all be seen as opportunities, if strategic direction accepts the challenges, and monitors erosions of their business core competencies. Competency development *does* come at a price, as strategic planning, Systems Engineering, and the implementation of the concepts require effort, but it does not necessarily require outspending the competition in research and development. Having the right mix of skills, especially in Systems Engineering, at the right time will aid in success. Add to the Business competencies the words "Global" and "Sustainable", and the business prospects and possibilities expand rapidly. Identification and implementation of a global Systems Engineering competency system IS a business advantage.

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## Biography

Eileen Arnold, CSEP, is currently employed as a principal systems engineer at BAE Systems in Fridley, Minnesota. She is a Certified Systems Engineering Professional with over 25 years of

experience in the engineering and management of hardware, software, and systems. Her varied experience includes product development, modeling and simulation management, SE competency identification, manager of quality assurance and configuration data management, manager of measurement and analysis, and systems process and course curriculum development and deployment management, for both the commercial avionics industry and defense sectors. She holds a B.S. in Electrical Engineering and a B.A. and M.A. in Geography. She is currently a member of the INCOSE Technical Leadership Team, a member of the Certification Advisory Group (CAG), and Certification Application Reviewer. She was a primary instigator in the formation of the Heartland Chapter of INCOSE in Cedar Rapids, Iowa, and served as one of the early Presidents. She has held the office of President, INCOSE North Star Chapter, in the Twin Cities area of Minnesota and is the Director of Business and Academia, editor of the Chapter newsletter *The Integrator* as well as acting web master for the chapter web site.