Application of a Global Systems Engineering Competency Framework

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Abstract. This paper was written to provide a competency model implementation example, emphasizing a usable competency framework as a continuation of the well-received International Council on Systems Engineering International Symposium 2008 paper entitled, "*Global Systems Engineering Competencies: A Business Advantag*e (Arnold, 2008). The framework addresses activities in the form of a case study for implementing a global East Meets West, 3-D Systems Engineering competency model at a hypothetical company, Global Avionics Proactive Systems (GAPS). The motivations for the development of this framework are based on the author's perceived business need for visualization of the lean, rapid creation and deployment of a 3-D competency framework usable at several layers of a global enterprise, applicable to a wide range of industry, government, and academic situations.

Introduction

Motivations. This paper was written to provide a competency model implementation example, emphasizing a usable competency model framework as a continuation of the International Council on Systems Engineering International Symposium 2008 paper entitled, "*Global Systems Engineering Competencies: A Business Advantag*e (Arnold, 2008). The activities provided in this paper provide additional detail in the usage of the Arnold global East Meets West, 3-Dimensional (3-D) Systems Engineering (SE) competency model utilizing a hypothetical case study to aid in visualization. "Having a standard, or framework, for competency is essential. However, it is fairly meaningless unless some mechanism for carrying out the assessments can be defined. Such a mechanism should be defined in a *competency assessment process* that will provide the capability for competency assessment and may, therefore, itself be assessed." (Holt et al, 2008)

The motivations for the development of this framework include:

- The author's perceived business need for the rapid creation and deployment of a 3-D competency model through the use of standards,
- A model with enough depth to be usable at several layers of a global enterprise,
- Applicable to a wide range of industry and academic situations, and
- The need for visualization of a competency framework life cycle.

The competency models available often stop at the theoretical, leaving the implementation details to the adopter. The development and implementation details have been witnessed to be a costly endeavour, as the reality of the complexity of the decision-making sets in. The flexible, modular, 3-D Competency Model forms the basis in which to improve the application of a simple global competency model using Systems Engineering as the cornerstone for the example, recognizing the need for flexibility in breadth and depth of organizational layer knowledge and experience.

There are more complex models and profiles available from consultants and publicly available papers, including a 4-D model (Ondore, 2004) with five knowledge source levels, if a more complex model and profile is desirable. This author has recognized that true value is often captured via simplicity, not complexity. Complexity tends to dilute the focus as to what is truly needed to improve an organization's competencies.

This paper seeks to provide enough detail for an organization to visualize and therefore eliminate the guess-work of implementing a competency system, reducing or eliminating costs by communicating enough detail to provide lean, value-based guidance to the adopter. Competency framework consultants may be a valuable resource, dependent upon the competencies your organization already possesses. At a minimum, the paper provides a contextual understanding of what to accomplish and ask for from a consultant in order to improve communication between your organization and a consultant. The framework encourages tailoring with built-in flexibility for your unique implementation. It was designed to circumvent competency identification and implementation paralysis.

Competency Model Background

The United Kingdom (UK) Chapter of INCOSE has been at the forefront of evolving a competency model (UK Chapter, 2004). Their framework identifies four knowledge sources levels and the recognition that a competency framework can be used to:

- Tailor/complement/supplement enterprise competency frameworks,
- Profile an enterprise,
- Profile a team,
- Provide job/role descriptions,
- Enhance recruitment,
- Identify gaps in a skill base.

Their model, supported and developed by a breadth of global government, defense, and universities with sites in the UK, base their systems engineering core competencies on key systems engineering standards such as the ISO15288 (ISO/IEC 15288, 2002), Capability Maturity Model Integrated (CMMI, 2006), EIA/IS 731.1 (EIA 731.1, 1999), INCOSE Guide to the Systems Engineering Body of Knowledge (G2SEBOK, 2003), NASA SE Handbook, (NASA Systems Engineering Handbook, 1992), and IEE/BCS Safety Competency guidelines (IEE/BCS, 2002). This INCOSE model serves as a major inspiration to the Arnold model and framework.

Although the UK Model provides top level guidance, a more robust visualization is desirable; with tailoring, of course! True to form, "Any time a group of experienced systems engineers gather to discuss "what SE is", divergent opinions emerge" (Baughman, 2008). Of particular interest, although not captured in this example framework, is the identified Effective Indicators of Knowledge and Experience (UK Chapter, 2004). Arnold has chosen instead, "years of experience" as a separator to alleviate some of the subjectiveness of knowledge source levels. In any case, model instantiation should be based on market need for your application and the refinement of existing principles, standards, concepts, techniques, etc.

Competency Model and Profile Application

Definitions. There are as many definitions for "Competency" as there are for "Capability", often using the same definition for both. This author distinguishes between the definitions for Capability and Competency, recognizing the reader may use other definitions as applicable. Capabilities will be considered to be the physical manifestations of technology, both the end products/systems and the physical infrastructure required to design, develop, manufacture, produce, verify and validate a technology or service. Competencies will refer to the knowledge and experience, skills, abilities, and attributes of an organization, made up of individuals' personal competencies.

Planning a Competency Model Framework. Systems Engineers are well-suited to lead the framework development effort due to their cognitive skills and cross-discipline experience, but should not be the only members and stakeholders of a Competency Leadership Team. Include members of senior leadership and representative layers of management, in addition to engineers. Timely decisions are one of the keys to success. If decisions are not being made in an efficient and effective manner; the Competency Leadership (CL) Team may need to employ a vote or assign a single "competency framework architect" to make the final, timely decisions. One of the recommended methods for rapid development and deployment is to reuse already-defined sources of roles, competency definitions, etc. obtained from standards or other available sources, including in-house documentation. Avoid creating from scratch. If it makes sense to tweak the standard definitions/descriptions, do so to satisfy the company needs, but only if agreement can be reached quickly. If this results in decision delays, either appoint a chief architect to make the final decision or revert back to definitions already captured in the literature, using a majority vote.

Defining your organization's needs for what you want to achieve in terms of results will be different from organization to organization and dependent upon the timing of implementation. What satisfies an organization's needs one year rarely satisfies the organizations needs the following year as a result of the dynamic nature of an organization and desire to improve. This dynamic behaviour should be expected and welcomed, as organizational stagnation would result in loss of competitiveness.

Planning begins after there is recognition that development of a global competency model may help an organization achieve enhanced business success. As an aid, the Systems Engineering Handbook (SEHBK, 2007) Life Cycle Stages could be employed as a life cycle model after tailoring. Planning is an interactive activity, occurring throughout the life cycle. Within each of these stages, requirements are developed, forming the basis for the competency system decisions.

Table 1: SE Handbook Life Cycle Stages

LIFE CYCLE STAGES	COMPETENCY FRAMEWORK PURPOSE
CONCEPT	Identify stakeholders and stakeholders' needs Explore competency framework concepts Propose viable solutions
DEVELOPMENT	Refine competency framework requirements Create solution description Build competency framework system Verify and validate the competency system
PRODUCTION	Produce the competency system Inspect and test [verify] the system
UTILIZATION	Deploy the competency system to satisfy needs
SUPPORT	Provide sustained capability and maintenance
RETIREMENT	Store, archive, or dispose of the competency system

The primary activities in the first four stages of the competency framework life cycle encompass the activities identified in Figure 1. The *support* and *retirement* stages are also recognized as integral stages of a competency framework life cycle.

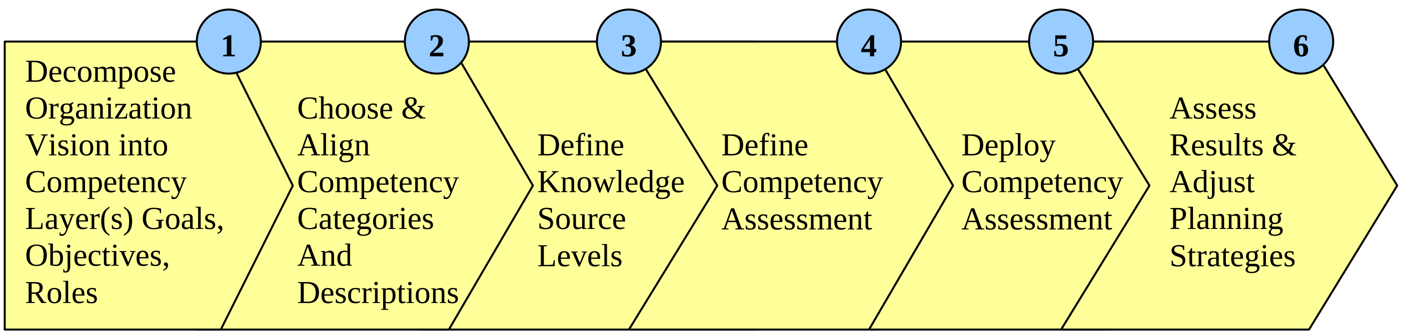


Figure 1. Activities Defining the Competency Model Definition and Implementation

Case Study Setup. Each activity will be explained in the following paragraphs in the context of a hypothetical company case study. The company, Global Avionics Proactive Systems (GAPS), is a global company with enterprise sites on three continents; Singapore, U.K, and U.S. The business includes both government and commercial customers. Their primary business capability centers on avionics, with competencies in the design, development, and integration of a family of avionics systems. The realization of the need for a global competency model was triggered by their enterprise layer vision.

GAPS identified a Competency Leadership (CL) Team early on, assigned a Project Manager, a Chief Systems Engineer, and a Systems Engineering Supervisor, all from different sites, as the core team members. The Chief Systems Engineer was assigned the role of architect and decision maker, chosen for her ability to listen and make timely decisions in a "big picture" context. The CL team identified their stakeholders, added additional members to the CL team and then identified various competency models and sources of competencies available.

One of the models identified, was the Arnold global competency model, Figure 2. Although the model indicates six *competency category* examples, GAPS understood tailoring was expected. This full model would be used if a broader base of competencies were important to an organization's growth and alignment with their vision. Figure 2 is indicative of a company that would focus on the SE expertise discipline with a defined set of cognitive competencies associated with the SE discipline, avionics domain, and environmental sustainability. Additionally, competencies under the competency categories of enterprise and behavioral are shown for a grand total of 27 competencies, a recommended maximum number for any competency assessment.

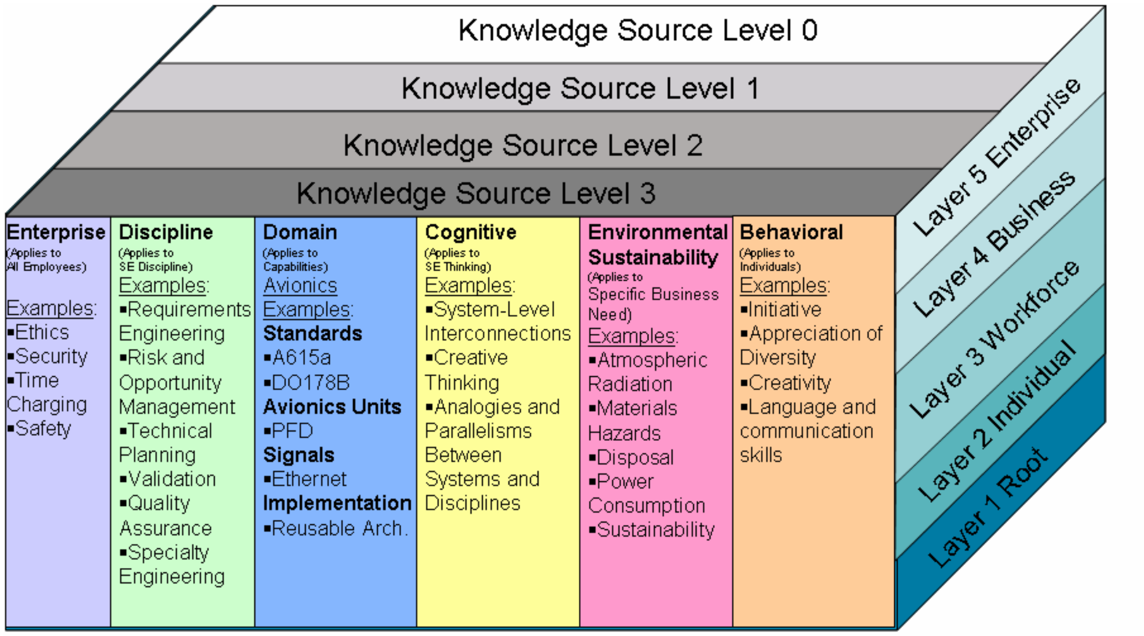


Figure 2. Arnold 3-D SE Competency Model

The top dimension, Knowledge Source Level, includes the recommended four levels of assessment ratings. Knowledge Source (KS) levels are refined to include Rote Learning Knowledge Source (RLKS) levels, the extent of knowledge gained from learning through courses or self-study and Experiential Learning Knowledge Source (ELKS), knowledge gained from experience. The four Levels include:

3 – Mastery
2 - Synthesis
1 - Comprehension
0 - Awareness

The layers of competency include a pick-list of five organization strata, Table 2. Implementation of the model would rarely include all layers, unless the organization was quite large, with complex needs flowed down through a corresponding set of goals, objectives, and competencies.

Table 2: 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.

Keep in mind that, "If a competency profile is to be used for hiring, career development, succession planning or formalized appraisal, then the process for building the competencies must be legally defensible and the process has to demonstrate that the competencies are predictive of high performance on the job. It is usually considered legally defensible when competencies and competency profiles begin with the responsibilities, accountabilities, and tasks the business assigns to each position" (Steele, 2007). Activity 1 supports this important concept.

Activity 1: Decompose Organization Vision into Competency Layer(s) Goals, Objectives, Roles. GAPS determined that a competency model would help them leverage a strategic business advantage over their competitors if enterprise layer (all three sites combined) core competencies were attained within a three year period. GAPS recognized the difference between basic competencies and core competencies. Basic competencies are those competencies that exist in an organization applied to the day-to-day business dealings. Core competencies are discriminating competencies applied to affect an edge over the competition.

The steps within Activity 1 include:

1. Review/align/create a business vision, goals, objectives, aligned to a strategic plan,
2. Align/determine a flow down of the vision/goals/objectives, and
3. Assign job roles to employees.

Activity 1, Step 1: Review/align/create a business vision, goals, objectives, aligned to a strategic plan. GAPS had established the need for assessing competency in their strategic plan, with a well-aligned vision in accordance with that plan.

GAPS Vision: To be the Systems Integrator of choice for global aircraft avionics.

Activity 1, Step 2: Align/determine a flow down of the vision/goals/objectives. Aligning their goals and objectives of the organization to the vision and values of the organization led to the goals and objectives captured in Table 3, created by their Senior Leadership Team, consisting of their President, Vice Presidents, and Engineering Directors of the enterprise. The Senior Leadership Team was composed of the primary creators and supporters of the Strategic Plan which outlined the need to improve the avionics SE integration competencies across the enterprise.

Table 3: GAPS Goals and Objectives

Vision: To be the Systems Integrator of choice for global aircraft avionics.		
Goal		Objective
Time frame: 3 years		**Time frame: 1 year**
Goal 1:	Instill Avionics Systems Engineering Integration Competencies across the Enterprise.	**Objective 1:** Identify enterprise layer SE integration competencies gap rolled up from employees assigned the role, "Avionics Systems Integration Engineer".
		Objective 2: Set 3-year enterprise layer SE avionics competency target for employees assigned the role, "Avionics Systems Integration Engineer".
		Objective 3: Attain 25% enterprise layer competency targets for the Avionics Systems Integration Engineer Workforce by July 31, 2010.

*Activity 1, Step 3: Assign job roles to employees***.** GAPS previously had assigned roles to each of their employees across the enterprise. Their vision aligns well with one specific role; that of *Avionics Systems Integration Engineer*.

Activity 2: Choose & Align Competency Categories And Descriptions. Recognizing the short time-frame allocated to achieve the aggressive enterprise competency targets, GAPS found the simple Arnold global competency model to work well for the organizational need, resulting in a jump-start in competency planning with minimal refinement and agreement negotiation. They retained other competency models for reference. Their approach to competency identification was conservative. They focused on the core competencies required for their business success, recognizing there were numerous basic competencies the GAPS enterprise possessed, that were indeed important, but not the primary focus of their current strategy based on their Strategic Plan. Several of their employees who had worked at other companies previously had witnessed numerous companies pursuing competency implementation with 40 or more competencies. It would have made competency planning lengthy, diluting the direction the business expected to focus on. GAPS knew the number of competencies chosen for gap analysis and subsequent alignment to the business needs should be around 25, maximum, but chose only five, to ensure they achieved a concise, focused set of competencies to match their goals.

Now that the competency goals were agreed to at the enterprise layer and with a role chosen, competency categories, competencies, and descriptions were the next targets for decision-making.

The 3 Steps identified within Activity 2 are:

1. Choosing Competency Categories,
2. Choosing Individual Competencies, and
3. Choosing Competency Descriptions.

Activity 2, Step 1: Choosing Competency Categories. The Arnold global competency model identified seven potential competency categories. The *enterprise category* was designated as a basic competency category by GAPS, as was the *behavioral category*. An action item was created to further investigate the *environmental sustainability category* for potential incorporation in GAPS' Strategic Plan at the next annual update, but was eliminated as a competency category to address this first year.

In order to satisfy the objectives, GAPS determined that three of the sample competency categories identified in the Arnold global competency model were the best suited for a determination of the gaps in employee competency. The competency categories chosen, tied directly to the vision flow down to objectives as follows:

- The *Discipline* of Systems Engineering with a focus on Integration,
- The *Domain* of Avionics, and
- The *Behavior* Characteristics of Systems Engineers.

Activity 2, Step 2: Choosing Individual Competencies. The Chief Systems Engineers from across the GAPS enterprise were identified as stakeholders. They chose to focus on a minimal set of individual competencies for each of the competency categories, aligned with the enterprise organization's vision and objectives. They recognized *emergent competencies*[1] (Arnold, 2008) would most likely appear, analogous to Michael Fagen's "Phantom Inspector" (Fagen, 1976), a methodology GAPS had used for their software inspections.

Two competencies, *Requirements* and *Integration Engineering* were deemed the focus of GAPS' competency model for the discipline of SE, since most of the projects at the GAPS enterprise sites were in the concept and development stages, moving towards the production stage.

A single competency was chosen for the avionics domain competency category, that of *standards*. The standards identified were global avionics standards and SE standards. GAPS wanted to ensure the SE discipline standards were applied to the competency assessment in addition to avionics-oriented standards. To place the ISO 15288 standard under the SE discipline instead of the avionics domain was a possibility. The CL team decided to focus on standards as a whole, hoping to capitalize on emergent competencies resulting from the integration of discipline and domain standards. Lastly, two of Moti Franks' (Frank, 2006) behavioral systems competencies were chosen as the core competency focus, those of *system-level understanding* and *system synergy*. These were chosen because they embodied the intent of the vision and flowed down objectives better than the others.

Activity 2, Step 3: Choosing Competency Descriptions. GAPS reviewed the INCOSE "Systems Engineering Core Competencies" (U.K. Chapter, 2004), Moti Frank's systems behavioral competency descriptions, the SEHBK process "Purposes" and INCOSE's certification competencies http://www.incose.org/educationcareers/certification/rightforme.aspx, as a source for each of the competency descriptions. Trade-offs were discussed. A decision was made to adopt the INCOSE certification competency descriptions for *Requirements* and *Systems Integration*, definitions already integrated into the engineering process at GAPS across the enterprise.

[1] Emergent Competencies are 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.

Activity 3: Define Knowledge Source Levels. GAPS reviewed the INCOSE "Systems Engineering Core Competencies" (U.K. Chapter, 2004) and the Arnold global competency model, this time as a source for differentiators between the *competency levels*, both for ELKS and RLKS. It was felt by the CL team that the "Systems Engineering Core Competencies" (U.K. Chapter, 2004) differentiators were too subjective; deciding to go with the differentiators contained in the Arnold Model, based on years, Table 4. This activity contains a single step that is crucial for defining the attainment of levels.

Table 4: Rote and Experiential Knowledge Levels

Level	Experience (ELKS)	Rote Knowledge (RLKS)
3 - Mastery	More than 5 years	3 or more years
2 - Synthesis	3 - 5 years	2 - 3 years
1 - Comprehension	1 - 3 years of Experience	1 - 2 years
0 - Awareness	Less than 1 year	Less than 1 year

Activity 4: Define Competency Assessment. Developing the tools and instruments of assessment deployment are, of course, critical in the development life cycle.

There are three Steps that further define Activity 4:

1. Determine which Tool would be used to administer the Assessment,
2. Create the Competency Assessment Instrument, and
3. Define Templates and Reports.

Activity 4, Step 1: Determine which Tool would be used to administer the Assessment. A competency assessment tool needs to be identified after the implementation of the model is sufficiently understood to identify tool requirements. Administration of a competency assessment model across the enterprise would require administration of the roll-out and capture of the assessment results in report form, as identified in requirements captured early in the competency assessment planning. At GAPS, tool discussions centered on using a spreadsheet for administration, which would automatically capture results in graphs used for reporting. Additionally, the creation of a web-based tool was discussed along with the use of creating a new application using PeopleSoft, the tool used at two out of three GAPS enterprise sites for other applications. PeopleSoft was eliminated for two reasons; 1) the tool was not being used across ALL sites and 2) there would be a long lead time to develop a compatible application.

A compromise of using a web-based application (a basic competency recognized at GAPS) to capture the information and data, whereby spreadsheet reports could be generated, was decided to be the most efficient and effective method.

Activity 4, Step 2: Create the Competency Assessment Instrument. The CL team created a spreadsheet for framework implementation as a prototype for the web-based Competency Management Tool (CMT). The spreadsheet appeared as in Table 5, which was then incorporated into the web-based application.

Table 5: Sample Competency Assessment Spreadsheet

Role: Avionics Systems Integration Engineer			
Competency	Competency Description	Knowledge Source	Rating
Discipline: SE **Competency: Requirements Engineering**	Analyzing customer and stakeholder needs, generate/develop requirements, perform functional analyses, derive requirements, ensure requirements quality, allocate requirements, control requirements, maintain requirements database, develop and implement Requirements Management Plans, develop measures of effectiveness and performance.	**ELKS:** **RLKS:**	
Discipline: SE **Competency: Integration**	Defining technical integration strategy, develop Integration Plans, develop integration test scripts, develop and implement integration test scenarios, conduct and document integration tests, track integration test results and retest status.	**ELKS:** **RLKS:**	
Domain: Avionics **Competency: Standards**	Understanding of ISO15288 Systems Engineering Lifecycle, EIA 632, 600 Series ARINC Specifications and Reports, ASTM F 2639 - Practice for Design, Alteration and Certification of Airplane Electrical Wiring Systems.	**ELKS:** **RLKS:**	
Cognitive: SE **Competency: System-Level Understanding**	Understanding the whole System and seeing the "big picture 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.	**ELKS:** **RLKS:**	
Cognitive: SE **Competency: System Synergy**	Understanding that a system is more than a collection of parts. Understand system properties, capabilities, and behaviors emerge from the system parts. The whole is more than the sum of the parts. Knowledge that Systems have emergent properties that do not exist in their individual parts.	**ELKS:** **RLKS:**	

Activity 4, Step 3: Define Templates and Reports. The CL team developed a framework mock-up of competency input templates and reports to validate their expectations among their peers. The CL team recognized the need to develop an *enterprise target profile* and a separate *supervisor target profile*. The CL team also recognized that the best teams are made up of individuals with differing strengths. Not all SE's need to have identical knowledge and expertise. "Systems engineering is a naturally broad field. No one engineer will perform all systems engineering activities at once…" (Sheard, 2008).

The reports were enhanced, as the stakeholders provided feedback to refine the look and feel of the reports, and adjust the graphics to depict what was desired. The three basic reports included target values for the enterprise and individual layers, a score summary sheet, and the profile graphs, with the gaps identified. A sample template for a Supervisor is provided in Table 6. A series of these tables can be strung together for a Supervisor team view.

Table 6: Supervisor Enterprise and Individual Target Values Template

Employee	Experiential Knowledge			Rote Knowledge		
<Employee Name>	Enterprise Target	Supervisor Target	Employee Knowledge	Enterprise Target	Supervisor Target	Employee Knowledge
Requirements Engineering	1	0		1	0	
Integration Engineering	2	0		3	2	
Standards	2	1		2	2	
System-Level Understanding	2	2		2	3	
System Synergy	2	1		2	1	

Activity 4, Step 4: Administering the Competency Assessment. Activity 4, Step 4 was borrowed and expanded from a human resources government workforce *succession planning model*, http://hr.dop.wa.gov/workforceplanning/mgmtcomp.htm. The CL team should communicate what is about to be rolled out to the Supervisors at the various sites during the planning, to alleviate surprises and gain a commonality of purpose, including the supervisors as members of the CL team when appropriate; recognizing them as key stakeholders in the model development aspects appropriate to their team needs. *All affected employees need to know ahead of roll-out what is expected and the benefits of competency assessment.*

After the end-to end planning is in place and to the degree competency assessment deployment risks are low, inform employees of the decision to roll out a competency assessment and what it will mean to them. Inform the management team first.

Communicate: Inform employees of the possible job opportunities that are anticipated over the designated time period (e.g., next three years). Communicate what key competencies are needed for those jobs. That is, what level of demonstrated skills and knowledge is management looking for in potential candidates for these jobs? Inform employees of the competency process that the organization intends to use (e.g., the steps in this model).

Identify Employee Interest: Give employees the opportunity to indicate interest in possible job openings and willingness to participate in competency planning activities. Clarify that participation in competency planning activities. Clarify that participation in competency planning is not a guarantee of advancement. However, participation could increase one's chances.

Develop Competency Plans: The Supervisor in conjunction with the employee prepares an individual development plan that outlines specific activities that the employee engages in to develop needed competencies. Include a timetable with milestones for assessing progress. The list of activities and timetable should be reflected in the employee's engineering development plan. In addition to individual plans, it may make sense to have a group development plan applicable to core competencies for a particular occupation level in which all interested employees should participate.

Provide Development Opportunities: Help the employee follow through with the development plan by setting up training options and providing realistic time to participate in the training activities indicated in the employee's development plan. The employee should also take personal responsibility to take the initiative and seek out activities that will help develop the targeted competencies. This display of initiative and follow through can show that the employee is serious about succession and may, in itself, be a core competency. Training options go well beyond the traditional classroom setting and do not have to be costly. Examples of development activities include mentoring, job shadowing, task force participation, special projects/assignments, Internet and journal research, conferences, time-limited job rotations, video/audio tapes, committee participation, etc.

Activity 5: Deploy Competency Assessment. After careful planning and with the tools in place, report formats set, and stakeholders informed, the time had arrived for deployment, a single step.

Deployment for GAPS entailed communicating the location of the web application, providing a date by which the competency assessment should be completed. A two-week time frame was decided upon by the stakeholders. GAPS ensured definitions were in place for all words in the assessment that might be misconstrued. They provided access via phone number and email to two

CL team members in case there were clarifications or questions the SEs taking the assessment might have. The progress on number of engineers completing the assessment was monitored with reminders sent periodically communicating the goals and needs of the organization.

Activity 6: Assess Results & Adjust Planning Strategies. After the two week deployment period, the first results were available. The assessment tool was disabled to enforce a hard freeze on data collection to prove that the assessment system was stable.

There are two steps to Activity 6:

1. Assess Results,
2. Adjust Planning Strategies.

*Activity 6, Step 1: Assess Results***.** The competency assessment was administered to determine the level of competencies GAPS had at the time the assessment was administered. The data-populated templates captured current profiles for the enterprise layer and for the workforce layer, which they equated to their three sites. Table 7 illustrates the data acquired for one site in terms of the number of assessment takers falling below the enterprise target. This view compares the numbers falling below target for the workforce site and the enterprise as a whole.

Table 7: SE Competency Gaps for the Organization and Enterprise

Role: Avionics Systems Integration Engineer					
Competency	Competency Description	Knwldg Source	Entrprs Target Value	Layer 3 Org Workforce # Emplys. Below Trgt	Layer 5 Entrprs # Emplys. Below Trgt
Discipline: SE **Competency: Requirements Engineering**	Analyzing customer and stakeholder needs, generate/develop reqts, perform functional analyses, derive reqts, ensure requirements quality, allocate reqts, control reqts, maintain reqts database, develop and implement reqts management plans, develop measures of effectiveness and performance.	**ELKS:**	1	3	17
		RLKS:	1	4	20
Discipline: SE **Competency: Integration Engineering**	Defining technical integration strategy, develop Integration Plans, develop integration test scripts, develop and implement integration test scenarios, conduct and document integration tests, track integration test results and retest status.	**ELKS:**	2	10	39
		RLKS:	3	12	52
Domain: Avionics **Competency: Standards**	Understanding of ISO15288 Systems Engineering Lifecycle, EIA 632, 600 Series ARINC Specifications and Reports, ASTM F 2639 - Practice for Design, Alteration and Certification of Airplane Electrical Wiring Systems.	**ELKS:**	2	2	123
		RLKS:	2	2	123
Cognitive: SE **Competency: System-Level Understanding**	Understanding the whole System and seeing the "big picture beyond its elements/subsystems/assemblies/components functions as part of the entire system.	**ELKS:**	2	5	64
		RLKS:	2	2	48
Cognitive: SE **Competency: System Synergy**	Understanding that a system is more than a collection of parts. Understand system properties, capabilities, and behaviors emerge from the system parts. The whole is more than the sum of the parts. Knowledge that Systems have emergent properties that do not exist in their individual parts.	**ELKS:**	2	8	45
		RLKS:	2	9	45
			Total Gap	**57**	**576**

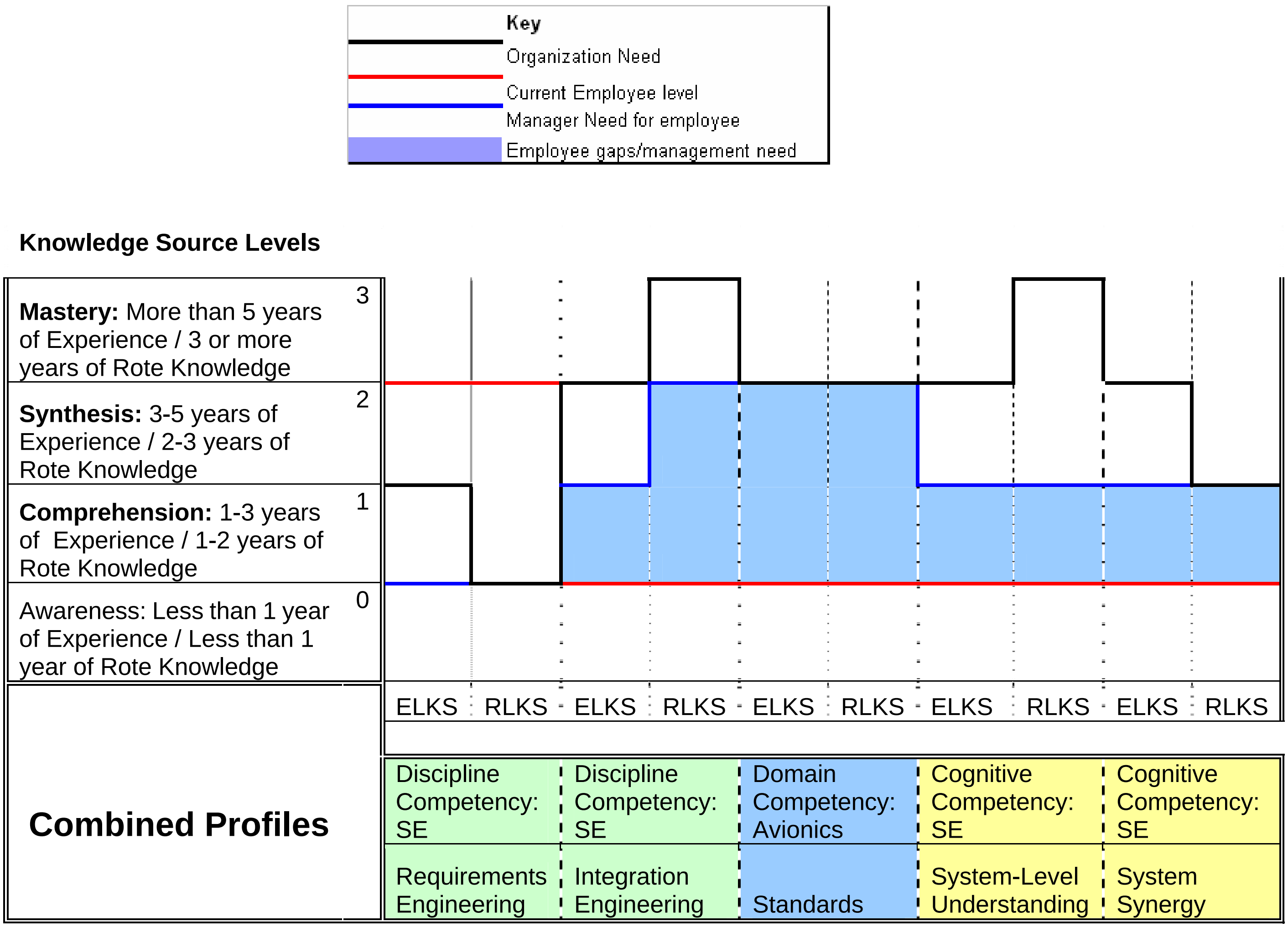
Additionally, the Supervisors had their own needs for data roll-up which were generated according to stakeholder needs, similar to Table 7, although not illustrated here. Profile views consisting of a suite of views corresponding to each of the data roll-up views were also central to the assessment.

An illustration of the profile for an individual, Table 8, indicates the target lines by colors identified in the Key. The profile indicates the employee is marginally deficient in experiential knowledge for integration, system level understanding, and system synergy. The employee has the least experience with the application of standards. Since the business objective indicates a three year compliance window, the employee's Supervisor must provide an opportunity for the employee to gain the necessary on-the-job experience, captured in the employee's performance development plan.

The profile indicates, for rote learning, deficiencies in integration and standards, and marginal needs for system level understanding, and system synergy. The Supervisor chose to have the employee sign up for a series of local systems engineering university courses as part of a continuing education program for all but the standards. The employee was assigned a mentor and given a reading assignment to satisfy the rote requirement.

Employees may rate themselves too highly or conservatively compared with others. The ratings are a starting place for discussions between the Supervisor and employee.

Table 8: Profile Example for an Individual Employee indicating Gaps



The employee and Supervisor must discuss the ratings to validate the results and to discuss the individual employee competency needs and plan of action. These ratings are private between the employee and Supervisor.

The CL team analyzes the enterprise and workforce profiles to determine where the organization is heading. If differences are significant across the enterprise each site may offer knowledge transfer or short term mentoring assignments.

The capture of other measures may be of interest to collect such as, “How long did the average assessment taker spend completing the assessment?”

Activity 6, Step 2: Adjust Planning Strategies. One of the strategy enhancements identified by GAPS, after verifying the system worked as planned, was to allow collection of real-time data as new employees came on board or employees from other areas joined the SE teams. The GAPS Competency Framework Plan was updated as a result.

Remaining Life Cycle Stages – Support and Retirement. As mentioned earlier, the support and retirement stages are recognized as integral stages of a competency framework.

Support provides sustained competency system capability and maintenance for the assessment instrument and tools. Enhancements are expected in a changing workforce environment. Changing a single word in the competency assessment may change the results significantly. Changes to the assessment should be minimal for the years allocated to reach the defined target. In the case of GAPS, the assessment should remain in place for three years. The assessment tool and reports are free to be enhanced, as long as a consistence set of metrics, obtained from a consistent data setup, is maintained.

As with any documentation and tools, there comes a time when the assessment, tools, and reports, are no longer needed. Store, archive, or dispose of the competency system in accordance with your internal retention criteria.

Summary. The paper provides a set of activities and steps to guide an organization interested in creating and implementing a global SE competency model framework. A hypothetical company, GAPS, was used to provide case study insight into the decision-making complexity of creating, and deploying rapidly, a global competency framework based on the Arnold 3-D Competency Model.

Key concepts covered included:

- Visualization of a competency framework life cycle,
- Recommended use of standards,
- Rapid decision-making suggestions for a more rapid framework deployment,
- Template/profile examples to aid in a kick-start, and
- Tailoring guidance.

Please let the author know if the guidance provided within this paper was of use to you and your organization via email to eparnold5@aol.com. Best wishes for YOUR organization's implementation!

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