DEVELOPMEMNT OF A MODELING AND SIMULATION TRAINING NEEDS MODEL FOR SELECTED DEFENSE ACQUISITION WORKFORCE COMMUNITIES

by

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ABSTRACT

The DoD Modeling and Simulation Steering Committee (M&S SC) identified Modeling and Simulation (M&S) as an educational objective for the Acquisition, Technology and Logistics (AT&L) workforce. Notably, past usages of M&S in system acquisitions for both DoD and commercial industry have demonstrated improvements in efficiency and effectiveness over traditional acquisition techniques. However, to achieve expected and consistent performance by this workforce in these new techniques, the M&S essential skill requirements for this workforce may be extensive. This research aims to validate the content and level of competency in selected M&S tools and technology necessary for consistent workforce performance. The notion here is to achieve greater efficiency and effectiveness in the acquisition process through thresholds of competency that must be resident in or available to the acquisition workforce. This research proposes a matrix of training objectives and levels of competency for portions of the AT&L workforce that was validated through survey by individuals who are leading experts in both M&S and acquisition. This effort combines rigorously defined learning objectives and parameters by academia with practical learning insights from the military and industry ground perspectives. The resultant Joint Learning Model aims to identify the workforce educational foundations necessary to achieve more widespread efficiency and effectiveness in current and future DoD acquisitions.

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LIST OF ABBREVIATIONS

ACTT	Air and Command Tactical Trainers
ADDIE	Analyze, Design, Develop, Implement, Evaluate
AT&L	Acquisition, Technology and Logistics
AVCATT	Aviation Combined Arms Tactical Trainer
BFT	Blue Force Tracker
CASE	Computer Aided Software Engineering
CCTT	Close Combat Tactical Trainer
CGF	Computer Generated Forces
CTIA	Common Training Instrumentation Architecture
DACP	Defense Acquisition Change Program
DAPA	Defense Acquisition Performance Assessment
DAU	Defense Acquisition University
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
DTIC	Defense Technical Information Center
ESR	Education Skills Requirement
FCS	Future Combat Systems
HLA	High Level Architecture
I-HITS	Initial Homestation Instrumentation Training Systems

ICMM	Integration of Commercial and Military Manufacturing
IRB	Institutional Review Board
ISD	Instructional System Design
JCATS	Joint Conflict and Tactical Simulation
JCIDS	Joint Capabilities Development Framework
JSIMS	Joint Simulation System
LVC-IA	Live Virtual Constructive- Integrated Architecture
M&S	Modeling and Simulation
M&S IPT	Modeling and Simulation Integrated Project Team
M&S CO	Modeling and Simulation Coordination Office
M&S SC	Modeling and Simulation Steering Committee
MANA	Map Aware Non-uniform Automata
MILES	Multiple Integrated Laser Engagement System
MMOG	Massively Multiplayer Online Game
MOD	Ministry of Defense
MSIAC	Modeling and Simulation Information Analysis Center
MSRR	Modeling and Simulation Resource Repository
MSSOC	Modeling and Simulation Staff Officer Course
NPS	Naval Postgraduate School
OneSAF	One Semi-Automated Forces
OneTESS	One Tactical Engagement Simulation System
OUSD (AT&L)	Office of the Under Secretary of Defense (Acquisition Technology and Logistics)

PLM	Performance Learning Model
PM	Program Management
PGSS	Precision Gunnery Simulation Systems
RAID	Real-time Adversarial Intelligence and Decision Making
RVS	Reconfigurable Vehicle Simulator
SAF	Semi-Automated Forces
SBA	Simulation-based Acquisition
SCORM	Sharable Content Object Reference Model
SE	Systems Engineering
SE Core	Synthetic Environment Core
SEDRIS	Synthetic Environment Data Representation and Interchange Specification
SIMNET	Simulator Networking
SME	Subject Matter Expert
SSL	Secure Sockets Layer
SWOT	Strength, Weakness, Opportunity, Threat
T&E	Test and Evaluation
TENA	Test and Training Enabling Architecture
TWGSS	Tank Weapons Gunnery Simulation System
UCF	University of Central Florida
UML	Unified Modeling Language
VV&A	Verification, Validation and Accreditation

CHAPTER ONE: INTRODUCTION TO DEFENSE SIMULATION-BASED ACQUISITION AND WORKFORCE EDUCATION

The idea to provide common Modeling and Simulation (M&S) environments applicable to acquisition and multiple domains was espoused as a vision in the Department of Defense (DoD) M&S Master Plan (USD(A&T), 1995). But while the concept of simulation-based acquisition (SBA) is not new, its developmental process is still evolutionary and the assimilation of which in the acquisition life-cycle is often constrained by workforce knowledge deficiency and cultural resistance. There is a current shortfall of M&S experts in the DoD Acquisition, Technology and Logistics (AT&L) workforce and M&S training options available (OUSD (AT&L), 2006). Consequently, M&S users and developers are often not adequately trained and lack sufficient understanding of modeling best practices and abstraction techniques to support their work. Additionally, cultural obstacles to simulation reuse and modernization persist, which negatively impact the cost effectiveness of SBA and hinder the realization of its full potential. To provide the general context for this thesis, this chapter presents the growing importance of SBA, commonly recognized as a strategic enabler to current defense transformation. In justifying the need for research in this area, a "levels-of-analysis" perspective (Ostroff Cheri, Ford J. Kevin, 1989) on SBA workforce education is also presented to highlight the current impetus in its development in the US military.

Research Context- SBA as a Strategic Enabler

The proposal to strengthen the use of M&S in defense acquisition was approved as early as the 1990s following the rapid development of simulation technology and uncovering of substantial needs and opportunities for improving the management and coordination of defense M&S activities (Piplani, Mercer, Roop, 1994). The increased affordability of M&S in the ensuing years with its associated project cost saving potential led to subsequent acceptance of the general concept of SBA and its formalization at both the joint and the service levels. Featuring an integrative approach throughout the life cycle of weapon systems, SBA supports the defense acquisition system objectives in system engineering and management while at the same time reduces the risk in cost, schedule and resources. SBA is positioned now in growing importance as a strategic enabler to the current defense transformation efforts.

SBA in Current Defense Transformation

The evolution of warfare through the end of the Cold War and the rise of global terrorism fueled the ongoing transformation in the US military to raise, train and sustain new capabilities to meet the wider spectrum of tasks and missions in the 21st century. In 2003, the DoD adopted the Joint Capabilities Integration and Development System (JCIDS) which promoted a collaborative systems-of-systems capability-based approach to capability development. Of note, the JCIDS provided a new acquisition policy

framework to define the best technical approach within the constraint of cost, schedule and technology maturity to develop, produce and field capabilities aligned to the national strategic direction (CJCSI, 2007). The JCIDS called for a better linkage in the acquisition strategy and consequently brought about a renewed focus on SBA as a vehicle to better drive and integrate the system life-cycle development and management of weapon systems. In parallel, the Acquisition Modeling and Simulation Master Plan was launched in 2006 to improve M&S support to the DoD acquisition process (OUSD (AT&L), 2006). One fundamental objective in this master plan is to "shape the workforce" with required SBA competencies via enhanced training and education.

Projected Benefits

SBA intends to promote a robust and collaborative use of simulation technology that is integrated across the acquisition phases and programs (MSIAC, 2007). If successfully ingrained in the defense acquisition system through institutionalized training, SBA is expected to transform the organization in three aspects namely in its "***process***, ***culture*** and ***environment***". In "process change", SBA will be embedded within the iterative acquisition process to support each phase of system life cycle engineering and management to help achieve an overall reduction in cost and schedule. M&S tools will be effectively exploited by the workforce to appropriately support concept development, weapon systems development, production, test and evaluation prior to and after delivery. In "culture change", SBA will help shape mindsets amongst the AT&L community in the use of M&S and lead to changing roles and responsibilities with the evolution of the new

acquisition culture. In "environmental change", SBA will lead to the formation of integrated and advanced engineering and management enterprises enabled by collaborative distributed engineering and integrated information repository.

SBA Education Needs Assessment- "Levels-of-Analysis" Perspective

To determine the driving forces and considerations for change in SBA education, training needs analysis is fundamental. The analysis in this section forms the key primary step in the Analyze, Design, Develop, Implement, Evaluate (ADDIE) cycle as part of common Instructional Systems Design (ISD) processes. The ADDIE cycle (Figure 1) drives a systems approach in viewing human organizations and activities in which inputs, outputs, throughputs, feedback and control elements are salient features of instructional design (Molenda, 2003). The focus on analysis in this section therefore acts as a primer to the systemic treatment in this research on SBA education in the AT&L organization.

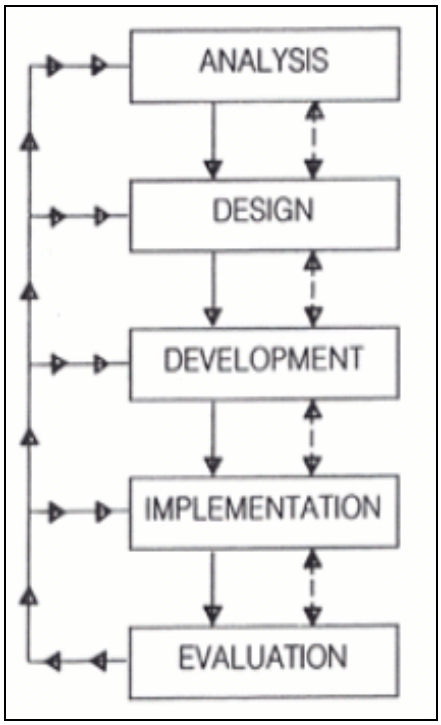


Figure 1: ADDIE Cycle (Molenda, 2003)

The ***levels-of-analysis*** approach was selected to address the needs assessment. This approach posits that events should be viewed not by themselves but within their larger context (Ostroff Cheri, Ford J. Kevin, 1989). It thus provides a comprehensive theoretical framework for the analysis of SBA training needs via explicit acknowledgement of the characteristics at the organization, group and individual levels as part of the entire system. To facilitate this analysis, the defense acquisition system is decomposed into three subsystems at the organizational, operational and person levels, each alluding to the elements directly responsible and affected by the quality of SBA education.

Organizational Level

The Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) or OUSD (AT&L) forms the highest office responsible for the overall defense acquisition system and is defined as the organizational level entity in this training needs analysis. Under the authority, direction and control of the Secretary of Defense, the USD (AT&L) is the principal staff assistant and advisor to the Secretary of Defense and Deputy Secretary of Defense on all matters in relation to the defense acquisition system. The OUSD (AT&L) comprises subsidiary functional cells and units affiliated cross the full range of AT&L functions as illustrated (Figure 2).

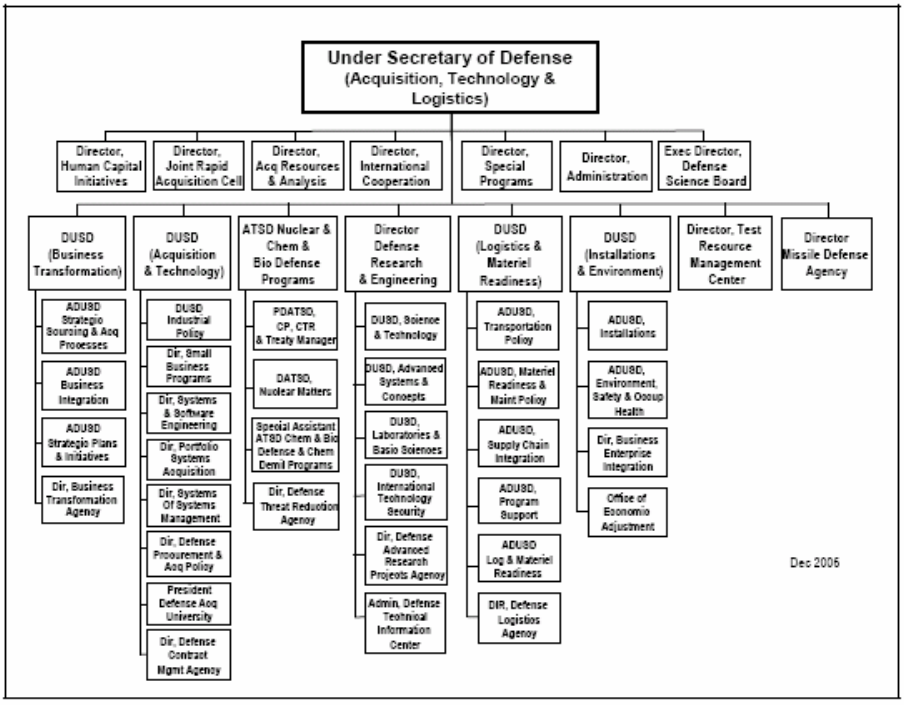


Figure 2: Organization of OUSD(AT&L) (DAU, 2007)

OUSD (AT&L) has a vested interest in the well-being, training and performance level of the AT&L workforce. One of the top priorities in alignment with the acquisition transformation initiatives is the formation of a "high performance, agile and ethical workforce" (DoD, 2007). The Defense AT&L Workforce Education, Training and Career Development Program was commissioned by the USD (AT&L) to provide greater training and development oversight at the organizational level to support the achievement of this goal. Notably, workforce education and training is one of the key functions directly supervised by the DUSD (Acquisition and Technology) under whom the Defense Acquisition University (DAU) is placed as the dedicated unit responsible for training of the AT&L Workforce.

Challenges and Constraints

One of the fundamental concerns at the OUSD (AT&L) level is the impending retirement of the Baby Boomer and older generation workforce, which comprise 76% of the current civilian acquisition workforce (DAU, 2007). The projected loss of experience and knowledge base pose a major organizational constraint in particular to workforce skills training. Aside from quantity, workforce quality has also been an issue of concern at the organizational level. Many recent studies including the Defense Acquisition Performance Assessment (DAPA) review concluded that DoD must continue to improve the acquisition workforce quality (DAU, 2007). Indeed, while the job market is healthy today, concerns have surfaced over the availability of sufficient talents within the science and engineering disciplines to meet future DoD workforce demands.

Compounding these issues are constraints from the effects of funding as well as military operational and force development plans and requirements. Funding for workforce training is limited as a proportion of the defense budget allocated to the defense acquisition system. Time available for training and turnover of the AT&L workforce on the other hand, is compressed by the organizational need to achieve a consistent and healthy throughput of subject matter experts to support military operations and force development. For instance, the long term operational need to support the ongoing war on terrorism including the delivery of time-critical military acquisition projects to support frontline troops underscores the constraint under which the OUSD (AT&L) is expected to ensure that its personnel are adequately trained to deliver its tasks and missions.

Measure of Performance in Workforce Education

At the organizational level, certification and education are the primary objective workforce quality indicators (DAU, 2007). A dual-tracked initiative was introduced by the USD (AT&L) to establish minimum certification rates for all functional communities and also milestone dates for validating certification information on individuals assigned to key leadership positions in acquisition programs. Job positions are only fulfilled by personnel who have been adequately trained and have attained the required certification level. With an improved demand management with certification, training resources could be optimized to assure a desired throughput of trained personnel and then ultimately measured with work performance in efficiency and operational cost effectiveness.

Concept of Measurement

At the organizational level, the concept of performance measurement should necessarily be both the reliability and validity of training. AT&L Core Plus was recently offered as a new framework for AT&L workforce certification on a broad range of competencies common across career and occupational specialized fields, more specialized competencies that relate to an acquisition function and additional training beyond that required for certification to perform certain tasks specific to individual jobs (DAU, 2007). The intent is to provide a very flexible and robust framework that is adaptable to the specific needs of the workforce at work thus meeting validity of training while at the same time, provide consistency of performance measurement across the various acquisition fields with standardization of basic training and performance grading.

Operational Level

Area of Responsibility

DAU, the corporate university dedicated to providing comprehensive acquisition training in the federal sector, is defined as the operational level entity in this needs analysis. Structurally, DAU is organized as an educational institution equipped with a collection of training resources (Figure 3). Its mission is to provide practitioner training,

career management and services to enable the AT&L community to make adequate business decisions as well as deliver timely and affordable capabilities to the war-fighter. With this mission scope in mind, DAU emerges as the major stakeholder at the operational level responsible for the actual delivery of SBA training content to the targeted training audience as well as to maintain quality of training in the acquisition community.

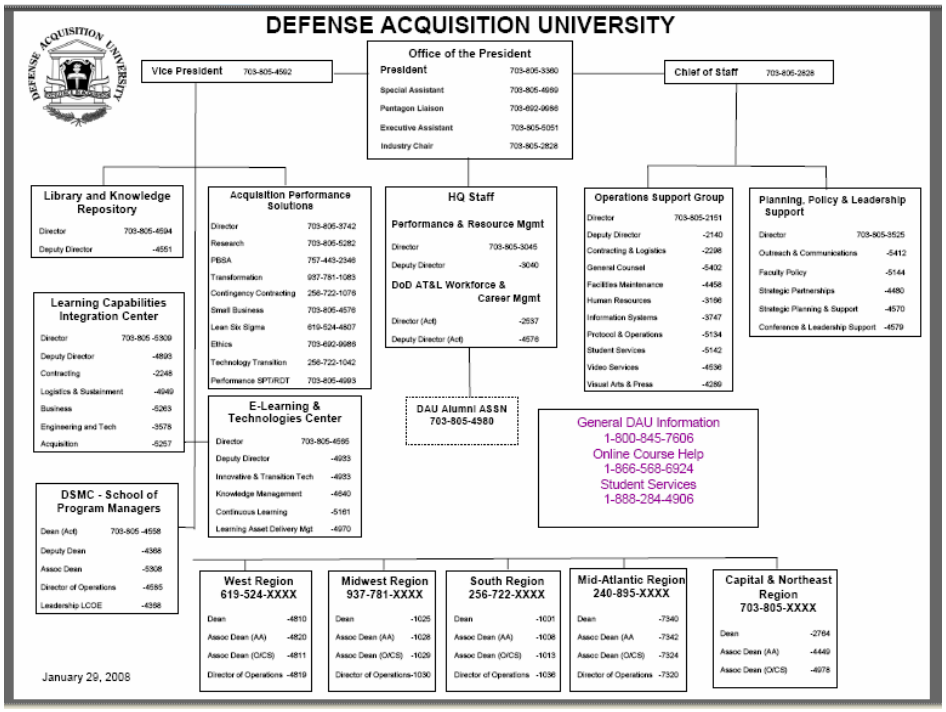


Figure 3: Organization of DAU (DAU website, 2008)

Challenges and Constraints

As a training delivery entity, DAU is constrained directly by the availability of budget and training resources. DAU has reported a 9% reduction in the size of its faculty

population since FY 00 and a stable budget without substantial increase for the seventh year through to FY 06 while the number of students and learning hours continued to rise steadily over the years (DAU, 2006). While most of its courses are continuous learning modules delivered online, the challenges of rising demands pose constraints on learning support and course content development. In fact, M&S training content in DAU certification courses has been found to be deficient in coverage and has remained static over time (OUSD (AT&L), 2006). While the cost per learning hour has decreased over time, demand for a comprehensive and quality education continues to remain high.

Measure of Performance in Workforce Education

DAU adopts the Performance Learning Model (PLM) as the overarching framework to shape an engaging learning environment that offers a range of training courses, knowledge sharing, continuous learning, and performance support with local learning resources and infrastructure available via a learning network. Training content is delivered primarily via the case-study approach to impart basic conceptual understanding of the subject matter and to a greater extent applicable knowledge. Ultimately, performance at the operational level is largely measured by the students' study progression in the number of modules taken and time in which they clear the modules. Additionally the number of graduates per year and cost per head are also monitored and measured against as performance indicators.

Concept of Measurement

Most of the modules offered by DAU are short duration courses offered online to facilitate distance learning and on-demand on-the-job training. As a result, performance is largely assessed on the basis of qualitative understanding of course materials via a common grading system. The concept of measurement at the operational level in DAU is thus crafted on the primary basis of reliability to insure common measurement of standards attained.

Person Level

Area of Responsibility

Each individual member of the AT&L workforce who participates in SBA is classified as the person level component in this needs analysis. His job vocation may range from the program manager, systems engineer or test and evaluation engineer etc. in any of the thirteen career fields in the AT&L workforce. In support of his SBA task, he needs to have a clear conceptual understanding of the principles of SBA, its applications throughout the system life cycle of weapon systems as well as gain deep knowledge of simulation support tools to effectively execute SBA. A direct recipient of the SBA

training, the individual is expected to return to make a contribution in his area of specialization at the end of training.

Challenges and Constraints

The key constraint faced at this level is the constraint of available time to be devoted to education and acquisition of new knowledge, especially so for on-the-job training or part-time training arrangements as in most cases in the AT&L workforce. While DAU courses are generally structured to be short in duration and focused on application learning, mastering of more complex subjects such as SBA and learning to use the associated simulation software will require considerable amount of devotion to learning. Additionally given the complexity of the subject matter, it would place considerable strain on the individual to translate what he learns from training to work application unless he is equipped with a strong technical knowledge foundation or if more extensive training support is made available.

Measure of Performance in Workforce Education

At the person level, performance during training is largely measured by the overall grades the individual attains in each of the modules he undertakes. Additionally, in the process of undergoing the training, his performance is also measured by the level of critique and learning feedback that he receives from attempting every training task

available in his course of study. Beyond training, his performance will be ultimately measured by his ability to leverage the tools and potential of SBA to achieve efficiency at work and support cost effectiveness acquisition.

Concept of Measurement

At the person level, the concept of performance measurement should ultimately be the validity of training that he receives. For he will eventually be exposed personally to the reality of his work environment under which he could be tested to apply his skills in SBA in the most trying of conditions. The grades and training feedback that he attains from his training courses, however reliable the system of measurement, could only serve to prepare him for the challenges in the real world. His training needs to be validated as the ultimate measure of training performance he has achieved.

Framing the Research Question

While the need to better enhance SBA education in the AT&L workforce has been recognized and currently work prioritized in the US military, the "levels-of-analysis" perspective offers an insight into the inherent constructs with respect to the requirements, constraints and performance measurement at each level of the defense acquisition system. It serves to demonstrate that while the training objective is consistent at all levels, to achieve consistent results the different constructs and issues will need to

be addressed ***within*** and ***across*** levels in the following phases of the ADDIE cycle in the development of any new SBA training curriculum.

So globally, the "levels-of-analysis" perspective offers a system view to guide subsequent development work on the new SBA training curriculum. Specific to this research thesis, it will provide the basic framework for addressing the approach and methodology used to design a slice of a new SBA educational curriculum as part of a DoD initiative to enhance AT&L workforce training. The following are the principal considerations for educational curriculum design, synthesized from the "levels-of-analysis" perspective.

Content Development

In recognition of the training and knowledge gaps in SBA that currently exist in the AT&L workforce, the primary step in new educational content development will be to determine specific training needs in the gap areas so that the scope and depth of SBA training currently offered could be improved upon. Content development should also take into account the breadth of content covered by DAU as the prime institution in AT&L to avoid duplication of effort. The new course curriculum should also be aligned with the course certification standards and workforce core skills requirement so as to meet the certification requirements at the organizational level. This concerted approach must be well suited to meet the workforce training needs in a comprehensive and structured manner.

Targeted Audience

OUSD (AT&L) sets a stringent entrance requirement of minimally a bachelor's degree for its job applicants to most of the thirteen career fields in the defense acquisition system. The resultant of this is a highly educated current AT&L Workforce with 74% of the civilians having bachelors or advanced degrees, exceeding that of the entire DoD white-collar workforce (DAU, 2007). Nonetheless, SBA or M&S remains a very niche subject few specialize in their universities and academic training. Henceforth, the targeted audiences of the new course are presumably well educated but lack the foundation training in M&S. Therefore, they should thus be first exposed to foundation level training, as a precursor to higher M&S skill level training where necessary.

CHAPTER TWO: REVIEW ON CURRENT TRAINING SYSTEM AND ALTERNATIVE APPROACH

The "levels-of-analysis" perspective on training in the AT&L Workforce in the previous chapter established broadly the need for enhanced SBA training across all levels to elevate the scope and extent to which M&S can be exploited in acquisition activities. Riding on the broader research impetus laid out in the first chapter, this chapter examines in closer detail the current training system in place via a ***SWOT*** framework, particularly with respect to the delivery of SBA training content. The intent is to determine in a contrasting fashion specific areas where training deficiency in SBA exists with respect to related or conflicting components. Coupling this review is a research survey on a current new approach in place to overcome the deficiencies. Specific research gaps are also identified in the process; they will be addressed as research questions that need to be answered in this thesis. The research task and concept are also introduced in this chapter as a primer to the next chapter on research methodology.

Current AT&L Workforce M&S Training System

The current AT&L workforce enters service with the majority armed with a university degree. In technical functions such as systems engineering and test and evaluation, the graduates should also have been equipped with science and engineering

training such as in engineering, physics, chemistry, mathematics, etc. However having prior M&S educational training or knowledge is not a pre-requisite for entry into service.

Once accepted into service, they are placed on an on-the-job training certification program to keep abreast of professional knowledge and skills acquisition in their areas of specialization. DAU, being the primary training institution in the defense acquisition system, develops the training curriculum based upon the education, experience, and core training required to meet the standards for certification in each acquisition career field. The DAU curriculum includes courses identified by USD (AT&L) as integral to the education and training of personnel in identified positions. These courses are intended to provide unique acquisition knowledge for specific assignments and to help the workforce maintain proficiency and currency with legislation, regulation, policy, program management, systems acquisition, construction, and advanced contract pricing. Annually, certification standards and assignment-specific training requirements are reviewed and updated. Any changes must be approved by the Director of Acquisition Education, Training, and Career Development before they are published in the DAU catalog. To ensure training requirements are being met, DoD and the military services use a centralized management information system that is automatically updated with training and personnel data.

Supporting the area of M&S knowledge propagation, the Modeling and Simulation Information Analysis Center (MSIAC) was established under the then Defense Modeling and Simulation Office (DMSO) and Defense Technical Information Center (DTIC) to support M&S development by providing users with an understanding of M&S best practices, abstraction techniques and context dependencies. MSIAC is also

responsible as a M&S central resource repository to support all source application of M&S including acquisition. It conducts short career courses such as Modeling and Simulation Staff Officer Course (MSSOC), Validation, Verification and Accreditation (VV&A) Workshop and Modeling and Simulation Test and Evaluation Workshop to train personnel in SBA related knowledge fields. Additionally, MSIAC also partners with educational institutions such as George Mason University to conduct tailored certificate courses such as the Models, Simulations and DoD Acquisition Certificate Program on the foundation and application knowledge of M&S specific to acquisition.

Strength

The key strength of this system is its system efficient, on-demand training of personnel via a combination of distance and face-to-face learning mechanisms. The main training delivery center, DAU, is recognized as the best corporate university in the US, and it delivers the most comprehensive acquisition training in the federal sector (DAU, 2007). Its recent awards include the 2006 Corporate University Best in Class Awards for Best Overall Corporate University, Best Mature Corporate University and Best Virtual Corporate University. It is equipped with modern training infrastructure including knowledge sharing tools, web-based performance support and offers resident, online or hybrid courses. To promote a career-long learning culture, DAU adopts the AT&L Learning Architecture, the Performance Learning Model (PLM). Providing the learning framework, PLM integrates all learning activities to enhance job performance and workplace capabilities for all individuals from entry levels through to leadership

positions. Via a three-pronged approach (Figure 4), the PLM offers knowledge sharing, continuous learning and performance support conveniently and economically accessible 24 hours a day, 7 days a week. DAU successfully certified 75% of all individuals filling critical positions while 65% met or have exceeded position level requirements. On the global scale, 66% of the entire AT&L Workforce are certified and 50% have exceeded their position level requirements (DAU, 2007).

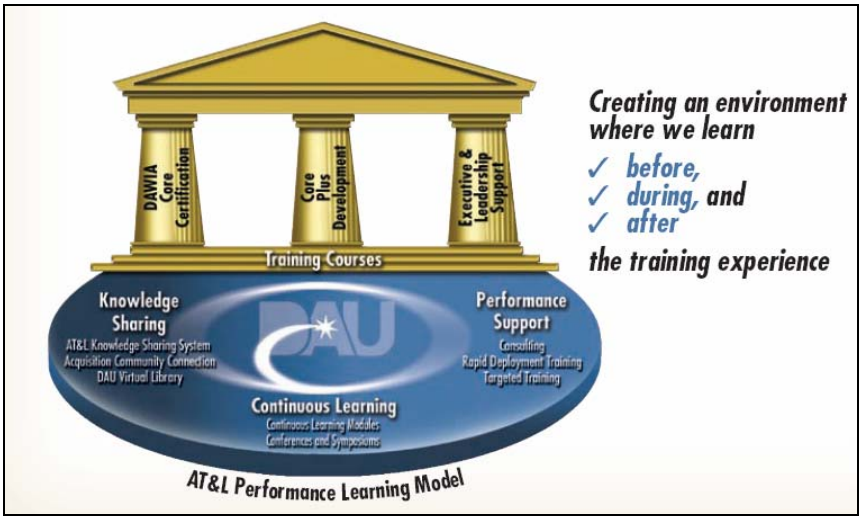


Figure 4: Performance Learning Model (DAU, 2007)

Weakness

There is no specification on candidature experience or training in M&S. As a result there is a shortage of trained subject matter experts in the field of M&S at the point of job entry. Even for senior positions in SBA related fields where advanced degrees are desired, there are no specifications of M&S degree or training as entry pre-requisites in

the DoD 5000 series position job descriptions. Although the system has put in place avenues for personnel to undertake sponsored studies in the specialized field of M&S at universities, many amongst the rest are dependant upon on-the-job training mainly by DAU and MSIAC. But even for this select group of personnel who undertakes M&S courses at academic institutions it was established that while academia is traditionally strong in the theoretical fundamentals of SBA as well as M&S technology and software applications, most academic programs are found to be attuned more to the developers than the users of M&S (Catalano and Didoszak, 2007). Henceforth, many who are sent for such advanced training are equipped more with technical skills in M&S but much less on the management and usage skills of M&S tools to advance acquisition activities.

The current on-the-job training courses offered to the workforce during the course of their career do not offer desired depth of training. Currently, there are only a limited number of online courses on the DAU catalogue that address SBA training requirements. Because these courses are designed to be short online courses, they could not offer content to the level of detail required in the subject matter especially for trainees holding senior appointments. Consequently, while M&S is a growing application field in acquisition and that some best practices already exist in specific areas, there are still broad areas where developers and users are unable to leverage on the experience and unique solutions evolved through lessons learned due to lack of awareness and training (M&S CO, 2006). Notably, MSIAC which has an objective to proliferate best practices in M&S has also not reached its full potential in supporting the acquisition community and has occasionally demonstrated insufficient familiarity with acquisition M&S practices and issues (OUSD(AT&L), 2006).

Additionally, having DAU as the executive training arm with MSIAC and other relevant agencies as proponents of M&S offering different training options poses a challenge to the coherence of the overall M&S training design and structure. There is no common look and feel of these courses and, due to the different modes of delivery these courses cannot be integrated into a coherent whole to effect continuous training (Olwell, Johnson, Didoszak, 2007). Consequently, the absence of continuous and coherent training will likely impact the effective and efficient development of M&S professionals in acquisition. This is so especially for military officers, who unlike most government civilians, experience rotational tours of duty transcending operational and staff functions and are thus constrained by shorter skills development cycles.

Threat

The primary threat to this training model is the projected shortage of engineering and science graduates joining the service in the near term. This burgeoning threat will aggravate the current knowledge deficiency in M&S in the organization for there will be less technically trained personnel in the workforce with the foundation technical knowledge to appreciate M&S. Being a technical subject, workforce personnel will find it hard to grasp the concept of M&S should they not have sufficient grounding in the field. This is of particular concern in the systems engineering and test and evaluation career fields where technical skills are required to facilitate their utilization of M&S technology.

A secondary but pertinent threat is the issue of funding for M&S education. For DAU, since FY 00 it has had a stable budget without substantial increase for seven years

through to FY 06 while the number of students and learning hours continued to rise steadily over the years (DAU, 2006). Concomitantly, the changing business environment outside DoD which saw the integration of commercial and military manufacturing (ICMM) presents new organizational demands on the re-structuring of training and education in the acquisition workforce (National Research Council, 2002). One key research recommendation was the need to create a "commercial acquisition academy" in DAU to offer training in commercial technology and terminology bench-marked with commercial best practices. In the United Kingdom (UK) for example, "commercial upskilling" has been a focus study area in its Defense Acquisition Change Program (DACP) offered by the Defense Academy to increase the level of professionalism of UK Ministry of Defense (MOD) acquisition personnel. Focus areas include program and project management, commercial practices and networking with industrial participation, etc. Contrastingly, the urgency to better equip the US defense acquisition workforce in commercial integration is now exacerbated with current DoD military transformation strategy and ground operational demands in Iraq and Afghanistan which rely on rapid introduction of new technology and replenishment of weaponry essential to force sustainability. The acquisition workforce needs to better understand how best to fully exploit the potential of the commercial base, its processes and technology to meet current threats and challenges.

Opportunity

Despite the challenges, opportunity for growth of the training system lies in the creation of the M&S Steering Committee (M&S SC) and an M&S Integrated Process Team (M&S IPT) to assist the USD(AT&L) in managing departmental common and cross-cutting M&S efforts. The Modeling and Simulation Coordination Office's (M&S CO) mission is to coordinate these efforts. Notably, the M&S CO's M&S Common and Cross-Cutting Business Plan identified the need to better train the DoD workforce in M&S so as to allow a better understanding of the credible uses, capabilities and limitations of M&S and thus support the institutionalization of M&S across the DoD's mission space (M&S CO, 2006). On a parallel track, based on findings of the DAPA Report which uncovered the lack of workforce experience and expertise in AT&L, AT&L launched the Acquisition Modeling and Simulation Master Plan to address amongst a list of requirements the need to "shape the workforce" via an enhanced training system. This mission objective is to be achieved from multiple avenues including assembling the M&S body of knowledge relevant to acquisition to be promulgated via the Modeling and Simulation Resource Repository (MSRR); promulgate the sharing of M&S knowledge via conferences, workshops and visits and expanding the set of DAU courses (OUSD(AT&L), 2006).

New Approach with Naval Postgraduate School

In support of these higher defense organizational objectives, Naval Postgraduate School (NPS) is leading an ongoing effort to design a new M&S educational curriculum to be delivered to 20,000 or more acquisition professionals by 2008 (Olwell, Johnson and Didoszak, 2007). As the lead agency, NPS is currently coordinating a multi-institutional effort with key partner universities in developing the education content for three key groups of AT&L workforce, namely the program mangers, systems engineers and test and evaluation engineers.

System Engineering Approach

A systems-engineering approach (Figure 5) was adopted in the design of the new curriculum. The resulting solution consists of four spirals. The first spiral focused on defining the problem via an analysis on market segmentation of the acquisition workforce, the current resources available, the state of the modeling and simulation body of knowledge, the desired educational outcomes for each market segment, and the gaps that existed between those outcomes and the existing resources. At each step in the process, key stakeholders from the acquisition, test and evaluation and training communities are involved to verify the training needs from the practitioner point of view. In the second spiral, the goal was to construct a learning architecture to cover the gaps identified in the

first spiral. The third and the fourth spirals comprise production runs of final educational products and delivery of the new curriculum.

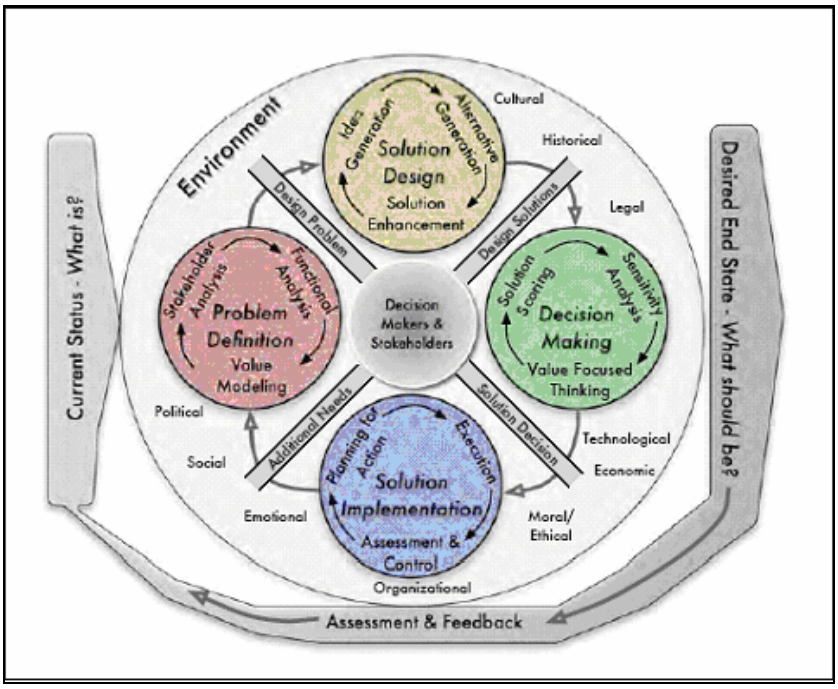


Figure 5: System Engineering Design Process (Olwell, Johnson and Didoszak, 2007)

Work Collaboration

In conjunction with the academic partners, including UCF, five acquisition market segments comprising "process", "program management", "operations" and logistics", "test and evaluation", and "engineering" where M&S will be involved are being studied. Under each of these five segments lies a set of "educational skill requirements" (ESR) which specify the core learning skills required under each of these segments. These ESRs within all five market segments have been vetted by users, sponsors, industry,

academic partners and other stakeholders and have been widely agreed upon as comprehensive in scope (Olwell, Johnson and Didoszak, 2007). Figure 6 shows the list of ESRs belonging to the "engineering" segment, perceived by the stakeholders as a key educational focus area. UCF was allocated ESR E8.

Depending on the system being acquired, a particular subset of these may apply:

E1) Structural Mechanics, Shock and Vibrations - Understand basic structural mechanics including stress-strain relations, buckling and fatigue, shock and vibration, and finite element methods in M&S.
E2) Fluid Dynamics and Weapon System - Understand the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.
E3) Dynamics and Control - Understand the basics of M&S in process and multi-physics (mechanical, electrical & hydraulic) based dynamic system controls.
E4) Thermodynamics and Heat Transfer - Understand the fundamentals of thermodynamics and heat transfer with applications to M&S in engineering power cycles, propulsion and auxiliary system cycle analysis and design.
E5) Materials and Fabrication - Possess a basic understanding of the materials technology associated with manufacturing, welding and corrosion control. Have an introduction to composite, superconducting materials, and fiber optics as applied to M&S.
E6) Acoustic and Electromagnetic Systems - Have a general awareness of the fundamentals of acoustic and electromagnetic wave propagation and application to DoD systems.
E7) Military Platform Systems Engineering - Appreciate the broad-based design oriented M&S approach for complex platforms that interact with air-land-sea-based hardware systems, command and control systems and combat systems.
E8) Computers - Recognize basic computer system architecture, operating systems, networking and introduction to engineering software and their applications. Possess at least a limited proficiency in a structured programming language such as Fortran or C, and be able to use such tools for code development. Gain exposure to finite element/difference codes, with application to solve engineering problems including experience with selected software packages.
E9) Electrical Engineering - Understand basic circuit analysis including DC and AC circuits. Gain an exposure to the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.
E10) C4ISR - Understand the requirement for Command, Control, Communications Computers, Intelligence, Surveillance and Reconnaissance in systems. Understand the basic components, methods and alternatives for transferring information from one point to another both internal and external to the system being considered. Have the ability to analyze all available technologies for achieving rapid/effective/jam-resistant information transfer.
E11) Networks - Understand the principles of networks applied to military applications including physical, command and control, and social networks and their implications for engineering design of system
E12) Environment - Understand the fundamentals of terrestrial science (geology, oceanography, meteorology, and near-earth space science) to describe how systems interact with and are influenced by their environment.
E13) Human Systems Integration - Understand the principles of Human Systems Integration. Describe the applications of M&S to support HSI design and analysis.
E14) Aerodynamics - Understand the principles of aerodynamics with applications to M&S. Understand the cost, schedule, and iterative development nature of simulation testbeds used for flight software development through formal qualification.

Figure 6: Engineering ESRs (Olwell, Johnson and Didoszak, 2007)

Research Gap- Model Building for ESR E8

With the ESRs firmly set in place and verified by stakeholders as key learning competencies in M&S, the research gaps posed to the education partners was the learning model development for each of these ESRs. For UCF, the research task is to develop an educational curriculum with respect to ESR E8. It will be developed cognizant of the learning matrix framework (Figure 7) shared amongst partner institutions which illustrates the matching of the sub-learning components under each ESR to the corresponding level of competency that is required for each of the three career fields personnel targeted for training.

	P13: Understand the trades between using a general model and a custom model, including the VV&A implications.								
	P13.1	P13.2	P13.3	P13.4	P13.5	P13.6	P13.7	P13.8	P13.9
PM									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Application	Mastery	Mastery
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
SE									
Basic	Understand	Understand	Understand	Und					
Intermediate	Understand	Application	Application	App					
Advanced	Understand	Application	Application	App					
T&E									
Basic	Understand	Understand	Understand	Und					
Intermediate	Understand	Application	Application	App					
Advanced	Understand	Application	Application	App					

P 13.1 Define general model and custom model
P 13.2 State advantages of general model
P 13.3 State disadvantages of general model
P 13.4 State advantages of custom model
P 13.5 State disadvantages of custom model
P 13.6 State VVA requirements of general model
P 13.7 State VVA requirements of custom model
P 13.8 Describe situations where each type of model is more appropriate
P 13.9 Given historical examples of each, describe and analyze which is more appropriate

Figure 7: ESR Learning Matrix (Olwell, Johnson and Didoszak, 2007)

E8 Course Development Concept

Conceptually, E8 will be developed into a course that is customized to meet the technical knowledge requirements of the AT&L workforce in program management (PM), systems engineering (SE) and test & evaluation (T&E) career fields. This course will provide insights into the theoretical fundamentals of basic computer system architecture, operating systems, engineering software and their applications. Using a case-based approach, students will gain exposure to practical defense M&S applications and system life cycle management tools to support simulation-based acquisition from the PM/SE/T&E perspectives.

Sub-ESR Itemization

The item of core concern in addressing this research gap is itemization of the sub-ESRs. Indeed, the content upon which E8 will be developed as a course will hinge upon the sub-ESR itemization. These sub-ESRs are crucial in defining the most important and required skills and knowledge across PM, SE and T&E personnel at the three levels of seniority, Level I, II and III based on the job description categorization in DoD 5000 series. At the same time, these sub-ESRs will need to be verified against any duplication both within the core syllabus offered through the NPS collaboration as well as with courses offered by other entities such as DAU and MSIAC.

Levels of Training Competency

Another item of research interest is in the determination of the level of training expertise one would need to attain in each of the sub-ESRs. Based on the given framework, each level of training can be allocated as either of four training competency levels based upon Bloom's Taxonomy namely "general awareness", "understand", "application" and "mastery". The research gap here is to assure that the level of training competency is appropriately identified for the specific targeted audience such that resources are optimized to prevent over or under training the individual.

Training Content

The corresponding research gap to sub-ESR itemization is the actual training content that will be developed under course E8. The training content should offer not just theoretical basics but also case studies of successful implementation of M&S in acquisition. A comprehensive yet concise deliberation of scope and depth of training that commensurate with the level of expertise required will insure that training can eventually both be efficiently and effectively carried out.

CHAPTER THREE: RESEARCH METHODOLOGY

Based on the motivation and planning considerations highlighted in the previous two chapters, this chapter is devoted to the articulation of the concept, approach and execution plan to advance the thesis research. To create the training needs model for ESR E8, a hybrid approach consisting of academic research and military user/defense industry validation is proposed. The ultimate objective is the creation of a comprehensive and rigorously defined set of training requirements supporting the course development on ESR E8.

Research Question

The general research question seeks to address the ***current knowledge gap*** of the defense acquisition workforce in ***M&S tools and technology*** and their application in acquisition programs with respect to UCF's allocated ESR E8. Specifically, it will address the "analysis" and "design" phases of UCF's course development on ESR E8, particularly in strengthening ESR E8 learning matrix proposal with a firm research foundation, in direct contribution to meeting M&S SC Common and Cross-Cutting Business Plan's Workforce Development objective A-WFD-2 in developing DoD-wide competency requirements. In doing so, this research will propose a set of validated learning objectives that are currently in demand by the users of M&S for acquisition but unavailable as yet in the current M&S training system. The outcome of this research will

serve as a basis upon which the next phase of curriculum development and delivery could be based.

Treatment- A Hybrid Approach

The approach to the design of ESR E8 curriculum considers the totality of the acquisition process matched with the highest demonstrated potential with which defense M&S could offer to enhance the process. The central idea is to leverage on the constructive synergy between a bottom-up proposal of a training model from academic research and a top-down validation of the model and study findings from the targeted military users and developers of the training system. This arrangement is constructive as the bottom-up proposal from academic research assures a comprehensively and logically defined baseline learning matrix to be studied upon while the top-down model validation provides practical insights on the training, operational and practical issues. This approach is synergistic as model validation provides the opportunity to strengthen the learning matrix proposal and serves to widen the scope and depth eventually in the development of ESR E8 course content. This is achieved via a two-staged iterative effort as follows.

Baseline Learning Matrix Proposal via Academic Research

As the fundamental step in this two-staged effort, the aim of the academic research is to firmly establish baseline training needs of the AT&L workforce in the subject matter of M&S tools and technology. This is achieved from a review of currently available M&S tools and technology and how are they being applied to defense acquisition. The approach is to comprehensively list all aspects of M&S technology knowledge requirements while at the same time assure that there are no overlaps in training content already currently being offered in the training system. To introduce a practical flavor to learning, popular case studies and product examples will also be cited.

Model Validation from Targeted Military User/ M&S Developers

The secondary step is to engage representative samples of the education stakeholder population in the defense community to assess and validate the proposed learning matrix so as to enhance its scope and rigor as a foundation block for learning architectural development. This is achieved by means of contextual data gathering in the form of surveys to elicit user feedback and requirement in the current employment of M&S in defense acquisition. The aim of the contextual data gathering is to achieve three coherent research objectives. First and foremost, the survey is aimed to elicit user feedback and assessment on the desired state of M&S competency in the acquisition

workforce. With user needs firmly established, the second objective is to utilize user feedback to validate the proposed E8 ESR learning model both in content and learning competency level proposed. As a channel to value-add to the learning model, the third objective is to elicit user feedback on how best to enhance the proposed model both in scope and in depth of content.

Hypothesis Testing

A process of hypothesis testing has been designed to drive the feedback loop of the work cycle between the baseline learning matrix proposal from academic research and model validation from the targeted military users/M&S developers. Essentially, the proposed learning matrix will be put to test via a hypothesis testing scenario in which the proposed learning model will be presented as the null hypothesis while deviations from the model will be presented as the alternative hypothesis.

Null Hypothesis

There are two sets of data presented as null hypotheses in this test. The first set of data (Table 1) presents the proposed list of sub-ESRs containing important training content to be developed in a course in ESR E8. Essentially, these sub-ESRs span topically from M&S theoretical fundamentals, technology and tools to system life cycle management/engineering tools. The concept behind the selection of these sub-ESRs is

based on three key considerations. One key consideration is that the learners are assumed to have no background knowledge in M&S and computer science which reflects a practical reality as no specific M&S entry training requirement is stated in DoD job descriptions for AT&L positions. Learners will need to first and foremost grasp the concepts of computing technology and specific aspects of the computer science and principles that are required in the subject area of M&S. The second consideration is based on the notion that M&S technology and tools can be demonstrated in terms of their creation and modification capabilities as well as in their existence in various environmental domains (e.g. live, virtual etc.). Thirdly, M&S should be viewed as a continuum applicable across the life cycle of any weapon systems. Notably, these are translated into the list of seven sub-ESRs that span the full spectrum of computer science technical base knowledge (E8.1), M&S creation/authoring tools (E8.2, E8.3), M&S types and their application (E8.4, E8.5, E8.6) and M&S system lifecycle engineering (E8.7). The intent is to comprehensively cover the main aspects of defense M&S namely, its science, creation, application and life cycle management and engineering capabilities.

Table 1: Proposed Sub-ESR for E8

E8.1 Demonstrate competency to the level specified in matrix on ***basic computer system architecture***, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory ***structured programming languages*** such as Fortran and C, and the use of such languages for ***software development.***
E8.2 Demonstrate competency to the level specified in matrix on the use of selected ***Runtime software systems*** to build ***M&S scenarios*** to support PMs, SEs, and T&E requirements across the system life cycle. [Case Study: Presagis Vega and AIS SVS]
E8.3 Demonstrate competency to the level specified in matrix on the use of selected ***Intelligent Agent software systems*** to build ***M&S scenarios*** to support PMs, SEs, and T&E requirements across the system life cycle. [Case Study: PEO-STRI OneSAF Objective System, Mak VR Forces with B-HAVE module, and SimBionic]
E8.4 Demonstrate competency to the level specified in matrix on using M&S, interoperability, and intelligent agent software tools to build massively ***online systems*** so as to support T&E with such software systems.
E8.5 Demonstrate competency to the level specified in matrix on how **Live training M&S** is used to ***support training and testing requirements***. [Case Study: Live simulation programs such as the PEO STRI OneTESS (One Tactical Engagement Simulation System) program is used to support key functional/technological areas such as geometric pairing, communications modeling, weapon/ballistic simulations]
E8.6 Demonstrate competency to the level specified in matrix on how ***SMART framework/tools*** are used specifically in ***exploiting virtual training M&S*** to benefit both acquisition and training throughout the system life cycle from the PM/SE/T&E perspectives. [Case Study: PEO-STRI training simulations such as Close Combat Tactical Training System]
E8.7 Demonstrate competency to the level specified in matrix on the use of ***Computer Assisted System Engineering*** tools to support project life cycle development/engineering.

Additionally, the second set of hypothesis (Table 2) posits the specific levels of expertise that is required in training the three targeted groups of personnel, PM, SE and T&E across and within their respective seniority levels. The concept behind the categorization essentially is to insure that training is job-centric so that personnel are trained appropriate to the level required recognizing that personnel and time are finite resources in the organization. The first category of learning objectives (E8.1) being theoretical and fundamental in nature are assigned as lower level training tasks for the PM and T&E who may not in the course of their work necessarily be involved directly in

applying the underlying principles and science of M&S to aid its development to support acquisition. The SE on the other hand may be involved in the coding aspects of M&S development which required an understanding of such core principles. They are hence accorded a higher level of training competency requirement for E8.1. On the second group of learning objectives on M&S tools and technology (E8.2-E8.6), they are generally more attuned to meeting the practical need to create/modify M&S scenarios with available software and applying them in acquisition activities as well as the need to assimilate with proven M&S tools in online/virtual/live/constructive domains so as to gain the leverage on these tools. Being a practical work requirement common to all three career fields, E8.2-E8.6 are given higher competency training ratings for PM/SE/T&E, although PM being more attuned to mainly the management of such tools, are given relatively lower competency requirement ratings. The last category of life cycle management M&S tools learning objectives (E8.7) pertains to meeting the training requirements of life cycle project management which are core responsibilities of the PM, SE and T&E personnel. Consequently, all three job categories are given largely comparative training requirement ratings for E8.7.

This proposed learning model was approved at the educational stakeholder's meeting coordinated by NPS on this project.

Table 2: Proposed Competency Levels for each Sub-ESR under E8

	Lower-level Engineering Skill Requirements						
	E8.1	E8.2	E8.3	E8.4	E8.5	E8.6	E8.7
PM							
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand
SE							
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Mastery	Mastery	Mastery	Mastery	Mastery	Application
T&E							
Basic	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Understand
Advanced	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Understand

Alternate Hypothesis

The alternate hypothesis for the first set of data is that either or both the scope and content of the information presented are not sufficient to address current training needs. On the second set of data, the alternative hypothesis is a mismatch of the competency levels assigned at the different levels. The aim of the validation process is to prove or disprove the null hypothesis.

Experimental Method and Data Collection Protocol

The survey is targeted at representatives of the three main groups of personnel from the PM, SE and T&E communities identified as the key groups who will directly benefit from the successful implementation of this program. Additionally, the survey will also reach out to key defense M&S providers to gather feedback from the industry point of view. The aim of the survey is thus to engage representative sample sizes from each of these groups of the acquisition workforce and the M&S industry, to facilitate subsequent statistical analysis of results. The survey (Appendix B) will be structured in three sections as follows.

Method of Analysis- Section A

Section A will introduce the proposed ESR E8 learning matrix complete with background study and explanation of terms including Bloom taxonomy which is used to grade the required competency level in each of the sub-ESRs. Section A will primarily seek demographical information as well as collect general opinions on M&S training and usage in the subjects' organization. It will comprise a combination of simple close and open questions on these issues. The intent is to provide the context for analysis of findings in subsequent sections. Descriptive statistics will be used to analyze the

demographic information of the subjects as well as chart the subjects' opinions on general M&S usage and development.

Method of Analysis- Section B

Section B will seek the subjects' quantitative feedback on the desired level of M&S competency of the personnel in the PM, SE and T&E career fields in the organization. It will comprise close-ended questions in which subjects will be asked to rate the level of competency desired of personnel in their organization by their grade and position with reference to the competency levels offered by Bloom's Taxonomy. On a scale of 1 to 5, with 1 pegged to "None", 2 pegged to "general awareness", 3 pegged to "understand", 4 pegged to "application" and 5 pegged to "mastery" level of competency, the subject will select the most appropriate choice reflecting their assessment. The intent is to elicit ground perception of the current state of need for M&S competency in each of the sub-ESR areas across the different seniority levels for PM/SE/T&E.

A statistical hypothesis testing will be used to analyze the level of agreement with the proposed Learning Model. Particularly, a non-parametric Wilcoxon Signed Rank Test will be conducted to examine whether the level of competency desired as perceived by the military user/defense industry matches with that proposed by the model. Wilcoxon Signed Rank Test for matched samples is selected as the parametric test of choice, given the properties of this test in supporting unknown probability distribution analysis and the absence of large sample sizes (Mendenhall and Sincich, 2007). The hypothetical population median value will indicated by the numerical representation of

the level of competency proposed by the model with respect to the rating system. This hypothetical population median will be the basis of comparison with all observed ratings in the hypothesis test steps devised as follows at 95% level of confidence (i.e. $\alpha = 0.05$).

Step 1: Two-tail Test

H_0= Observed – Expected (model) = 0

$H_1 \neq 0$

Test Statistics= Wilcoxon Signed Rank

If P> α, fail to reject H_0= 0 at $\alpha = 0.05$

⇨ No significant difference between observed and expected values

If P ≤ α , reject H_0= 0 at $\alpha = 0.05$

⇨ Significant difference between observed and expected values

⇨ Go to Step 2

Step 2: One-tail Test (to determine direction)

H_0= Observed – Expected (model) = 0

H_1 > (or <) 0

Test Statistics= Wilcoxon Signed Rank

If P ≤ α , reject H_0= 0 at $\alpha = 0.05$

⇨ Significant difference and direction of difference between observed and expected values is determined

This hypothesis test will be repeated for all entries in the learning matrix to comprehensively determine the difference between the proposed model and the observed results.

In a similar fashion, the Wilcoxon Signed Rank Test will be applied to provide hypothesis testing of the differences between related samples of observed results at the ***intra-job*** category level as well as the ***inter-job*** category level. This is to facilitate instructional development effort in subsequent research. All hypothesis testing will be conducted with MINITAB statistics software.

Method of Analysis- Section C

Section C aims to elicit user qualitative suggestions on ways to improve the matrix both in scope and depth of content. It will comprise a series of open-ended questions with respect to each of the sub-ESRs. Subjects will be asked to comment on each sub-ESR and contribute by citing case studies and examples where deemed to fit. The intent is to strengthen the learning matrix and lay the work foundation for subsequent content development for a course in ESR E8. A non-statistical treatment of data will be used to qualitatively synthesize information of users' feedback and comments and suggestions on the current learning model.

CHAPTER FOUR: DATA AND ANALYSIS

This chapter aims to collate and analyze data collected from the survey in accordance to the research methodology highlighted in the previous chapter. Demographic data are analyzed by means of descriptive statistics. Quantitative data in relation to the proposed learning model are treated with a combination of descriptive and inferential statistics to adequately quantify differences and agreements between the survey respondents' opinions and those originally expressed via the learning matrix. Qualitative data on the other hand are collated and synthesized. The resultant key product in this analysis is the ***Joint Learning Model*** which fuses the learning objectives and parameters of the originally proposed learning model with practical insights gathered from the survey participants. It comprises the ***Joint Learning Matrix*** which merges the proposed learning matrix with quantitative responses from the survey participants and the ***Joint Learning Thematic Framework*** which synthesizes thematic emphasis, practical insights, knowledge and case studies offered by the survey respondents via open-ended responses from the survey. This Joint Learning Model aims to provide the guiding framework and thematic content to support subsequent instructional design stages.

Research Survey and Participation

To address key issues of this research, an exploratory survey (Appendix B) was prepared to elicit insights and responses from the ground perspective via a targeted

audience in the military, industry and academia. Prior to commencement of the data collection process, the research survey was first submitted and endorsed by the University of Central Florida Institutional Review Board (UCF IRB). Due to the confidentiality of the survey, a waiver of documentation of consent was granted by UCF IRB via a Notice of Exempt Review Status (Appendix A). The survey was subsequently placed online SSL enabled at surveymonkey.com and proliferated to the targeted audience. A total of about fifty to sixty professionals and experts from the field of defense M&S were approached to take the survey. During the six weeks of data collection, a total of twenty seven people (Table 3) responded to the survey and their results were tabulated, forming the basis of this data analysis. Throughout the data collection process, responses were kept strictly anonymous and the respondents were free to answer questions which they felt comfortable with, in accordance to the principles of UCF IRB research guidelines.

Table 3: Survey Participation

	Response Percent	Response Count
View Consent Form	25.9%	7
Skip Consent Form	**74.1%**	20
answered question		27
skipped question		0

Participants' Demography

Career and Education

The organizational background of the survey participants spans from the military, academia and industry (Table 4). The majority, or 58.3%, of these survey respondents are active military personnel while the rest are mostly from the industry (33.3%). Amongst the predominant group from the military, the respondents are chiefly from the US Army. The rest of the respondents are from the US Navy, academia and the Department of Defense. Overall, although the academia was not well represented, a military-industry balance of representation was achieved in this survey.

Table 4: Survey Participants' Career Domain

	Response Percent	Response Count
Air Force	0.0%	0
Army	**50.0%**	12
Navy	8.3%	2
Marine Corps	0.0%	0
Industry	33.3%	8
Academia	4.2%	1
Other (please specify)	4.2%	1
	answered question	24
	skipped question	3

In terms of the educational background of the respondents, the majority possesses higher educational degrees beyond basic levels (Table 5). The top 33.3% hold or are currently pursuing PhD degrees predominantly in the field of M&S and computer science. While M&S was the field of specialization by most with MS and BS degrees, many among the rest are specialized in complimentary disciplines ranging from government and strategic studies, contract studies, business administration and management.

Table 5: Survey Participants' Educational Background

	Response Percent	Response Count
HS (please specify discipline)	8.3%	2
BS (please specify discipline)	33.3%	8
MS (please specify discipline)	**66.7%**	16
Ph.D (please specify discipline)	33.3%	8
answered question		24
skipped question		3

Experience and Specialization

Over 80% of the survey respondents have had more than fifteen years of work or related experience in the DoD. In terms of DoD M&S or related experience, more than half the respondents have had more than fifteen years of such experience. Additionally, almost all, or 90%, of those in active duty or have previously served with the military or are government civilians belong to the rank category of Level 3 (Table 7), the most senior

grade range within the job categories of PM, SE and T&E. In fact, about two-thirds of the respondents are currently serving or have served in these functions in the DoD (Table 7). The rest are affiliated with related fields in science and technology management, requirements development and simulation operations.

Table 6: Survey Participants' Experience in DoD and M&S

	Number of years of DoD or associated experience	Number of years of DoD M&S or associated experience
< 6 years	0 (0%)	3 (12.5%)
6-15 years	4 (16.7%)	8 (33.3%)
16-25 years	14 (58.3%)	10 (41.7%)
26-35 years	5 (20.8%)	3 (12.5%)
> 35 years	1 (4.2%)	0 (0%)
Answered question	24	24
Skipped question	3	3

Table 7: Survey Participants' Career Level and Field of Specialization

	Response Percent	Response Count
Level 1 (Entry: minimum: Military 0-1; Civilian GS-5)	4.8%	1
Level 2 (Middle minimum: Military 0-3; Civilian GS-9)	4.8%	1
Level 3 (Senior: minimum: Military 0-4; Civilian GS-13)	**90.5%**	19
answered question		**21**
skipped question		**6**

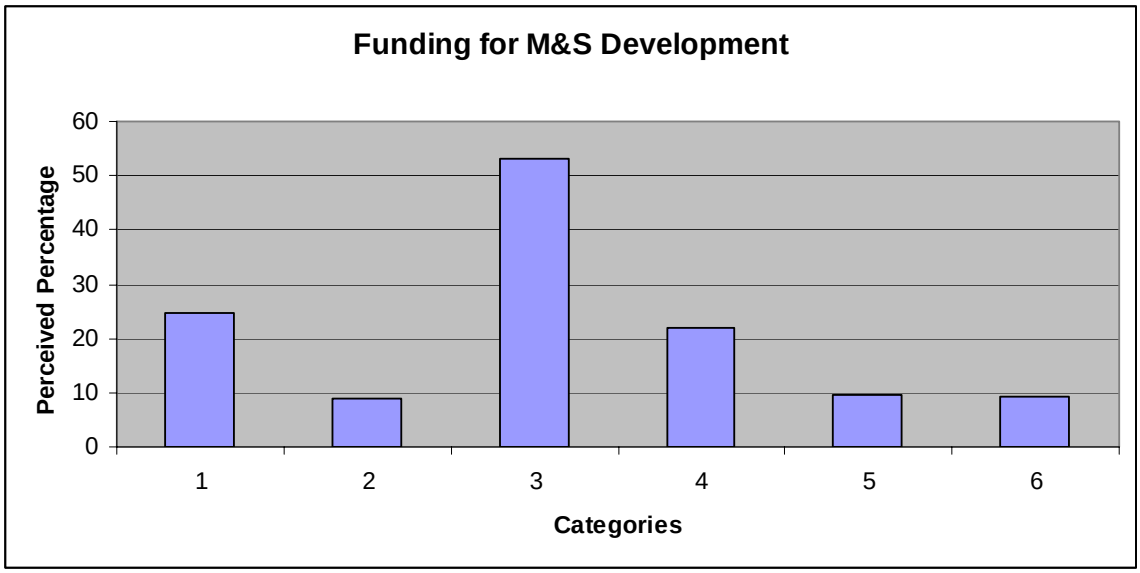
	Response Percent	Response Count
Acquisition Program Management career field	25.0%	6
Acquisition Systems Engineering career field	29.2%	7
Acquisition Test and Evaluation career field	4.2%	1
Other (please specify)	**41.7%**	10
answered question		**24**
skipped question		**3**

General Outlook on M&S Development

Slightly more than half of the survey participants addressed the issue of DoD's funding and investment in M&S, leveraging on their experience and knowledge in M&S development. Notably, most, or about 60%, of DoD funding was perceived to have been devoted to industrial investment and federally funded research and development (Table 8). Staff development only garners about a third of that investment. Investment in civilian universities on research or curriculum ranks a distant fourth in total. While these

statistics are only derivative from the select few in this survey, it is indicative of the ground perception gathered on the relative funding commitment in research and development vis-à-vis that of staff and training development in the DoD today.

Table 8: Participants' Outlook of M&S Development Funding



Cat1: Internal DoD M&S Staff
Cat2: Federally Funded Research and Development Centers
Cat3: Outside Industrial Contractors
Cat4: Other Organizations in the Federal Government
Cat5: Civilian Universities and Colleges
Cat6: Other

Preliminary Analysis of Participants' Responses to Learning Model

This preliminary analysis presents the collated responses from the participants with regard to their assessment of the required levels of competency for personnel in the PM, SE and T&E career fields for all three levels of seniority in each of the seven lower-level ESRs. Descriptive statistics are applied in this analysis to determine both mean ratings as well as mode ratings to provide perspectives on the perceived average levels of

competency required as well as the levels of competency at which most survey participants agreed upon for all entries in the learning matrix. The mode ratings are derived in a contrasting fashion via the color coded matrices. Cells in which there are agreements between collected responses and the original model are shaded green and with their borders emboldened. The rest of the cells with 30% and above hits, 10%-29% hits and less than 10% hits are coded red, yellow and pink, respectively. In this manner, the matrix presents not just the percentage of votes in favor of the original learning model at a particular job category and skill level but also reflects the degree of the variability of data.

Lower-level Educational Skill Requirement 1

It can be observed that in the PM category, there is major consensus on the level of competency across all seniority levels with more than 50% of the votes at each level coinciding with that of the proposed learning model. There are similar agreements within the SE category, albeit with greater variability of votes at the lower seniority levels, and with Level III not in agreement with the proposed level. There are two modes at Level III of the SE category, showing a clear polarization of views. In T&E category, there are also large variations of votes especially at higher seniority levels with modes and means higher than the proposed levels.

Table 9: Competency Rating for E8.1

Competency Scale and Rating	None	General Awareness	Understand	Application	Mastery	Mean Rating (1-5)
	1	2	3	4	5	
Career	**Program Management**					
Level I	0%(0)	52.6%(10)	31.6%(6)	5.3%(1)	10.5%(2)	2.74
Level II	0%(0)	26.3%(5)	57.9%(11)	15.8%(3)	0%(0)	2.89
Level III	5.3%(1)	26.3(5)	52.6%(10)	15.8%(3)	0%(0)	2.79
Career	**Systems Engineering**					
Level I	0%(0)	15.8%(3)	36.8%(7)	26.3%(5)	21.1%(4)	3.53
Level II	0%(0)	0%(0)	31.6%(6)	57.9%(11)	10.5%(2)	3.79
Level III	0%(0)	5.3%(1)	31.6%(6)	15.8%(3)	47.4%(9)	4.05
Career	**Test and Evaluation**					
Level I	0%(0)	31.6%(6)	26.3%(5)	31.6%(6)	10.5%(2)	3.21
Level II	0%(0)	10.5%(2)	26.3%(5)	57.9%(11)	5.3%(1)	3.58
Level III	5.3%(1)	15.8%(3)	10.5%(2)	47.4%(9)	21.1%(4)	3.63

Lower-level Educational Skill Requirement 2

The majority of the participants are in general agreement with the proposed model as far as PM and SE categories are concerned. However for T&E, while there are agreements at seniority Levels I and II with the proposed values, there are strong views with 63.2 % of the voters who felt that Level III personnel should only be trained to the competency level of application but not mastery as the original model suggests.

Table 10: Competency Rating for E8.2

Competency Scale and Rating	None	General Awareness	Understand	Application	Mastery	Mean Rating (1-5)
	1	2	3	4	5	
Career	**Program Management**					
Level I	0%(0)	52.6%(10)	23.3%(5)	10.5%(2)	10.5%(2)	2.79
Level II	0%(0)	15.8%(3)	63.2%(12)	21.1%(4)	0%(0)	3.05
Level III	5.3%(1)	15.8%(5)	57.9%(11)	21.1%(4)	0%(0)	3.16
Career	**Systems Engineering**					
Level I	0%(0)	10.5%(2)	47.4.%(9)	26.3%(5)	15.8%(3)	3.47
Level II	0%(0)	0%(0)	26.3%(5)	63.2.%(12)	10.5%(2)	3.84
Level III	0%(0)	5.3%(1)	21.1%(4)	31.6%(6)	42.1%(8)	4.11
Career	**Test and Evaluation**					
Level I	5.3%(1)	21.1%(4)	31.6%(6)	31.6%(6)	10.5%(2)	3.21
Level II	0%(0)	5.3%(1)	36.8%(7)	52.6%(10)	5.3%(1)	3.58
Level III	5.3%(1)	5.3%(1)	15.8%(3)	63.2%(12)	10.5%(2)	3.68

Lower-level Educational Skill Requirement 3

There is observably less consensus forged by participants with regard to this skill requirement. Votes are visibly more varied across the scale with only PM Level I and SE Level II with clear agreement with the proposed model. There are dual modes for PM Levels II and III as well as SE Level III demonstrating a divergence of views at these levels. Nevertheless despite such divergence, participants are still largely in agreement in the PM and SE categories. For T&E, there is now an observed trend following the earlier two skills requirements that participants tend to favor application as the level of competency required for top level T&E personnel.

Table 11: Competency Rating for E8.3

Competency Scale and Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Mean Rating (1-5)
Career	**Program Management**					
Level I	0%(0)	63.2%(12)	15.8%(3)	10.5%(2)	10.5%(2)	2.68
Level II	0%(0)	36.8%(7)	36.8%(7)	26.3%(5)	0%(0)	2.89
Level III	5.3%(1)	36.8%(7)	36.8%(7)	21.1%(4)	0%(0)	2.74
Career	**Systems Engineering**					
Level I	0%(0)	15.8%(3)	42.1%(8)	31.6%(6)	10.5%(2)	3.37
Level II	0%(0)	5.3%(1)	31.6%(6)	57.9%(11)	5.3%(1)	3.63
Level III	0%(0)	11.1%(2)	33.3%(6)	22.2%(4)	33.3%(6)	3.78
Career	**Test and Evaluation**					
Level I	0%(0)	26.3%(5)	36.8%(7)	26.3%(5)	10.5%(2)	3.21
Level II	0%(0)	10.5%(2)	36.8%(7)	47.4%(9)	5.3%(1)	3.47
Level III	5.3%(1)	15.8%(3)	10.5%(2)	47.4%(9)	21.1%(4)	3.63

Lower-level Educational Skill Requirement 4

For this skills requirement, there are visibly more divergent views by the survey participants across the rating categories. All except two cells have votes and there are more 10%-29% in relation to 30% and above percentiles votes in all categories and all levels. In general however, there are still agreements by modes ratings at the junior levels in all three job categories. There is a clear proposition by voters that Level III of both SE and T&E categories should be trained at lower levels of competency than what were proposed to be.

Table 12: Competency Rating for E8.4

Competency Scale and Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Mean Rating (1-5)
Career	**Program Management**					
Level I	10.5%(2)	57.9%(11)	10.5%(2)	10.5%(2)	10.5%(2)	2.53
Level II	5.3%(1)	47.4.%(9)	21.1%(4)	26.3%(5)	0%(0)	2.68
Level III	10.5%(2)	31.6%(6)	36.8%(7)	21.1%(4)	0%(0)	2.68
Career	**Systems Engineering**					
Level I	10.5%(2)	26.3%(5)	31.6%(6)	21.1%(4)	10.5%(2)	2.63
Level II	5.6%(1)	27.8%(5)	11.1%(2)	50.0%(9)	5.6%(1)	3.22
Level III	10.5%(2)	10.5%(2)	31.6%(6)	26.3%(5)	21.1%(4)	3.37
Career	**Test and Evaluation**					
Level I	10.5%(2)	31.6%(6)	26.3%(5)	21.1%(4)	10.5%(2)	2.89
Level II	5.6%(1)	22.2%(4)	16.7%(3)	50.0%(9)	5.6%(1)	3.28
Level III	10.5%(2)	10.5%(2)	31.6%(6)	42.1%(8)	5.3%(1)	3.21

Lower-level Educational Skill Requirement 5

Although there are no cells with more than 50% votes, there are clear agreements with the proposed model for the entire PM job category and junior levels of the SE and T&E job categories. Level III of SE and T&E attracted votes supporting lesser training competencies than that of the proposed model.

Table 13: Competency Rating for E8.5

Competency Scale and Rating	None	General Awareness	Understand	Application	Mastery	Mean Rating (1-5)
	1	2	3	4	5	
Career	**Program Management**					
Level I	5.3%(1)	47.4%(9)	31.6%(6)	5.3%(1)	10.5%(2)	2.68
Level II	0%(0)	26.3.%(5)	47.4%(9)	26.3%(5)	0%(0)	3.00
Level III	10.5%(2)	15.8%(3)	36.8%(7)	26.3%(5)	10.5%(2)	3.11
Career	**Systems Engineering**					
Level I	5.3%(1)	21.1%(4)	47.4%(9)	10.5%(2)	15.8%(3)	3.11
Level II	0%(0)	16.7%(3)	27.8%(5)	44.4%(8)	11.1%(2)	3.5
Level III	5.3%(1)	5.3%(1)	31.6%(6)	36.8%(7)	21.1%(4)	3.63
Career	**Test and Evaluation**					
Level I	5.3%(1)	10.5%(2)	47.4%(9)	15.8%(3)	21.1%(4)	3.37
Level II	0%(0)	15.8%(3)	21.1%(4)	47.4%(9)	15.8%(3)	3.63
Level III	10.5%(2)	5.3%(1)	15.8%(3)	42.1%(8)	26.3%(5)	3.68

Lower-level Educational Skill Requirement 6

The majority of the respondents are in agreement with all cells belonging to the PM and SE categories, thus providing the most accurate model validation as far as mode ratings could provide. Mean ratings for PM Level I and SE Level III however differ more significantly from the modes than the rest, given the spread of the probability distributions. There are also general agreements for T&E Level I and Level II, while voters of Level III yet again indicated preference for application training competency over mastery as originally proposed.

Table 14: Competency Rating for E8.6

Competency Scale and Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Mean Rating (1-5)
Career	**Program Management**					
Level I	5.3%(1)	36.8%(7)	31.6%(6)	15.8%(3)	10.5%(2)	2.89
Level II	0%(0)	21.1.%(4)	47.4%(9)	31.6%(6)	0%(0)	3.11
Level III	10.5%(2)	10.5%(2)	42.1%(8)	31.6%(6)	5.3%(1)	3.11
Career	**Systems Engineering**					
Level I	5.3%(1)	21.1%(4)	36.8%(7)	21.1%(4)	15.8%(3)	3.21
Level II	0%(0)	22.2%(4)	11.1%(2)	61.1%(11)	5.6%(1)	3.50
Level III	5.6%(1)	11.1%(2)	27.8%(5)	22.2%(4)	33.3%(6)	3.67
Career	**Test and Evaluation**					
Level I	5.3%(1)	21.1%(4)	36.8%(7)	21.1%(4)	15.8%(3)	3.21
Level II	0%(0)	21.1%(4)	21.1%(4)	52.6%(10)	5.3%(1)	3.42
Level III	10.5%(2)	10.5%(2)	10.5%(2)	47.4%(9)	21.1%(4)	3.58

Lower-level Educational Skill Requirement 7

In relation to the PM job category, there are common agreements between the majority of the survey participants and the proposed model. The mean rating of PM Level I however was drawn to the right due to the strength of votes for the understand level. There are also agreements at the junior levels of SE while the general perception of SE Level III is that mastery is more preferred to application as proposed in the model. There are distinctively divisive views between the survey participants and that of the model with regard to the T&E job category. Survey participants generally preferred a step higher in competency ratings as far as this skill requirement is concerned.

Table 15: Competency Rating for E8.7

Competency Scale and Rating	None	General Awareness	Understand	Application	Mastery	Mean Rating (1-5)
	1	2	3	4	5	
Career	**Program Management**					
Level I	0%(0)	52.6%(10)	31.6%(6)	5.3%(1)	10.5%(2)	2.74
Level II	0%(0)	21.1.%(4)	57.9%(11)	21.1%(4)	0%(0)	3.00
Level III	10.5%(2)	10.5%(2)	57.9%(11)	21.1%(4)	0%(0)	2.89
Career	**Systems Engineering**					
Level I	0%(0)	15.8%(3)	42.1%(8)	26.3%(5)	15.8%(3)	3.42
Level II	0%(0)	10.5%(2)	21.1%(4)	47.4%(9)	21.1%(4)	3.79
Level III	5.3%(1)	5.3%(1)	15.8%(3)	26.3%(5)	47.4%(9)	4.05
Career	**Test and Evaluation**					
Level I	0%(0)	26.3%(5)	42.1%(8)	10.5%(2)	21.1%(4)	3.26
Level II	0%(0)	10.5%(2)	26.3%(5)	52.6%(10)	10.5%(2)	3.63
Level III	10.5%(2)	0%(0)	15.8%(3)	47.4%(9)	26.3%(5)	3.79

Formulation of the Joint Learning Model

The previous section has demonstrated via descriptive statistics, an overview of the data distributions amongst the cells within the training needs matrices. Overall, it was observed that the mode and the mean almost always do not coincide, given the variability of the data for all seven lower-level ESRs. The variability of data is exceptional in some cases where there are lesser agreements between the modes or means with the competency levels proposed in the model. The findings from these preliminary treatments of data provide the impetus for a more rigorous derivation of the true significance of the collected results.

The concept of a Joint Learning Model is conceived to adequately quantify collected data and provide content base to support the statistical derivations. This model comprises two major components namely a ***Joint Learning Matrix*** which superimposes participants' responses with the original set of propositions espoused in the proposed Learning Matrix, and a ***Joint Learning Thematic Framework***. The later is a collation of thematic ideas and case study suggestions by the survey respondents, thus providing basic framework guidance to support future training developmental effort.

Joint Learning Matrix

Inferential statistics are applied in this section to compare the observed responses with the expected data in order to quantify the degree of adherence or non-conformity between the two. A non-parametric test, and specifically the Wilcoxon Signed Rank Test for matched data, is chosen and applied in this analysis (Appendix E). Every single observed response was matched and compared with its corresponding expected response in hypothesis tests of differences between the two, at 95% level of confidence in accordance to the methodology highlighted in Chapter 3.

The resultant product from this effort is the creation of a superimposition of participants' quantitative responses over the proposed matrix to form the Joint Learning Matrix (Table 16). Where the hypothesis test fails to reject the null hypothesis at 95% level of confidence that the observed value equates the expected value, the cell in the Joint Learning Matrix is shaded green with indication of the level of competency purported in the original proposed matrix. Where the hypothesis test rejects the null

hypothesis at 95% level of confidence, the cell is shaded red if the observed value is greater than the expected; or yellow if the observed value is lesser than the expected. The mean and mode of the observed data derived from the previous section are also overlaid in this Joint Learning Matrix to provide representations of the observed data in the red and yellow cells.

Table 16: Joint Learning Matrix

	Lower-level Engineering Skill Requirements						
	E8.1	E8.2	E8.3	E8.4	E8.5	E8.6	E8.7
PM							
Bsc.	H_0= GA H_1 > GA Mode= GA Mean= GA-U	H_0= GA H_1 > GA Mode= GA Mean= GA-U	H_0= GA H_1 > GA Mode= GA Mean= GA-U	GA	H_0= GA H_1 > GA Mode= GA Mean= GA-U	H_0= GA H_1 > GA Mode= GA Mean= GA-U	H_0= GA H_1 > GA Mode= GA Mean= GA-U
Inter.	U	U	U	U	U	U	U
Adv.	U	U	U	U	U	U	U
SE							
Bsc.	H_0= U H_1 > U Mode= U Mean= U-A	U	U	U	U	U	U
Inter.	A	A	A	H_0= A H_1 < A Mode= A Mean= U-A	A	A	A
Adv.	A	H_0= M H_1 < M Mode= M Mean= A-M	H_0= M H_1 < M Mode= U & M Mean= U-A	H_0= M H_1 < M Mode= U Mean= U-A	H_0= M H_1 < M Mode= A Mean= U-A	H_0= M H_1 < M Mode= M Mean= U-A	A
T&E							
Bsc.	H_0= GA H_1 > GA Mode= GA & A Mean= U-A	U	U	U	U	U	H_0= GA H_1 > GA Mode= U Mean= U-A
Inter.	H_0= U H_1 > U Mode= A Mean= U-A	H_0= A H_1 < A Mode= A Mean= U-A	H_0= A H_1 < A Mode= A Mean= U-A	H_0= A H_1 < A Mode= A Mean= U-A	A	H_0= A H_1 < A Mode= A Mean= U-A	H_0= U H_1 > U Mode= A Mean= U-A
Adv.	H_0= U H_1 > U Mode= A Mean=U-A	H_0= M H_1 < M Mode= A Mean= U-A	H_0= M H_1 < M Mode= A Mean= U-A	H_0= M H_1 < M Mode= A Mean= U-A	H_0= M H_1 < M Mode= A Mean= U-A	H_0= M H_1 < M Mode= A Mean= U-A	H_0= U H_1 > U Mode= A Mean= U-A

Overall, the Joint Learning Matrix indicates that thirty-five of the sixty-three hypothesis tests at 95% level of confidence resulted in failures in rejecting the null hypothesis of equality between the observed and expected values. A general derivation from this finding is that the proposed model is approximately 55% accurate in predicting the total outcome of the survey with inferential statistics.

There are some clear observable trends within the PM category in the Joint Learning Matrix. There is total agreement between the participants' model and the proposed model for seniority Levels II and III for all skills requirements. Complete matching of training needs perception is attained with respect to skill requirement E8.4. However for all other Level I cells, the hypothesis tests rejected the null hypothesis of equality, resulting in skill competency levels higher than those originally proposed. General awareness seemingly does not suffice as the entrant competency requirement for all Level I Program Managers. Overall, the Joint Learning Matrix suggests that the proficiency gaps across the three seniority levels in the PM job category are closer than originally postulated to be.

There are also apparent trends within the ranks of the SE job category. These trends however tend to be asymmetrically different from that of the PM job category. Instead of having rating conformities at more senior levels, the Joint Learning Matrix unveils conformities at the junior levels but non-conformities at the more senior levels. With respect to the middle block of sub-skill requirements on M&S tools and technologies from E8.2 to E8.6, survey participants favor uniformly a lesser than mastery level of training competency capstone requirement. Overall, the Joint Learning Matrix

indicates the preferred cap of application as the highest level of competency across all skills areas in the SE job category.

In the T&E job category, there are apparent differences between the participants' responses and the proposed model. For sub skills requirements E8.1 and E8.7, the participants' competency level preferences are consistently higher than those proposed by the original model. As for the middle block of sub-skill requirements E8.2 to E8.6, while there are general agreements with the competency levels for entrant Level I T&E personnel, the levels of competency required taper off at more senior levels with the general perception that the required competencies are lower than that proposed in the original model.

Joint Learning Matrix- Relative Competency Analysis

The preliminary analysis provided the basic overview of collated results, indicative of their variability and central tendencies. The formulation of the Joint Learning Matrix on the other hand represents the fundamental attempt to statistically determine the conformity between the survey participants' responses and the original proposed model.

Yet the next level of analysis lies in the determination of the relative required competency at the inter-job categories and intra-job categories levels so as to justify the degree for training customization required to meet different needs. Recognizing that the Joint Learning Matrix is inadequate in addressing issues of relative competency especially where the exact values of required competency are unknown given the

disparity between mean and mode values, this section on relative competency analysis is construed to help address these issues statistically. It does so by quantifying in a two-way analysis whether required training competency significantly differentiates between each seniority level across all three job categories as well as that between seniority levels in each job category. By so doing, the downstream benefit is that instructional designers will then be able to cater to appropriating differentiation of training levels for different training audience to achieve economy of effort.

Relative competency analysis is performed via non-parametric hypothesis testing (Appendix E). Similar to previous section, relative competency is determined via Wilcoxon Signed Rank Test for matched-pair data where corresponding cells in the participants' response data are matched and compared in the process.

Lower-level Educational Skill Requirement 1

There are consistent trends at all seniority levels that the level of competency required is progressive from PM to SE or PM to T&E. This is in line with the original argument that SE or T&E will require a higher level of training in technically orientated skill areas than the PM due to differences in their job scope. However, there are no significant competency requirement differentials between T&E and SE as opposed to the proposed model, indicative of the general perception that T&E personnel requires similar level of training as SE. Notably, results from the survey point to no significant differences between levels of seniority, for all three job categories. This finding seems to suggest that no amount of effort is perhaps necessary to differentiate computer training

for different seniority levels, thereby challenging the traditional notion of progressive training in tandem with seniority.

Table 17: Relative Competency for E8.1

Column vs Row		PM			SE			T&E		
		Bsc	Inter	Adv	Bsc	Inter	Adv	Bsc	Inter	Adv
PM	Bsc		=	=	<			<		
	Inter	=		=		<			<	
	Adv	=	=				<			<
SE	Bsc	>				=	=	=		
	Inter		>		=		=		=	
	Adv			>	=	=				=
T&E	Bsc	>			=				=	=
	Inter		>			=		=		=
	Adv			>			=	=	=	

Lower-level Educational Skill Requirement 2

The inter-relations between the cells are identical to that of ESR 8.1. Given the technical nature of this skill requirement on synthetic natural environment development, the notion of progressive learning from PM to SE or PM to T&E is justified. Similarly, training proficiency of SE and T&E are perceived to be similar while no significant difference could be established across seniority levels for all job categories.

Table 18: Relative Competency for E8.2

Column vs Row		PM			SE			T&E		
		Bsc	Inter	Adv	Bsc	Inter	Adv	Bsc	Inter	Adv
PM	Bsc		=	=	<			<		
	Inter	=		=		<			<	
	Adv	=	=				<			<
SE	Bsc	>				=	=	=		
	Inter		>		=		=		<	
	Adv			>	=	=				=
T&E	Bsc	>			=				=	=
	Inter		>			>		=		=
	Adv			>			=	=	=	

Lower-level Educational Skill Requirement 3

The matrix for ESR 8.3 is identical to that of ESR 8.2, thus demonstrating the consistency of results. Secondly, it also reinforces the concept that both ESRs 8.2 and 8.3 are not dissimilar subject matter and that both belongs to the category of technical applications of M&S.

Table 19: Relative Competency for E8.3

Column vs Row		PM			SE			T&E		
		Bsc	Inter	Adv	Bsc	Inter	Adv	Bsc	Inter	Adv
PM	Bsc		=	=	<			<		
	Inter	=		=		<			<	
	Adv	=	=				<			<
SE	Bsc	>				=	=	=		
	Inter		>		=		=		=	
	Adv			>	=	=				=
T&E	Bsc	>			=				=	=
	Inter		>			=		=		=
	Adv			>			=	=	=	

Lower-level Educational Skill Requirement 4

ESR 8.4 deals with the contemporary focus on massively online gaming in defense M&S. Contrastingly, it features stark differences in the relative competency trends. With the exception of PM, SE and T&E Level III which follows the consistently progressive pattern, the hypothesis tests failed to reject the equality of competency levels in Levels I and II across all three job categories. Additionally, there is also no significant evidence to reject the equality of competency requirements across seniority levels within each of the three job categories.

Table 20: Relative Competency for E8.4

Column vs Row		PM			SE			T&E		
		Bsc	Inter	Adv	Bsc	Inter	Adv	Bsc	Inter	Adv
PM	Bsc		=	=	=			=		
	Inter	=		=		=			=	
	Adv	=	=				<			<
SE	Bsc	=				=	=	=		
	Inter		=		=		=		=	
	Adv			>	=	=				=
T&E	Bsc	=			=				=	=
	Inter		=			=		=		=
	Adv			>			=	=	=	

Lower-level Educational Skill Requirement 5

ESR 8.5 matrix features consistent pattern as observed in ESR 8.2 and 8.3. This links ESR 8.5, characteristically with that of ESR 8.2 and 8.3, as part of the block of technical application-orientated M&S skill areas.

Table 21: Relative Competency for E8.5

Column vs Row		PM			SE			T&E		
		Bsc	Inter	Adv	Bsc	Inter	Adv	Bsc	Inter	Adv
PM	Bsc		=	=	<			<		
	Inter	=		=		<			<	
	Adv	=	=				<			<
SE	Bsc	>				=	=	=		
	Inter		>		=		=		=	
	Adv			>	=	=				=
T&E	Bsc	>			=				=	=
	Inter		>			=		=		=
	Adv			>			=	=	=	

Lower-level Educational Skill Requirement 6

ESR 8.6 matrix offers a trend similar to that of ESR 8.2, 8.3 and 8.5. However one exception to the observation being that PM and T&E Level I appears to share the same level of training competency. One explanation to this could be that the competency requirement for Level I PM is significantly higher than the proposed level, leading to the match-up with that of Level I T&E in the final comparison. This perhaps underscores the ubiquity or importance of virtual simulation in defense M&S to the extent that PM training competency levels in this area matches that of T&E.

Table 22: Relative Competency for E8.6

Column vs Row		PM			SE			T&E		
		Bsc	Inter	Adv	Bsc	Inter	Adv	Bsc	Inter	Adv
PM	Bsc		=	=	<			=		
	Inter	=		=		<			<	
	Adv	=	=				<			<
SE	Bsc	>				=	=	=		
	Inter		>		=		=		=	
	Adv			>	=	=				=
T&E	Bsc	=			=				=	=
	Inter		>			=		=		=
	Adv			>			=	=	=	

Lower-level Educational Skill Requirement 7

The trend and pattern of this skill requirement matrix returns to the previous, similar to that of ESR 8.2, 8.3 and 8.5 regardless of the fact that ESR 8.7 was originally classified as a management support skill requirement perceived as more useful to the PM. One notable difference is that unlike all others, the training competency of Level III T&E is proven statistically higher than that of Levels I and II, supporting the notion of progressive training with seniority espoused in the original model.

Table 23: Relative Competency for E8.7

Column vs Row		PM			SE			T&E		
		Bsc	Inter	Adv	Bsc	Inter	Adv	Bsc	Inter	Adv
PM	Bsc		=	=	<			<		
	Inter	=		=		<			<	
	Adv	=	=				<			<
SE	Bsc	>				=	=	=		
	Inter		>		=		=		=	
	Adv			>	=	=				=
T&E	Bsc	>			=				=	<
	Inter		>			=		=		=
	Adv			>			=	>	=	

Joint Learning Thematic Framework

The second component of the Joint Learning Model is the Joint Learning Thematic Framework. This framework provides the general impression of the content-based ideas contributed by the survey participants on the pertinent issues related to the seven core skill requirements. It is structured to provide coherent information, derived from the open-ended responses from the survey participants. Information is laid out at two levels, addressing the thematic emphasis on the subject matter and specific case studies and knowledge requirements (Table 24).

Lower-level Educational Skill Requirement 1

M&S is recognized as a subset of the broad and complex subject of computer science. Survey respondents are of the general opinion that specialized training and education in ESR 8.1, though theoretical in nature are necessary as the foundation to prepare M&S acquisition professionals in understanding the development in this field of knowledge. While understanding the general capabilities is important, the presence of a subject matter expert (SME) is recognized as key to success to any team effort. This SME is referenced as the systems engineer whose job scope revolves around research and engineering activities. In any case, it was opined that a DAU course should suffice in providing these basic theoretical training. Topics of interest include understanding the basics of computer systems such as hardware, firmware, operating systems and programming language such as C++ and JAVA. Issues of M&S system interoperability should also be addressed with focus on interoperable architecture such as the current Test and Training Enabling Architecture (TENA), High Level Architecture (HLA)-Evolve, Common Training and Instrument Architecture (CTIA) and the next generation Army multi-echelon, joint training and mission rehearsal enabling Live Virtual Constructive-Integrated Architecture (LVC-IA). Case studies of interoperable systems such as One Semi-Automated Forces (OneSAF) and Joint Simulation Systems (JSIMS) should also be incorporated in the training curriculum.

Table 24: Joint Learning Thematic Framework

Lower-Level Educational Skills Requirements						
E8.1	E8.2	E8.3	E8.4	E8.5	E8.6	E8.7
Basic computer systems	Scenario building with Runtime software systems	Scenario building with Intelligent Agent systems	Game-based, Massively Online systems	Live Training Simulation	Interactive or Virtual Training Simulation	Computer Assisted Systems Engineering tools
Thematic Emphasis						
- Have SME in team - SE is the SME - M&S is subset of Computer Science - Specialized training required - Understand general capabilities and limitations - DAU overview course sufficient	- Technology is evolutionary, never a "complete rethink" or "unique creation - "Overstated", need to understand computer systems and performance requirements - Not important if not doing virtual development, niche issue	- Of "extreme interest" but not universally applicable - Limitations indistinguishable from problem, wasted resources - Performance-level based - Experimental design, data mining, regression methods	- Have appreciation of what is available - Non HLA is a good start - Not sure if massively online is direct replacement - Academic, commercial standard - Need more leadership training content	- Understand resource requirement and desired levels of accuracy - Limitations, advantages and cost of approach - Limitations of wireless comms in training environ - Use of live trg data in acquisitions	- Understand availability of tool - Parameters and goals of interactive simulation - Needs to know where simulation fits in program life cycle, how it support actual trg - Virtual training data in acquisition decisions	- Tools exist for almost any specialty area - DAU should teach awareness - Not as important as understanding language like UML, systems architectural framework like DoDAF
Case Studies/Application Knowledge						
- Hardware, firmware, assembler, kernel, OS, CPU design, C++, Java - TENA, HLA-Evolve, CTIA, LVC-IA, JLVC, JLCCTC, Warsim2000, OneSAF, JSIMS - Failure of HLA	- Evolution of SIMNET, DIS, HLA, TENA, CTIA - SE CORE Terrain protocols and standards - SEDRIS Defense Terrain models - MANA bitmap terrains for agents - RAID - Existing interoperability protocols, criteria	- Evolution of SAF ideas SIMNET SAF, Mod SAF, CGF, CCTT SAF, ACTT SAF, Joint SAF, OneSAF - Contrast with limited intel with JANUS, JTLS, JCATS - Temporal, Spatial, Processing, Input Decision, Learning, World Agents	- SCORM compliance, game-based OS, LMS America's Army - MMOG, no dominant MMOG with direct DoD applications - Similarities with distributed training - Different fidelity with constructive - Validation of game-based systems	- How Army trains, training obj task decomposition, communications over space - One TESS Longbow, TESS TWGSS/ PGSS MILES, I-HITS, HITS BFT - FCS Milestone B decision - MILES & OneTESS	- Human-computer interfaces - Impact of virtual generation on processing speed - Entity management - CCTT, AVCATT RVS - Flight School XXI at Fort Rucker, initial flight training with simulators	- Arena, visio - Windows Excel export products relational databases - CASE tools and impact on acquisition decision making - History, current state, future - Opportunity to create M&S modified DoDAF for M&S

Lower-level Educational Skill Requirement 2

Knowledge in runtime software and scenario development tool is recognized as a "niche" area which may not be crucial if one is not directly involved in virtual simulation development. Concomitantly there is also a certain element of skeptism that current knowledge level of M&S community in this field is "over-stated" and that the community's understanding of computer systems theory is still fundamental. Examples of required practical knowledge in this field include Synthetic Environment Core (SE Core) Terrain protocols and rapid terrain generation standards and capabilities. Case studies should include successful applications of Synthetic Environment Data Representation and Interchange Specification (SEDRIS) defense terrain models, Map Aware Non-uniform Automata (MANA) bitmap terrain for agents as well as Real-time Adversarial Intelligence and Decision Making (RAID). It is also perceived that this skill requirement is intertwined with knowledge in simulation interoperability protocols.

Lower-level Educational Skill Requirement 3

Agent technology has been developed extensively over time with evolution of ideas and systems in use by the military. The subject generates "extreme interest" and understanding of general capabilities and lessons learnt from its developmental history is reckoned as important. The focus of study includes fundamental agent system design principles such as emergent behavior, interaction in high dimension space and multiple

regression methods. It also includes the study of the various types of agents ranging from Temporal Agents, Spatial Agents, Input Agents, Processing Agents, Decision Agents, Learning Agents and World Agents. Last but not least, the study of agency should also include case studies of the development of the semi-automated forces (SAF) ideas and systems including that of Simulation Networking (SIMNET) SAF, computer generated forces (CGF), Close Combat Tactical Trainer (CCTT) SAF, Air and Command Tactical Trainer (ACTT) SAF, Joint SAF and OneSAF, in contrast with the limited intelligence feature residing in legacy constructive systems such as Joint Conflict and Tactical Simulation (JCATS).

Lower-level Educational Skill Requirement 4

Game-based M&S systems are recognized as belonging to the "academic and commercial standards", the variety of which the acquisition community needs to appreciate. Contrastingly, military HLA-systems are beset with mounting technical challenges that having "non-HLA is a good start". However, there is no certainty that massively online gaming is the choice replacement to HLA-based applications due to the lack of validation of such systems, deficiency of military leadership training content and no dominant Massively Multiplayer Online Game (MMOG) with direct DoD applications. Nonetheless, the training content for this skill requirement should contain knowledge of game-based operating systems, Sharable Content Object Reference Model (SCORM) compliance standards and Learning Management Systems through which online games could be hosted and delivered to the trainee. Other areas of focus include understanding

how MMOG functions, how it fits into the concept of distributed training and its inherent differences with constructive systems both in content and fidelity.

Lower-level Educational Skill Requirement 5

In order to excel in this skill requirement, the acquisition community needs to have practical insights from Army live training doctrine, training objectives, resources requirements and training task compositions. Only with such insights that the acquisition community could appreciate the inherent live training issues of interoperability and particularly, pertinent limitations of wireless communications in the operating environment across terrestrial space. Such appreciation of training issues should then be coupled with knowledge of the limitations and advantages of live M&S systems, cost of approach and how live M&S training data can be used to support acquisition decision making. Case studies include Future Combat System (FCS) milestone B decision making and successful applications of One Tactical Engagement Simulation System (OneTESS) Longbow, Tank Weapons Gunnery Simulation System (TWGSS), Precision Gunnery Simulation Systems (PGSS), Multiple Integrated Laser Engagement System (MILES), Initial Homestation Instrumentation Training Systems (I-HITS) and Blue Force Tracker (BFT).

Lower-level Educational Skill Requirement 6

Virtual simulation is an important component of simulation-based acquisition. Consequently, the acquisition community needs to be aware of the availability of the tool as well as know where it exactly fits in the overall schema of program life cycle. In cases appropriate, virtual simulation can effectively facilitate and may even replace actual training. Key knowledge in the subject matter includes understanding the parameters and goals of interactive simulation and credible usage of virtual simulation data to acquisition decision making. Suggested case studies include applications of Close Combat Tactical Trainer (CCTT), Aviation Combined Arms Tactical Trainer (AVCATT) Reconfigurable Vehicle Simulator (RVS) as well as on Flight School XXI at Fort Rucker where the majority of initial flight training is accomplished with simulators. Additionally knowledge pursuit in the related field of human computer interface in virtual simulation systems is in direct complementary to enhancing proficiency in this particular skill requirement.

Lower-level Educational Skill Requirement 7

It is recognized that having computer assisted systems engineering tools contribute to overall program success. Given the strategic advantage of implementing Computer Aided Software Engineering (CASE) in project life cycle, it was opined that

awareness of these tools "for any specialty" should be proliferated, probably via similar means offered by DAU. Key knowledge areas include both understanding how to use the tools as well as appreciation of successful examples of the usage of CASE tools and data in acquisition decision making. System engineering tools such as Arena and Visio are identified as good examples of CASE tools. Other applications include supporting web-based products such as Windows Excel export products and relational databases. Importantly, basic understanding of Unified Modeling Language (UML) and governing systems architectural framework such as the Department of Defense Architecture Framework (DoDAF) is recommended, above and beyond readily available commercial tools and applications training.

CHAPTER FIVE: SUMMARY AND CONCLUSION

This chapter forms the essence of this research in providing a broad review summary of the research motivation, methodology, data collection and analysis. Central to this effort is the concentration of key conclusions drawn from the entirety of this research, collated, generalized and presented in a sequential and coherent manner. Research limitations are also addressed in this chapter, in providing both the scope and testing limitations incurred in the course of this research. Lessons learned on the other hand provide useful insights into the ways in which this research could have been improved upon with the benefit of hindsight. Together with research limitations, lessons learned form the basis for addressing the need and direction of future research which will be built upon the present work effort.

Thesis Summary

This research centers on the need to develop training and education, in support of the enhancement and realization of the full potential of SBA in its central role in defense program life cycle. It rides on the current change effort underway in the US defense operating structure and work process, with the creation of the M&S SC and its slew of major initiatives in managing and proliferating cross-cutting M&S efforts in defense. Chief amongst the these efforts is M&S CO's M&S Common and Cross-Cutting Business Plan which identified the need to better train DoD workforce in M&S so as to

strengthen the institutionalization of M&S (M&S CO, 2006). The need to "shape the workforce" via an enhanced training system in M&S is also echoed by the AT&L community which launched the Acquisition Modeling and Simulation Master Plan to enhance the professionalism of the acquisition community in the area of SBA (OUSD(AT&L), 2006). The on-going effort of NPS and its group of partner universities, of which UCF is part of, further provides timely academia-industry implementation support to this extensive inter-agency project.

This research was scoped to provide technical rigor in the exploration of one of M&S educational topic- ESR E8 tasked to UCF in the academic partnership with NPS. It serves particularly to address the "analysis" of training needs step in the ADDIE cycle as part of the ISD process in relation to ESR E8. This was achieved via a two-staged approach first and foremost to devise a proposed learning model initiated and endorsed by the academic partners, which was subsequently presented via a survey and validated by select experts and professionals in the field of M&S from the military and industry. This approach combined the rigor of academic research and practical insights from the ground perspective offered by the military and industry. Indeed via extensive hypothesis testing, while the validation process confirmed many propositions of the original academic training needs model, it also uncovered potential areas of conciliation between the academic and the military-industry perspectives. Conclusively, a Joint Learning Model was devised to merge the two into one cohesive model to address both training needs as well as thematic training requirements. The formulation of the Joint Learning Model thereby lays the research foundation for the sequential "design" step in ADDIE cycle by providing indicative direction of progress and future work development.

Conclusions and Major Findings

The conclusions and major findings of this research are couched in three categories, each corresponding to key research products formulated and analyzed in detail in the previous chapters.

Identification of Current M&S Training Gaps

Specific to ESR E8, an original training needs model was proposed, comprising seven topical lower-level ESRs each specifying particular training content deemed important to fulfill the training requirements of the overall ESR. The approach taken was to ensure that these seven core skill areas are as inclusive as possible, covering a full range of subject matter from theoretical fundamentals, technology and tools to system life cycle management/engineering applications. At the same time, the guiding principle in the identification of these seven skill areas was to assure that none of them duplicates what is currently already available in the defense M&S training system and that there are no overlaps with other concurrent educational curriculum development efforts by other academic partners. These seven skill areas were not refuted by the working committee chaired by NPS as essential training requirements of ESR E8.

Development of Enhanced Framework for M&S Training Implementation

Based on these seven skill areas, a learning matrix was constructed to determine the level of competency required in each of the select three job categories of PM, SE and T&E. The principal consideration behind the accordance of skill competency levels at each seniority level in all three job categories, was to ensure that personnel are to be trained but only to the level at which their job demands them to be, recognizing that both personnel and time are finite resources in the organization. Similar to the seven skill areas, this learning matrix was approved at the NPS working committee level.

Packaged as the proposed learning model, these propositions were tested against the inputs and comments from M&S experts and professionals from the military and industry. It was found that while there were generally no disagreements as to the scope of skill areas coverage there were areas of conciliation as to the exact training competency levels required at various job and seniority levels. Statistically proven with non-parametric hypothesis testing, the survey participants agreed to thirty-five out of sixty-three or 55% of skill level entries in the proposed learning matrix. The proposed learning model was thus found to be confirmed in part. Inconsistencies in the model and the feedback from the survey participants are discussed in detail in the previous chapters and highlighted below through statistical findings arising out of the Joint Learning Model composed for every essential skill requirement cell. Specifically, these findings are yielded from the Joint Learning Matrix which statistically represented the level of conformity between the survey participants' responses and the original proposed model

as well as from the Joint Learning Thematic Framework which synthesized the thematic training content required.

Key Generalizations from Joint Learning Model

Higher Entrant-Level Training Competency for PM

The Joint Learning Matrix indicates that survey participants generally do not agree in six out of seven skill areas that PM Level I should be trained only up to the general awareness level. Hypothesis testing established that all these training levels should be higher than originally proposed, with the means and modes indicating that application is the more preferred entry training competency level. This generalization is indicative of ground emphasis on the technical skill sets of entry level PM despite his managerial role in defense acquisition. The inference for this finding is that incoming entry level PMs must either possess or be given upfront application-level training for the various lower-level ESRs in question.

Non-Mastery SE and T&E Capstone Training Requirement

Additionally, the Joint Learning Matrix also indicates the almost unanimous ground sentiments that training top level SE and T&E personnel to mastery competency is not required in any of the seven skill areas. This is so despite the fact that the E8.2 to

E8.6 are inherently technical application-centric and suited to support the technical work nature of SE and T&E personnel. This finding has training policy implications in that perhaps application-level course is sufficient to prepare even the top-tiered personnel to perform in their jobs. It also infers that skill mastery by the SE and T&E personnel is not in these computer-related skills, but rather in other disciplines.

Progressive Change Pattern of Training Competency Requirement across Job Categories

The relative competency analysis uncovered a progressive change pattern that exists almost always in all the seven skill areas, across the three job categories. It has been proven statistically via hypothesis testing that at each seniority level, as we move from PM to SE or PM to T&E, the level of competency increases. This phenomenon is perhaps justifiable given the more technically-inclined job nature of SE or T&E over PM. However as we move from SE and T&E, it is statistically likely that the competency level remains the same, indicating the perceived equivalence of ESR E8 training competency requirements between SE and T&E.

No Significant Difference in Training Competency Requirements within Job Category

The relative competency analysis also challenged the proposed notion that training competency requirement increase or at best stay the same for personnel of increasing seniority. The extensive hypothesis testing indicated that despite the factor of

seniority or with its associated scope and depth of responsibilities, there is insufficient evidence to suggest that the level of training competency required should be increased. This is perhaps attributable to opposing philosophical views that increased seniority implies less technical work requirements or vice versa.

Recognition of M&S Theoretical Fundamentals

Based on open-ended contributions from the survey respondents which constituted the Joint Learning Thematic Framework, there is clear recognition of the importance of the theoretical fundamentals of M&S as the foundation in the study of ESR E8. Particularly, M&S is recognized as closely related to the discipline of computer science and that engineering work in M&S especially in synthetic environment building and intelligent agent technology requires an appreciation of the first principles embedded in basic computing system theories. These first principles are perceived as requisite knowledge in the appreciation of the various case studies cited.

Endorsement of SBA Traditional Domains and Acceptance of New Growth Avenues

The survey participants generally endorsed the traditional domains of SBA, namely via constructive, virtual and live M&S systems. They were able to cite many successful case studies of how such traditional domains are successfully applied to support acquisition decisions. However at the same time, they recognized the

shortcomings with these traditional domains particularly in the field of interoperability and agent technology. Towards this end, they were openly acceptant of emerging commercial technology in massively online gaming systems as possible enhancement to the current systems. Nonetheless, they were equally concerned about the current state of development of such new systems in supporting the traditional role of DoD training.

Research Limitations

Scope Limitations

This research is limited in scope as it is only addressing a slice of the total effort currently underway to revamp the training and education of M&S professionals. This research is also primed to achieve the limited objectives of establishing the training needs and training competency requirements specific to ESR E8, as well as determine the training content developmental emphasis within the constraints of available research resources.

Testing Limitations

The main testing limitation of this research is the conservative sample size from which data was drawn and analyzed. Although participants were representative of M&S experts from the industry and military, the conservative sample size makes it difficult to

establish generalization of the larger population in the defense industry. As a resultant of this, analysis and conclusions drawn though based on rigorous statistical treatment could only qualify as indicative and at best an extrapolation of the ground truth.

Secondly, due to the extensive hypothesis tests conducted to yield the Joint Learning Matrix and to subsequently support the relative competency analysis, the overall joint confidence level in the Joint Learning Model is lowered. Consequently while the level of confidence at which individual hypothesis tests were unaffected, the overall confidence in the accuracy of the model decreases. This is an inherent statistical limitation given the way the experiment was designed in this research to achieve its targeted objectives.

Key Lessons Learned

One key lesson learned with hindsight is the need to strategize data collection to meet the intended research outcome. This is so because the quality and quantity of data are key determinants to credible research in empirical studies like this. To strategize data collection is beyond perfecting the data collection means of choice, but to have built-in contingency mechanism such as multiple data collection means so as to cover the shortcomings inherent in each means of collection, reconciliate data differences and re-confirm data accuracy. Having multiple data collection means would also help to address the issue of depth of coverage, which would have significantly enhanced the Joint Learning Model in achieving its intended purposes.

Suggested Future Research

This research was intended to initiate the instructional system design work cycle in the design of a new educational curriculum in ESR E8 for the targeted audience in the military. Future research should henceforth be directed to build on the scope of this paper to extend the study into the realm of curriculum development and beyond using the Joint Learning Model as a possible working framework. Given the scope/testing limitations and lessons learnt from this research, it is however also recommended that a parallel effort be committed to extend the quantity of data and then using the analytical methodology in place to validate and ultimately strengthen the conclusions drawn in this research. Expanding the survey base to include representations from the other services such as the Air Force and Marine Corps may also be necessary to provide added rigor in the research. Additionally, a detailed study of the military-industry complex may yield a widened perspective on the issue of SBA training and education, bench-marked to commercial standards both locally and overseas.

In part as epilogue and part of future research, both the content and level of engineering education required of the different career fields and levels of advancement within those career fields remains an open question. As evidence of this point, the NPS working committee rebalanced the amount of resources devoted to the engineering educational curriculum. The design of the engineering curriculum by NPS also took on a decidedly different character. In terms of E8 content, the amount was greatly reduced

and the focus shifted from M&S computer skills to more general, computer science oriented skills as indicated below:

"Module 5: Introduction to computers and computing (5 hours).
i. 5.1 Operating Systems (1 hr)
ii. 5.2 Programming Languages (1 hr)
iii. 5.3 Finite Difference, Volume, and Element Methods (1 hr)
iv. 5.4 Computer Program Pre-processing (1 hr)
v. 5.5 Computer Program Post-processing (1 hr)"

This outcome raises a number of research questions: Do the services have widely divergent perspectives in terms of the nature of the content of M&S computer-based essential skills needed on the part of workforce career fields? Do service M&S computer skill competencies expectations differ in terms of career field or career level?

Even beyond the potential differences between the services, on the part of commercial overseas firms like Toyota or Honda, do M&S computer skill differ in terms of the nature of the content or competency expectations for career field or for career level? If M&S computer skill content requirements and education expectations differ from DoD, do these differences translate into better, faster, cheaper, or safer products? Further, what methodology is best suited to answer these questions?

APPENDIX A: NOTICE OF EXEMPT STATUS

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901, 407-882-2012 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Notice of Exempt Review Status

From: **UCF Institutional Review Board**
FWA00000351, Exp. 5/07/10, IRB00001138

To: **Lik Chun Peh**

Date: **December 05, 2007**

IRB Number: SBE-07-05332

Study Title: **Development of a Modeling and Simulation Training Needs Model for Selected Defense Acquisition Workforce Communities**

Dear Researcher:

Your research protocol was reviewed by the IRB Chair on 12/3/2007. Per federal regulations, 45 CFR 46.101, your study has been determined to be **minimal risk for human subjects and exempt** from 45 CFR 46 federal regulations and further IRB review or renewal unless you later wish to add the use of identifiers or change the protocol procedures in a way that might increase risk to participants. Before making any changes to your study, call the IRB office to discuss the changes. **A change which incorporates the use of identifiers may mean the study is no longer exempt, thus requiring the submission of a new application to change the classification to expedited if the risk is still minimal.** Please submit the Termination/Final Report form when the study has been completed. All forms may be completed and submitted online at https://iris.research.ucf.edu.

The category for which exempt status has been determined for this protocol is as follows:

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures, or the observation of public behavior, so long as confidentiality is maintained.
   - (i) Information obtained is recorded in such a manner that the subject cannot be identified, directly or through identifiers linked to the subject, **and/or**
   - (ii) Subject's responses, if known outside the research would not reasonably place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing or employability or reputation.

A waiver of documentation of consent has been approved for all subjects. Participants do not have to sign a consent form, but the IRB requires that you give participants a copy of the IRB-approved consent form, letter, information sheet, or statement of voluntary consent at the top of the survey.

All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

On behalf of Tracy Dietz, Ph.D., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 12/05/2007 02:54:49 PM EST

Joanne Muratori

IRB Coordinator

APPENDIX B: SURVEY QUESTIONAIRE

Survey Overview

Thank you for your participation in this exploratory survey.

The Department of Defense (DoD) Modeling and Simulation Steering Committee's (M&S SC) Common and Cross-Cutting Business Plan has an objective to develop "DoD-wide competency requirements" to address current knowledge deficiency in Modeling & Simulation (M&S). As part of the overall effort, the University of Central Florida (UCF) is partnering with US Naval Postgraduate School (NPS) and other academic partners to develop and deliver educational products to help address this deficiency.

The need for Department of Defense Acquisition workforce to receive current education in the area of Modeling and Simulation continues to receive emphasis at the highest levels of DoD. Yet there remains considerable discussion as to the nature and depth of the minimum M&S engineering skills required for the Acquisition work force in career fields Program Management, Systems Engineering, and Test and Evaluation. As part of a more comprehensive review of the educational skills and competency levels required of DoD employees in these career fields, the goal of this survey is to gather insights from key current and former DoD leaders. A better understanding of your valuable insights and expectations of the minimum competency levels for selected Engineering and Computer Science skills applicable to Modeling and Simulation may help determine content and priority of educational materials to be developed in the future.

This survey comprises three short sections. Section A intends to determine the profile of each survey respondent so as to provide the contextual basis to support the analysis of results from subsequent sections. Section B seeks your expert opinion on minimum competency levels of the Acquisition Workforce (DoD 5000.52M Position Category Description: Program Management, Systems Engineering, Test and Evaluation) for selected M&S engineering skills. Section C is an open ended section dedicated to gather your views and comments on the content and scope of the Learning Model. Please answer questions that you feel competent and comfortable in addressing. Include any comments that you may have.

You are not required to give details of your personal information nor will demographic information be linked to you personally. Your responses will be kept strictly anonymous.

Feel free to contact Lik Chun Peh at likchun@hotmail.com or Dr. Michael Proctor, LTC (Ret) US Army at mproctor@mail.ucf.edu if you need any assistance or clarification. Once again, your participation is greatly appreciated. Thank you.

Michael Proctor

PhD Associate Professor,

LTC(Retired)

Lik Chun Peh

Graduate Student

This research has been endorsed by the University of Central Florida's Institutional Review Board (UCF IRB). A signed informed consent form has been waived and is not required. You may view discussion of the informed consent form if you desire. Please select "View Consent Form" if you wish to read the form before commencing on the survey. To go straight to the survey without reading the form, please select "Skip Consent Form" and you will be directed immediately to the survey.

a. View Consent Form (See Appendix C)

b. Skip Consent Form

Section A: Respondent's Professional Experience and Demography

Please circle the most appropriate selection:

A1. What organization/field are you currently in?

a. Air Force
b. Army
c. Navy
d. Marine Corps
e. Industry
f. Academia
f. Other (please specify) _____

A2. While a member of DoD, what is/was your primary career field?

a. Acquisition Program Management career field
b. Acquisition Systems Engineering career field

c. Acquisition Test and Evaluation career field

d. Other career field (please identify) _____

A3. What Career Path Certification level do you currently hold or for current industry/academia employees previously obtain while in DoD?

a. Level 1 (Entry: minimum: Military 0-1; Civilian GS-5)

b. Level 2 (Middle minimum: Military 0-3; Civilian GS-9)

c. Level 3 (Senior: minimum: Military 0-4; Civilian GS-13)

A4. What is the highest formal educational degree that you hold and in what discipline?

a. HS

b. BS (please specify discipline) _____

c. MS (please specify discipline) _____

d. Ph.D (please specify discipline) _____

A5. How many years has your career been involved or otherwise associated with DoD?

a. Please specify total number of years: _____

A6. In total how many years of work experience have you had in your DoD career and association that can be directly related to DoD Modeling and Simulation use or development?

a. Please specify total number of years: _____

A7. While you were in DoD, in terms of total DoD funding devoted to M&S use or development that you directed or otherwise managed throughout your DoD career, please provide a best guess estimate of the overall percentage of those funds that went to the following M&S users/producers (percentages for "a" through "e" should sum to 100%):

a. Internal DoD M&S Staff Percentage:_____

b. Federally Funded Research and Development Centers Percentage:_____

c. Outside Industrial Contractors Percentage:_____

c. Other organizations in the Federal Government Percentage:_____

d. Civilian Universities and colleges Percentage:_____

e. Other (please specify) _____ Percentage: _____

f. Did not direct or manage funding devoted to M&S use or development

Section B: Respondent's Assessment of Learning Model Matrix for the DoD Workforce

In this section, you will be asked to assess by completing a Learning Model Matrix indicating the minimum competency rating for a particular M&S engineering skill and career level that you believe is required for personnel in the DoD Acquisition workforce Program Management, Systems Engineering and Test and Evaluation career fields respectively. These personnel are categorized by Level I (Entry level: minimum: Military 0-1; Civilian GS-5), II (Middle Level: Military 0-3; Civilian GS-9), III (Senior Level (minimum: Military 0-4, Civilian rank GS-13) in accordance to DoD 5000.52M Position Category Description.

For the Engineering Skill Requirement termed "Computers" seven lower-level skill requirements are being considered. A Learning Model Matrix is provided for you to indicate your expectation of competency for Acquisition Career Levels and the M&S Engineering Skill Requirements (ESR) of interest in this survey.

Example: For a given ESR and Acquisition Career Level, simply mark your expectation of the minimum competency for an employee at that career level.

Competency Scale and Rating	**None**	**General Awareness**	**Understand**	**Application**	**Mastery**
	1	**2**	**3**	**4**	**5**
Career	**Program Management**				
Level I		**X**			
Level II			**X**		
Level III				**X**	
Career	**Systems Engineering**				
Level I			**X**		
Level II				**X**	
Level III					**X**
Career	**Test and Evaluation**				
Level I				**X**	
Level II				**X**	
Level III				**X**	

Five assignable levels of competency are identified in the tables. The first level is "None" to indicate no competency required now or in the future. The other four levels of competency are associated with the terms "General Awareness", "Understand", "Application" or "Mastery." These four levels were derived from Bloom's Taxonomy for instructional design. The meanings of those terms are more fully discussed below. NOTE: "Mastery" is best associated with education obtained in a graduate level semester long course.

Competency Level	Bloom's Taxonomy	Definition	Synonym	Examples
General Awareness	Knowledge	- Recall or recognize data or information	Define, identify, recall, list	- Recite a policy - Quote data from memory
Understand	Comprehension	- Understand the meaning, translation, interpolation and interpretation of instructions and problems - State a problem in one's own words	Explain, able to give examples, translates to others	- Explain in one's own words the steps for performing a complex task
Application	Application	- Use a concept in a new situation or unprompted use of an abstraction - Applies what was learned in the classroom into novel situations in the work place - Put theory into practice, use knowledge in response to real circumstances	Construct, modify, operate, prepare	- Apply laws of statistics to evaluate the reliability of a written test
Mastery	Analysis	- Separates material or concepts into component parts so that its organizational structure may be understood - Distinguished between facts and inferences	Compare and contrast, diagram, analyze, relate	- Recognize logical fallacies in reasoning. - Troubleshoot a piece of equipment by using logical deduction
	Synthesis	- Builds/develops new structures, systems, models,	Create, organize, plan, write,	- Write a organizational operations or process

		approaches or patterns from diverse elements. - Put parts together to form a whole with emphasis on creating a new meaning or structure	rewrite,	manual - Design a machine to perform a specific task
	Evaluation	- Make judgments about the value of ideas or materials - Assess effectiveness of whole concepts in relation to values, outputs, efficacy, viability, critical thinking, strategic comparison and review	Appraise, criticizes, critiques, defends, evaluates, justifies	- Select the most effective solution - Explain and justify a new budget

The overall Engineering Skill Requirement (Overall ESR) being considered is: "Computers- Recognize basic computer system architecture, operating systems, M&S software and applications. Have an introduction to structured programming languages such as Fortran and C, and the use of such tools for code development. Gain exposure to computer-based applications to solve systems engineering problems across the acquisition life cycle including experience with selected computer systems."

The Specific Lower Level Engineering Skill Requirement (Lower Level ESR) being considered are:

1. Computer system architecture, programming languages, and software development (e.g. Fundamental architectures and tools)
2. Modeling, Simulation, and Runtime software (e.g. Synthetic Natural Environment Modeling and Scenario development tools)
3. Intelligent Agent software (e.g. OneSAF Objective System or similar agent software)
4. Game-based or other non-DIS, non-HLA Massively Online systems (e.g Forterra)
5. Live Training Simulation (e.g. OneTESS or similar live training simulation)
6. Interactive or Virtual Training Simulation (e.g. Close Combat Tactical Training System or similar interactive or virtual training simulation)
7. Computer Assisted System Engineering Tools (e.g. Rational)"

Questions B1-B7 below depict seven specific Lower Level ESR of interest.

Please mark in the appropriate box your assessment of the ***minimum required*** training competency level (on the continuous scale from 0 being "None" to 4 being "Mastery") for individuals in the DoD career field and Level indicated. If you are not able to assess the specific level and/or career field, please do not make an entry for that level and/or career field. An example is shown as follows.

B1. Expected minimum Engineering skill competency rating for an individual in the given career field at the specific career level for use and development of "Computer system architecture, programming languages, and software development (e.g. Fundamental architectures and tools)" is:

Competency Scale and Rating	**None**	**General Awareness**	**Understand**	**Application**	**Mastery**
	0	**1**	**2**	**3**	**4**
Career	**Program Management**				
Level I					
Level II					
Level III					
Career	**Systems Engineering**				
Level I					
Level II					
Level III					
Career	**Test and Evaluation**				
Level I					
Level II					
Level III					

B2. Expected minimum Engineering skill competency rating for an individual in the given career field at the specific career level for use and development of "Modeling, Simulation and Runtime software (e.g. Synthetic Natural Environment Modeling and Scenario development tools)" is:

Competency Scale and Rating	None 0	General Awareness 1	Understand 2	Application 3	Mastery 4
Career	**Program Management**				
Level I					
Level II					
Level III					
Career	**Systems Engineering**				
Level I					
Level II					
Level III					
Career	**Test and Evaluation**				
Level I					
Level II					
Level III					

B3. Expected minimum Engineering skill competency rating for an individual in the given career field at the specific career level for use and development of "Intelligent Agent software (e.g. OneSAF Objective System or similar agent software)" is:

Competency Scale and Rating	None 0	General Awareness 1	Understand 2	Application 3	Mastery 4
Career	**Program Management**				
Level I					
Level II					
Level III					
Career	**Systems Engineering**				
Level I					
Level II					
Level III					
Career	**Test and Evaluation**				
Level I					
Level II					
Level III					

B4: Expected minimum Engineering skill competency rating for an individual in the given career field at the specific career level for use and development of "Game-based or other non-DIS, non-HLA Massively Online systems (e.g. Halo game, Forterra)" is:

Competency Scale and Rating	None 0	General Awareness 1	Understand 2	Application 3	Mastery 4
Career	**Program Management**				
Level I					
Level II					
Level III					
Career	**Systems Engineering**				
Level I					
Level II					
Level III					
Career	**Test and Evaluation**				
Level I					
Level II					
Level III					

B5: Expected minimum Engineering skill competency rating for an individual in the given career field at the specific career level for use and development of "Live Training Simulation (e.g. OneTESS or similar live training simulation)" is:

Competency Scale and Rating	None 0	General Awareness 1	Understand 2	Application 3	Mastery 4
Career	**Program Management**				
Level I					
Level II					
Level III					
Career	**Systems Engineering**				
Level I					
Level II					
Level III					

Career	Test and Evaluation				
Level I					
Level II					
Level III					

B6: Expected minimum Engineering skill competency rating for an individual in the given career field at the specific career level for use and development of "Interactive or Virtual Training Simulation (e.g. Close Combat Tactical Training System or similar interactive or virtual training simulation)" is:

Competency Scale and Rating	None 0	General Awareness 1	Understand 2	Application 3	Mastery 4
Career	**Program Management**				
Level I					
Level II					
Level III					
Career	**Systems Engineering**				
Level I					
Level II					
Level III					
Career	**Test and Evaluation**				
Level I					
Level II					
Level III					

B7: Expected minimum Engineering skill competency rating for an individual in the given career field at the specific career level for use and development of "Computer Assisted System Engineering Tools (e.g. Rational)" is:

Competency Scale and Rating	**None** **0**	**General Awareness** **1**	**Understand** **2**	**Application** **3**	**Mastery** **4**
Career	**Program Management**				
Level I					
Level II					
Level III					
Career	**Systems Engineering**				
Level I					
Level II					
Level III					
Career	**Test and Evaluation**				
Level I					
Level II					
Level III					

Section C: Respondent's Assessment of Learning Model Matrix for the DoD Workforce

In this section, you are invited to include your comments on the seven Lower Level ESRs examined in Section B as well as offer suggestions on improving them both in content and scope of coverage. Your contribution in this section will help shape the content development of future Engineering Skill Requirements that pertain to "Computers" as well as Learning Matrix Models.

For C1-C7, please provide your professional insights on desirable practical knowledge which you like to see the workforce in your organization trained under each of these seven skill areas. You are also invited to include work examples or relevant case studies to aid in case-based training content development in each of these seven skill areas. Please fill in the blanks.

C1. "Computer system architecture, programming languages, and software development (e.g. Fundamental architectures and tools)"

Desirable Practical Knowledge: _____

Case Study Suggestion: _____

C2. "Modeling, Simulation, and Runtime software (e.g. Synthetic Natural Environment Modeling and Scenario development tools)"

Desirable Practical Knowledge: _____

Case Study Suggestion: _____

C3. "Intelligent Agent software (e.g. OneSAF Objective System or similar agent software)"

Desirable Practical Knowledge: _____

Case Study Suggestion: _____

C4: "Game-based or other non-DIS, non-HLA Massively Online systems (e.g. Forterra)"

Desirable Practical Knowledge: _____
Case Study Suggestion: _____

C5: "Live Training Simulation (e.g. OneTESS or similar live training simulation)"

Desirable Practical Knowledge: _____
Case Study Suggestion: _____

C6: "Interactive or Virtual Training Simulation (e.g. Close Combat Tactical Training System or similar interactive or virtual training simulation)"

Desirable Practical Knowledge: _____
Case Study Suggestion: _____

C7: "Computer Assisted System Engineering Tools (e.g. Rational)"

Desirable Practical Knowledge: _____
Case Study Suggestion: _____

C8. Please provide comments if any on the adequacy of this Learning Model in terms of its scope of coverage that pertain to the Engineering Skill Requirements "Computers". Do feel free to offer suggestions on additional areas which you believe should be considered.

_____

End of Questionnaire

APPENDIX C: INFORMED CONSENT FORM (ATTACHED TO SURVEY)

Informed Consent for an Adult in a Non-medical Research Study

Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study which will include about 100 people. You can ask questions about the research. You can read this form before you decide to take part in this survey. You will be told if any new information is learned which may affect your willingness to continue taking part in this study. You have been asked to take part in this research study because you are a professional in the field of defense acquisition as well as modeling and simulation. You must be 18 years of age or older to be included in the research study.

The person doing this research is Lik Chun, Peh of the University of Central Florida. Because the researcher is a graduate student he is being guided by Dr. Michael Proctor, a UCF faculty supervisor in the Department of Industrial Engineering and Management Systems.

Study title: Development of a Modeling and Simulation Training Needs Model for Selected Defense Acquisition Communities.

Purpose of the research study: The purpose of this study is to validate a training needs model via gathering feedback from experts in the industry on the scope and level of learning competencies required for modeling and simulation professionals.

What you will be asked to do in the study: Answer a short three-part questionnaire online.

Voluntary participation: You should take part in this study only because you want to. There is no penalty for not taking part, and you will not lose any benefits. You have the right to stop at any time. You will be told if any new information is learned which may affect your willingness to continue taking part in this study.

Location: Online

Time required: 20-30mins

Audio or video taping: This study does not include any audio or video taping.

Risks: There are no expected risks for taking part in this study. You do not have to answer every question or complete every task. You will not lose any benefits if you skip questions or tasks. You do not have to answer any questions that make you feel uncomfortable.

Benefits: There are no expected benefits to you for taking part in this study.

Compensation or payment: There is no compensation or other payment to you for taking part in this study.

Anonymous research: This study is anonymous. That means that no one, not even members of the research team, will know that the information you gave came from you.

Study contact for questions about the study or to report a problem: Lik Chun, Peh, Graduate Student, Interactive Simulation and Training Systems, Department of Industrial Engineering and Management Systems, likchun@hotmail.com or Dr. Michael Proctor, Faculty Supervisor, Department of Industrial Engineering and Management Systems at mproctor@mail.ucf.edu

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

How to return this consent form to the researcher: A waiver of documentation of consent has been approved for all subjects. Participants do not have to sign a consent form.

APPENDIX D: RAW SURVEY DATA

	Response Count
View Consent Form	7
Skip Consent Form	20
Answered question	27
Skipped question	0

A1

	Response Count
Air Force	0
Army	12
Navy	2
Marine Corps	0
Industry	8
Academia	1
Other 1. DoD	1
Answered question	24
Skipped question	3

A2

	Response Count
Acquisition Program Management career field	6
Acquisition Systems Engineering career field	7
Acquisition Test and Evaluation career field	1
Other 1. Requirements Development (ORSA) 2. Science and Technology Management (Research) 3. Science and Technology Management 4. Science and Technology Manager (Research) 5. Member of industry 6. Science and Technology Management 7. Simulation operations 8. PM and T&E 9. I have never been a DoD employee 10. Science and Technology	10
Answered question	24
Skipped question	3

A3

	Response Count
Level 1 (Entry, minimum Military O-1; Civilian GS-5)	1
Level 2 (Middle, minimum Military O-3; Civilian GS-9)	1
Level 3 (Senior, minimum Military O-4; Civilian GS-13)	19
Answered question	21
Skipped question	6

A4

	Response Count
HS (please specify discipline) 1. Science Prep 2. No specialty	2
BS (please specify discipline) 1. Physics 2. Mechanical Engineering 3. Industrial Engineering 4. Computer Engineering 5. Industrial Engineering 6. BSEE 7. Business Administration 8. Electrical Engineering	8
MS (please specify discipline) 1. ORSA 2. Govt Acquisition and Contract Mgt. 3. Operations Research Stochastic Modeling 4. Operations Research- Stochastic Modeling 5. Simulation and Training 6. Computer Science and Strategic Planning 7. Computer Science and Strategic Planning 8. MBA 9. National Security and Strategic Studies 10. ORSA 11. Simulation/Interactive Training Systems 12. MS Computer Engineering 13. Business Administration 14. Industrial Engineering and Business Administration 15. Telecommunications Management 16. Modeling and Simulation	16
Ph.D (please specify discipline) 1. Currently pursuing PhD in M&S in UCF 2. Currently pursuing Modeling and Simulation PhD program 3. Industrial Engineering 4. Systems and Information Engineering 5. Industrial Engineering 6. Computer Science 7. Computer Science 8. Computer Science	8

Answered question	24
Skipped question	3

A5

	Response Count
1. 39 2. 25 3. 24 4. 19 5. 6 6. 19 7. 21 8. 21 9. 20 10. 32 11. 32 12. 26 13. 27 14. 16 15. 18, DoD sponsored R&D since 1990 16. 12 17. 17 18. 7 19. 20 20. 20 21. 8 22. 21 23. 30 24. 25	24
Answered question	24
Skipped question	3

A6

	Response Count
1. 33 2. 25 3. 6 4. 17 5. 6 6. 17 7. 12 8. 19 9. 6 10. 27 11. 28 12. 17 13. 13 14. 16	24

15. 18 16. 5 17. 4 18. 7 19. 12 20. 20 21. 5 22. 20 23. 15 24. 25	
Answered question	24
Skipped question	3

A7

	Response Count
Internal DoD M&S Staff (please specify percentage) 1.all 2. 0 3. 1 4. 5 5. 50 6. 20 7. 10 8. 5 9. 50 10. 15 11. 30 12. 10	12
Federally Funded Research and Development Centers (please specify percentage) 1. 20 2. 10 3. 20 4. 1 5. 0 6. 20 7. 0 8. 2 9. 10 10. 5	10
Outside Industrial Contractors (please specify percentage) 1. 50 2. 1 3. 85 4. 50 5. 40 6. 50 7. 80 8. 50 9. 80 10. 50 11. 50	11

Other organizations in the Federal Government (please specify percentage) 1. 80 2. 20 3. 80 4. 1 5. 0 6. 10 7. 15 8. 5 9. 5 10. 5	10
Civilian universities and colleges (please specify percentage) 1. 20 2. 1 3. 10 4. 0 5. 5 6. 5 7. 5 8. 30	8
Other (please describe and specify percentage) 1. 0 2. 1 3. 0 4. 10 5. 35	5
Answered question	15
Skipped question	12

B1

Competency Scale and Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Response Count
Career	**Program Management**					
Level I	0	10	6	1	2	19
Level II	0	5	11	3	0	19
Level III	1	5	10	3	0	19
Career	**Systems Engineering**					
Level I	0	3	7	5	4	19
Level II	0	0	6	11	2	19
Level III	0	1	6	3	9	19
Career	Test and Evaluation					
Level I	0	6	5	6	2	19
Level II	0	2	5	11	1	19
Level III	1	3	2	9	4	19
Answered questions						19
Skipped questions						8

B2

Competency Scale And Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Response Count
Career	**Program Management**					
Level I	0	10	5	2	2	19
Level II	0	3	12	4	0	19
Level III	1	3	11	4	0	19
Career	**Systems Engineering**					
Level I	0	2	9	5	3	19
Level II	0	0	5	12	2	19
Level III	0	1	4	6	8	19
Career	Test and Evaluation					
Level I	1	4	6	6	2	19
Level II	0	1	7	10	1	19
Level III	1	1	3	12	2	19
Answered questions						19
Skipped questions						8

B3

Competency Scale And Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Response Count
Career	**Program Management**					
Level I	0	12	3	2	2	19
Level II	0	7	7	5	0	19
Level III	1	7	7	4	0	19
Career	**Systems Engineering**					
Level I	0	3	8	6	2	19
Level II	0	1	6	11	1	19
Level III	0	2	6	4	6	19
Career	Test and Evaluation					
Level I	0	5	7	5	2	19
Level II	0	2	7	9	1	19
Level III	1	3	2	9	4	19
Answered questions						19
Skipped questions						8

B4

Competency Scale And Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Response Count
Career	**Program Management**					
Level I	2	11	2	2	2	19
Level II	1	9	4	5	0	19
Level III	2	6	7	4	0	19
Career	**Systems Engineering**					
Level I	2	5	6	4	2	19
Level II	1	5	2	9	1	19
Level III	2	2	6	5	4	19

Career	Test and Evaluation					
Level I	2	6	5	4	2	19
Level II	1	4	3	9	1	19
Level III	2	2	6	8	1	19
Answered questions						19
Skipped questions						8

B5

Competency Scale And Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Response Count
Career	**Program Management**					
Level I	1	9	6	1	2	19
Level II	0	5	9	5	0	19
Level III	2	3	7	5	2	19
Career	**Systems Engineering**					
Level I	1	4	9	2	3	19
Level II	0	3	5	8	2	19
Level III	1	1	6	7	4	19
Career	Test and Evaluation					
Level I	1	2	9	3	4	19
Level II	0	3	4	9	3	19
Level III	2	1	3	8	5	19
Answered questions						19
Skipped questions						8

B6

Competency Scale And Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Response Count
Career	**Program Management**					
Level I	1	7	6	3	2	19
Level II	0	4	9	6	0	19
Level III	2	2	8	6	1	19
Career	**Systems Engineering**					
Level I	1	4	7	4	3	19
Level II	0	4	2	11	1	19
Level III	1	2	5	4	6	19
Career	Test and Evaluation					
Level I	1	4	7	4	3	19
Level II	0	4	4	10	1	19
Level III	2	2	2	9	4	19
Answered questions						19
Skipped questions						8

B7

Competency Scale And Rating	None 1	General Awareness 2	Understand 3	Application 4	Mastery 5	Response Count
Career	**Program Management**					
Level I	0	10	6	1	2	19
Level II	0	4	11	4	0	19
Level III	2	2	11	4	0	19
Career	**Systems Engineering**					
Level I	0	3	8	5	3	19
Level II	0	2	4	9	4	19
Level III	1	1	3	5	9	19
Career	Test and Evaluation					
Level I	0	5	8	2	4	19
Level II	0	2	5	10	2	19
Level III	2	0	3	9	5	19
Answered questions						19
Skipped questions						8

C1

	Response Count
1. with all of these subjects a key component of the development of any training model, sim, or device is the presence and input of a Subject Matter Expert. It Has been my experience that the best case is if the SME IS one of the systems engineers -- this was the case for me and I believe it is critical for system success 2. Knowledge in hardware, firmware, assembler, kernel, operating system, applications and CPU Design. For Programming Languages C++ and JAVA 3. Desirable Practical Knowledge: Interoperability TENA, HLA-Evolve, CTIA, LVC-IA, JLVC, JLCCTC Case Studies: Warsim 2000 OneSAF JSIMS WARSIM (later variant as a program) I2AB 4. M&S engineering is a subset of the Computer Science discipline. The acqusiition workforce needs to understand M&S developments require specialized training and education. 5. Understanding of general capabilities and lessons learned as applied to program management. 6. This is dependent on whether you are doing SW development. Knowledge of Architecture, programming languages and SW development should be couched interms of history, current state and future. This would include limitations of approaches. Case study would be the failure of HLA. Grand goals subverted by solutions inappropriate for the problem. 7. (a) Software project management and project estimating techniques (b) Case studies relevant to above 8. a) This can be covered in a DAU or other overview course that sufficiently addresses how computer architecture works, how programming languages are used, and how SW development is conducted. b) No knowledge of case studies that would be of value. 9. Recommend you break the competence areas into smaller pieces... for example "interactive virtual simulation" could be several categories: virtual training augmented or mixed reality intelligent tutoring synthetic environments interactive design of virtual simulations This would give you more insight into required skills.	9
Answered question	9
Skipped question	16

C2

	Response Count
1. Knowledge in service oriented architecture implementation software. 2. Desirable Practical Knowledge: SE CORE Terrain protocols and standards rapid terrain generation Case Studies: SEDRIS Defense Terrain models MANA bitmap terrain for agents 3. Specialized runtime software knowledge is over stated by the M&S community. The acquisition community needs to understand that all computer based programs have hardware, sofwtare and operating system requirements that depend on desired or required performance levels. 4. Understanding of general capabilities and lessons learned as applied to program management. 5. If you are not doing virtual development this is not important. This is a niche issue. Understanding the contribution and limitations of approaches. Case study RAID. Raid is a practical application heavily dependent on SNE. 6. (a) Existing interoperability protocols and criteria for selecting among them for a given project (b) Example successful applications of the different interoperability protocols 7. No comment 8. Evolution of SIMNET, DIS, ALSP, HLA, TENA, and CTIA. There is a common thread here that people should understand. Each of these is a reaction to the limitations of those previous to it and often adds a few new ideas, but almost never is a complete rethink, redesign, or unique creation.	8
Answered question	8
Skipped question	19

C3

	Response Count
1. Knowledge in Physical Agents and Temporal Agents Also: Temporal Agents, Spatial Agents (that relate to the physical real-world);Input Agents (that process and make sense of sensor inputs - example neural network based agents neural network); Processing Agents (that solve a problem like speech recognition); Decision Agents (that are geared to decision making); Learning Agents (for building up the data structures and database of other Intelligent agents); World Agents 2. Desirable Practical Knowledge: Experimental Design, specifically Nearly Orthogonal Latin Hypercube Design of Experimentation -Response surface methods -other data mining techniques -Agency, emergent behavior, interaction in high dimensional space -multiple regression methods -strong background in statistics Practical Examples MANA, Pythagoras, NetLogo, OneSAF 3. The acquisition community needs to make the M&S community define their needs based in required performance levels. 4. Understanding of general capabilities and lessons learned as applied to program management. 5. Personally of extreme interest, but not universally applicable. General knowledge of technology vice any particular implementation e.g. OneSAF. The problem is that that the limitations of a particular solution become indistinguishable from the the problem being solved. This results in wasted resources going down dead end trails. OneSAF OTB (ModSAF 5.0 base) & JSAF (ModSAF 5.1 Base) 6. (a) Configuring and executing OneSAF for different applications (b) Example uses of OneSAF 7. Evolution of SAF ideas and systems: SIMNET SAF, ModSAF, IST SAF/CGF, Oden SAF, CCTT SAF, ACTT SAF, Joint SAF, OneSAF. Perhaps also show the limited intelligence in systems like JANUS, JTLS, and JCATS.	7

Answered question	7
Skipped question	20

C4

	Response Count
1. Knowledge of game based Operating Systems, SCORM compliance and Learning Management systems 2. Not qualified on this one, really. Games are not my strong suit. 3. The acquisition community needs to have an appreciation for the variety of M&S tools that are available. (Game theory based M&S is an academic and commercial standard. To say non-HLA does not make sense. DIS is not defined.) 4. Understanding of general capabilities and lessons learned as applied to program management. 5. Non HLA is a good start. Not sure if massively online games are a direct replacement. Forterra 6. (a) Validation (or lack thereof) of game-based systems (b) Applications of America's Army 7. a) Practical knowledge should be limited to the similarities that the online gaming community has with distributed training. Also of note is the difference in fidelity between a constructive or CPX like simulation, and a virtual environment. b) No knowledge of case studies that would be of value. 8. Understand how MMOG's work. There are no dominant MMOGs with direct DOD applications. Need something with more leadership play, not just a run and shoot system.	8
Answered question	8
Skipped question	19

C5

	Response Count
1. Practical Knowledge How the unit trains (Army or other service doctrine) Training objective task decomposition (see Dick and Carey) Communications across terrestrial problem space interoperability Case Studies: OneTESS Longbow TESS TWGSS/PGSS MILES I-HITS HITS BFT 2. The acquisition community needs to understand the resource requirements and desired levels of accuracy. 3. Understanding of general capabilities and lessons learned as applied to program management. 4. Limitations, advantages and cost of approach Case study FCS milestone B decision 5. (a) Credible use of live training data in acquisition decisions (b) Successful examples of live training data in acquisition decisions 6. No comment. 7. Limitations of wireless comms in training environments. Functions of MILES and new capabilities of OneTESS	7
Answered question	7
Skipped question	20

C6

	Response Count
1. Knowledge in Human Computer Interfaces. 2. Practical knowledge: -Virtual generation impacts on processing -entity management - security of facilities when working on classified information Suggested Case Studies: CCTT AVCATT RVS 3. The acquisition community needs to understand availability of the tool. If development of the tool is needed, then development should be treated as a computer system development. 4. Understanding of general capabilities and lessons learned as applied to program management. 5. General parameters & goals of Interactive or Virtual Training Simulation. Case Study CCTT 6. (a) Credible use of virtual training data in acquisition decisions (b) Successful examples of virtual training data in acquisition decisions 7. a) Acquisition personnel need to know where simulation fits into the program life cycle and how training devices can facilitate or even replace actual training. b) Look into institution of Flight School XXI at Fort Rucker in recent years. Majority of initial flight training is now done in simulators. 8. The evolution of the protocols in #2 is really synonymous with a set of simulations that they support. In most cases, the protocols were created specifically because a new simulator was under development and needed more capabilities than the previous protocols provided.	8
Answered question	8
Skipped question	19

C7

	Response Count
1. Desirable practical knowledge: Web-based products Windows Excel export products relational databases Case Studies: Can't think of a good sys eng tool other than Arena Maybe visio 2. DAU should teach awareness that tools exist for almost all specialty areas. 3. Understanding of tie to improved systems engineering for the program. 4. history, current state and future. This would include limitations of approaches. Case study would be HLA and ignoring systems engineering 5. (a) How to use standard CASE tools (b) Successful examples of CASE tool use in acquisition decisions 6. No comment. 7. I don’t think the commercial tools are as important as understanding a language like UML and a set of diagrams like DoDAF. The latter is not specifically meant to be applied to M&S. It lacks some diagrams on abstraction that would be useful and mandates some coms-like diagrams that are a hindrance. Perhaps there is an opportunity to create M&S Modified DoDAF for our community. In this case, I don't think a historical evolution is useful. I think understanding the currently dominant diagrams is sufficient.	7
Answered question	7
Skipped question	20

C8

	Response Count
1. None 2. please simply the questions. 3. Understanding of general capabilities and lessons learned as applied to program management. 4. Should have had question that related to the relevance of the technologies in the general scheme. 5. Program Managers and Testers do not need a high level of "engineering" proficiency, but an overall understanding of what tools there are, and what they can do. Systems Engineers need a much higher level of proficiency. 6. None. 7. I think there should be some common classifications for models. A model of a phenomena might fall into categories like: - Binary decision - Mathematic Abstraction - Stochastic - Logical - Physical/Physics Has anyone tried to generalize all of the ways to build a model?	7
Answered question	7
Skipped question	20

APPENDIX E: STATISTICAL TESTING WITH MINITAB

Wilcoxon Signed Rank Test: O1-E1 (PM1)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (PM1)  19      9       45.0  0.009     0.5000
```

Wilcoxon Signed Rank Test: O1-E1 (PM1)

```
Test of median = 0.000000 versus median > 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (PM1)  19      9       45.0  0.005     0.5000
```

Wilcoxon Signed Rank Test: O1-E1 (PM2)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon           Estimated
             N   Test  Statistic      P       Median
O1-E1 (PM2)  19      8       13.5  0.575  0.000000000
```

Wilcoxon Signed Rank Test: O1-E1 (PM3)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon           Estimated
             N   Test  Statistic      P       Median
O1-E1 (PM3)  19      9       13.5  0.314  0.000000000
```

Wilcoxon Signed Rank Test: O1-E1 (SE1)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (SE1)  19     12       64.5  0.050     0.5000
```

Wilcoxon Signed Rank Test: O1-E1 (SE1)

```
Test of median = 0.000000 versus median > 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (SE1)  19     12       64.5  0.025     0.5000
```

Wilcoxon Signed Rank Test: O1-E1 (SE2)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon           Estimated
             N   Test  Statistic      P       Median
O1-E1 (SE2)  19      8        9.0  0.234  0.000000000
```

Wilcoxon Signed Rank Test: O1-E1 (SE3)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon           Estimated
             N   Test  Statistic      P       Median
O1-E1 (SE3)  19     16       72.0  0.856  0.000000000
```

Wilcoxon Signed Rank Test: O1-E1 (TE1)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (TE1)  19     13       91.0  0.002      1.000
```

Wilcoxon Signed Rank Test: O1-E1 (TE1)

```
Test of median = 0.000000 versus median > 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (TE1)  19     13       91.0  0.001      1.000
```

Wilcoxon Signed Rank Test: O1-E1 (TE2)

```
Test of median = 0.000000 versus median not = 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (TE2)  19     14       91.0  0.017     0.5000
```

Wilcoxon Signed Rank Test: O1-E1 (TE2)

```
Test of median = 0.000000 versus median > 0.000000

                N for   Wilcoxon         Estimated
             N   Test  Statistic      P     Median
O1-E1 (TE2)  19     14       91.0  0.009     0.5000
```

Wilcoxon Signed Rank Test: O1-E1 (TE3)

```
Test of median = 0.000000 versus median not = 0.000000

               N for   Wilcoxon         Estimated
            N   Test  Statistic      P     Median
O1-E1 (TE3)  19     17      118.5  0.049      1.000
```

Wilcoxon Signed Rank Test: O1-E1 (TE3)

```
Test of median = 0.000000 versus median > 0.000000

               N for   Wilcoxon         Estimated
            N   Test  Statistic      P     Median
O1-E1 (TE3)  19     17      118.5  0.025      1.000
```

Joint Learning Matrix- Comparing Observed vs Expected for ESR 8.2

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
O-E PM1  19      9       45.0  0.009     0.5000
```

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
O-E PM1  19      9       45.0  0.005     0.5000
```

Wilcoxon Signed Rank Test: O-E PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
O-E PM2  19      7       16.0  0.800  0.000000000
```

Wilcoxon Signed Rank Test: O-E PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
O-E PM3  19      8       16.0  0.834  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
O-E SE1  19     10       47.0  0.053     0.5000
```

Wilcoxon Signed Rank Test: O-E SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
O-E SE2  19      7        8.0  0.353  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
O-E SE3  19     11        0.0  0.004     -1.000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median < 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
O-E SE3  19     11        0.0  0.002     -1.000
```

Wilcoxon Signed Rank Test: O-E TE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
O-E TE1  19     13       57.0  0.442  0.000000000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
O-E TE2  19      9        4.5  0.038    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19      9        4.5  0.019    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     17        0.0  0.000     -1.000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     17        0.0  0.000     -1.000
```

Joint Learning Matrix- Comparing Observed vs Expected for ESR 8.3

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19      7       28.0  0.022     0.5000
```

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19      7       28.0  0.011     0.5000
```

Wilcoxon Signed Rank Test: O-E PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E PM2  19     12       32.5  0.638  0.000000000
```

Wilcoxon Signed Rank Test: O-E PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM3  19     12       24.0  0.255    -0.5000
```

Wilcoxon Signed Rank Test: O-E SE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE1  19     11       51.0  0.120     0.5000
```

Wilcoxon Signed Rank Test: O-E SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE2  19      8        4.0  0.059    -0.5000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  18     12        0.0  0.003     -1.000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median < 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  18     12        0.0  0.001     -1.000
```

Wilcoxon Signed Rank Test: O-E TE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E TE1  19     12       50.5  0.388  0.000000000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19     10        4.5  0.022    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19     10        4.5  0.011    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     15        0.0  0.001     -1.000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     15        0.0  0.000     -1.000
```

Joint Learning Matrix- Comparing Observed vs Expected for ESR 8.4

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19      8       31.0  0.080     0.2500
```

Wilcoxon Signed Rank Test: O-E PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM2  19     15       37.5  0.211    -0.5000
```

Wilcoxon Signed Rank Test: O-E PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM3  19     12       22.0  0.196    -0.5000
```

Wilcoxon Signed Rank Test: O-E SE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE1  19     13       24.0  0.142    -0.5000
```

Wilcoxon Signed Rank Test: O-E SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE2  18      9        2.0  0.018     -1.000
```

Wilcoxon Signed Rank Test: O-E SE2

```
Test of median = 0.000000 versus median < 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE2  18      9        2.0  0.009     -1.000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  19     15        0.0  0.001     -1.500
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median < 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  19     15        0.0  0.000     -1.500
```

Wilcoxon Signed Rank Test: O-E TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E TE1  19     14       47.0  0.754  0.000000000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  18      9        2.5  0.021    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  18      9        2.5  0.010    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     18        0.0  0.000     -1.500
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     18        0.0  0.000     -1.500
```

Joint Learning Matrix- Comparing Observed vs Expected for ESR 8.5

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19     10       51.0  0.019     0.5000
```

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19     10       51.0  0.010     0.5000
```

Wilcoxon Signed Rank Test: O-E PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E PM2  19     10       27.5  1.000  0.000000000
```

Wilcoxon Signed Rank Test: O-E PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E PM3  19     12       43.5  0.754  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E SE1  19     10       32.5  0.646  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE2  18     10        8.0  0.053    -0.5000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  19     15        0.0  0.001     -1.500
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  19     15        0.0  0.000     -1.500
```

Wilcoxon Signed Rank Test: O-E TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE1  19     10       41.0  0.185     0.5000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19     10       12.0  0.126    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     14        0.0  0.001     -1.000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     14        0.0  0.001     -1.000
```

Joint Learning Matrix- Comparing Observed vs Expected for ESR 8.6

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19     12       74.0  0.007      1.000
```

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19     12       74.0  0.003      1.000
```

Wilcoxon Signed Rank Test: O-E PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E PM2  19     10       33.0  0.610  0.000000000
```

Wilcoxon Signed Rank Test: O-E PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E PM3  19     11       37.0  0.756  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E SE1  19     12       49.5  0.433  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE2  18      7        2.0  0.052    -0.5000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  18     12        0.0  0.003     -1.500
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE3  18     12        0.0  0.001     -1.500
```

Wilcoxon Signed Rank Test: O-E TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E TE1  19     12       49.5  0.433  0.000000000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19      9        3.0  0.024    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19      9        3.0  0.012    -0.5000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     15        0.0  0.001     -1.000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median < 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     15        0.0  0.000     -1.000
```

Joint Learning Matrix- Comparing Observed vs Expected for ESR 8.7

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19      9       45.0  0.009     0.5000
```

Wilcoxon Signed Rank Test: O-E PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E PM1  19      9       45.0  0.005     0.5000
```

Wilcoxon Signed Rank Test: O-E PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E PM2  19      8       18.0  1.000  0.000000000
```

Wilcoxon Signed Rank Test: O-E PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E PM3  19      8       14.0  0.624  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E SE1  19     11       52.5  0.091     0.5000
```

Wilcoxon Signed Rank Test: O-E SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E SE2  19     10       18.0  0.359  0.000000000
```

Wilcoxon Signed Rank Test: O-E SE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
O-E SE3  19     14       58.5  0.730  0.000000000
```

Wilcoxon Signed Rank Test: O-E TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE1  19     14      105.0  0.001      1.000
```

Wilcoxon Signed Rank Test: O-E TE1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE1  19     14      105.0  0.001      1.000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19     14       92.0  0.014     0.5000
```

Wilcoxon Signed Rank Test: O-E TE2

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE2  19     14       92.0  0.007     0.5000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     16      110.0  0.032      1.000
```

Wilcoxon Signed Rank Test: O-E TE3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
O-E TE3  19     16      110.0  0.016      1.000
```

Relative Competency Analysis- Comparisons in ESR 8.1

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE1-PM1  19     12       78.0  0.003      1.000
```

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE1-PM1  19     12       78.0  0.001      1.000
```

Wilcoxon Signed Rank Test: TE1-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE1-SE1  19      5        0.0  0.059  0.000000000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE1-PM1  19     10       50.0  0.025     0.5000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE1-PM1  19     10       50.0  0.012     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  19     14      105.0  0.001      1.000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  19     14      105.0  0.001      1.000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE2-SE2  19      4        0.0  0.100  0.000000000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  19     11       66.0  0.004     0.5000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  19     11       66.0  0.002     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE3-PM3  19     14      105.0  0.001      1.250
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  19     14      105.0  0.001      1.250
```

Wilcoxon Signed Rank Test: TE3-SE3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-SE3  19     10       10.0  0.083    -0.5000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  19     11       66.0  0.004      1.000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  19     11       66.0  0.002      1.000
```

Wilcoxon Signed Rank Test: PM2-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM2-PM1  19      9       30.0  0.407  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM2  19      7       10.5  0.612  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM1  19     12       40.0  0.969  0.000000000
```

Wilcoxon Signed Rank Test: SE2-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE2-SE1  19     11       48.0  0.197     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE2  19     12       54.0  0.255     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE1  19     14       73.5  0.198     0.5000
```

Wilcoxon Signed Rank Test: TE2-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-TE1  19     13       70.0  0.093     0.5000
```

Wilcoxon Signed Rank Test: TE3-TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-TE2  19      9       27.0  0.636  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-TE1  19     16       92.5  0.215     0.5000
```

Relative Competency Analysis- Comparisons in ESR 8.2

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE1-PM1  19     12       78.0  0.003     0.5000
```

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE1-PM1  19     12       78.0  0.001     0.5000
```

Wilcoxon Signed Rank Test: TE1-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE1-SE1  19      6        3.0  0.142  0.000000000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE1-PM1  19      9       40.5  0.038     0.5000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE1-PM1  19      9       40.5  0.019     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  19     12       78.0  0.003      1.000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  19     12       78.0  0.001      1.000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-SE2  19      9       41.5  0.028     0.5000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-SE2  19      9       41.5  0.014     0.5000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  19      9       41.5  0.028     0.5000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  19      9       41.5  0.014     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE3-PM3  19     13       91.0  0.002      1.000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE3-PM3  19     13       91.0  0.001      1.000
```

Wilcoxon Signed Rank Test: TE3-SE3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE3-SE3  19     12       18.0  0.108    -0.5000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE3-PM3  19     13       86.0  0.005      1.000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE3-PM3  19     13       86.0  0.003      1.000
```

Wilcoxon Signed Rank Test: PM2-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
PM2-PM1  19     11       48.0  0.197     0.5000
```

Wilcoxon Signed Rank Test: PM3-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM2  19      7       10.5  0.612  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM1  19     14       59.0  0.706  0.000000000
```

Wilcoxon Signed Rank Test: SE2-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE2-SE1  19     13       70.0  0.093     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE2  19     13       63.0  0.235     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE1  19     16       98.0  0.127      1.000
```

Wilcoxon Signed Rank Test: TE2-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-TE1  19     13       70.0  0.093     0.5000
```

Wilcoxon Signed Rank Test: TE3-TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-TE2  19      8       24.0  0.441  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE3-TE1  19     16      100.5  0.098     0.5000
```

Relative Competency Analysis- Comparisons in ESR 8.3

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE1-PM1  18     10       55.0  0.006     0.5000
```

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE1-PM1  18     10       55.0  0.003     0.5000
```

Wilcoxon Signed Rank Test: TE1-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE1-SE1  18      4        2.0  0.361  0.000000000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE1-PM1  18      8       36.0  0.014     0.5000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE1-PM1  18      8       36.0  0.007     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  18      9       45.0  0.009     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  18      9       45.0  0.005     0.5000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE2-SE2  18      3        0.0  0.181  0.000000000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  18      7       28.0  0.022     0.5000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  18      7       28.0  0.011     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  18     12       78.0  0.003      1.000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  18     12       78.0  0.001      1.000
```

Wilcoxon Signed Rank Test: TE3-SE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-SE3  18     10       20.0  0.476  0.000000000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  18     12       78.0  0.003      1.000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  18     12       78.0  0.001      1.000
```

Wilcoxon Signed Rank Test: PM2-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM2-PM1  18      9       30.0  0.407  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM2  18      5        2.5  0.225  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM1  18     11       29.5  0.790  0.000000000
```

Wilcoxon Signed Rank Test: SE2-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE2-SE1  18     10       38.5  0.285  0.000000000
```

Wilcoxon Signed Rank Test: SE3-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE3-SE2  18     12       45.5  0.638  0.000000000
```

Wilcoxon Signed Rank Test: SE3-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE1  18     13       57.5  0.422     0.5000
```

Wilcoxon Signed Rank Test: TE2-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE2-TE1  18     10       38.5  0.285  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-TE2  18      8       21.5  0.674  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-TE1  18     11       44.0  0.351     0.5000
```

Relative Competency Analysis- Comparisons in ESR 8.4

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE1-PM1  17      5       15.0  0.059  0.000000000
```

Wilcoxon Signed Rank Test: TE1-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE1-SE1  17      2        0.0  0.371  0.000000000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE1-PM1  17      4       10.0  0.100  0.000000000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE2-PM2  17      5       15.0  0.059  0.000000000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE2-SE2  17      1        0.0  1.000  0.000000000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE2-PM2  17      4       10.0  0.100  0.000000000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  17      7       28.0  0.022     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  17      7       28.0  0.011     0.5000
```

Wilcoxon Signed Rank Test: TE3-SE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-SE3  17      6        6.0  0.402  0.000000000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  17      8       32.5  0.050     0.5000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  17      8       32.5  0.025     0.5000
```

Wilcoxon Signed Rank Test: PM2-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM2-PM1  17      9       30.0  0.407  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM2  17      8       18.0  1.000  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM1  17     11       37.5  0.722  0.000000000
```

Wilcoxon Signed Rank Test: SE2-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE2-SE1  17     11       48.0  0.197     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE3-SE2  17     11       42.0  0.450  0.000000000
```

Wilcoxon Signed Rank Test: SE3-SE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE1  17     13       61.5  0.279     0.5000
```

Wilcoxon Signed Rank Test: TE2-TE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-TE1  17     12       58.5  0.136     0.5000
```

Wilcoxon Signed Rank Test: TE3-TE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-TE2  17      5        9.0  0.787  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-TE1  17     14       74.0  0.187     0.5000
```

Relative Competency Analysis- Comparisons in ESR 8.5

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE1-PM1  18      7       28.0  0.022     0.5000
```

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
```

```
SE1-PM1  18      7       28.0  0.011     0.5000
```

Wilcoxon Signed Rank Test: TE1-SE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE1-SE1  18      4       10.0  0.100  0.000000000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE1-PM1  18     10       55.0  0.006     0.5000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE1-PM1  18     10       55.0  0.003     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  18      7       28.0  0.022     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  18      7       28.0  0.011     0.5000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE2-SE2  18      4        8.0  0.361  0.000000000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-PM2  18      8       36.0  0.014     0.5000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-PM2  18      8       36.0  0.007     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  18      8       33.0  0.042     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  18      8       33.0  0.021     0.5000
```

Wilcoxon Signed Rank Test: TE3-SE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-SE3  18      6       12.0  0.834  0.000000000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  18     10       50.5  0.022     0.5000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  18     10       50.5  0.011     0.5000
```

Wilcoxon Signed Rank Test: PM2-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
PM2-PM1  18     11       48.0  0.197     0.5000
```

Wilcoxon Signed Rank Test: PM3-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM2  18      9       24.5  0.859  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
PM3-PM1  18     13       55.0  0.529     0.5000
```

Wilcoxon Signed Rank Test: SE2-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE2-SE1  18     12       58.5  0.136     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE3-SE2  18      8       22.5  0.575  0.000000000
```

Wilcoxon Signed Rank Test: SE3-SE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE3-SE1  18     14       70.5  0.272     0.5000
```

Wilcoxon Signed Rank Test: TE2-TE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE2-TE1  18     10       38.5  0.285  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE3-TE2  18      7       14.0  1.000  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE3-TE1  18     13       55.5  0.507  0.000000000
```

Relative Competency Analysis- Comparisons in ESR 8.6

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE1-PM1  18      6       21.0  0.036     0.5000
```

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
```

```
SE1-PM1  18      6       21.0  0.018     0.5000
```

Wilcoxon Signed Rank Test: TE1-SE1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE1-SE1  18      4        5.0  1.000  0.000000000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE1-PM1  18      5       15.0  0.059  0.000000000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  18      7       28.0  0.022     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  18      7       28.0  0.011     0.5000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE2-SE2  18      3        2.0  0.789  0.000000000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  18      6       21.0  0.036     0.5000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-PM2  18      6       21.0  0.018     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  18      8       36.0  0.014     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-PM3  18      8       36.0  0.007     0.5000
```

Wilcoxon Signed Rank Test: TE3-SE3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-SE3  18      6        7.5  0.600  0.000000000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  18      8       36.0  0.014     0.5000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-PM3  18      8       36.0  0.007     0.5000
```

Wilcoxon Signed Rank Test: PM2-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM2-PM1  18      9       30.0  0.407  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM2  18     10       25.0  0.838  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM1  18     13       47.5  0.917  0.000000000
```

Wilcoxon Signed Rank Test: SE2-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE2-SE1  18     10       38.5  0.285  0.000000000
```

Wilcoxon Signed Rank Test: SE3-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
SE3-SE2  18     11       42.0  0.450  0.000000000
```

Wilcoxon Signed Rank Test: SE3-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE1  18     13       59.5  0.345     0.5000
```

Wilcoxon Signed Rank Test: TE2-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE2-TE1  18      9       30.0  0.407  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-TE2  18      9       27.0  0.636  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-TE1  18     13       58.0  0.402     0.5000
```

Relative Competency Analysis- Comparisons in ESR 8.7

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE1-PM1  19     10       55.0  0.006     0.5000
```

Wilcoxon Signed Rank Test: SE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE1-PM1  19     10       55.0  0.003     0.5000
```

Wilcoxon Signed Rank Test: TE1-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE1-SE1  19      5        3.0  0.281  0.000000000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE1-PM1  19      8       36.0  0.014     0.5000
```

Wilcoxon Signed Rank Test: TE1-PM1

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE1-PM1  19      8       36.0  0.007     0.5000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  19     10       55.0  0.006      1.000
```

Wilcoxon Signed Rank Test: SE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE2-PM2  19     10       55.0  0.003      1.000
```

Wilcoxon Signed Rank Test: TE2-SE2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE2-SE2  19      4        2.0  0.361  0.000000000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE2-PM2  19      8       36.0  0.014     0.5000
```

Wilcoxon Signed Rank Test: TE2-PM2

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-PM2  19      8       36.0  0.007     0.5000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE3-PM3  19     15      120.0  0.001      1.000
```

Wilcoxon Signed Rank Test: SE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
SE3-PM3  19     15      120.0  0.000      1.000
```

Wilcoxon Signed Rank Test: TE3-SE3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon           Estimated
         N   Test  Statistic      P       Median
TE3-SE3  19      8        8.0  0.183  0.000000000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median not = 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE3-PM3  19     12       78.0  0.003      1.000
```

Wilcoxon Signed Rank Test: TE3-PM3

```
Test of median = 0.000000 versus median > 0.000000

            N for   Wilcoxon         Estimated
         N   Test  Statistic      P     Median
TE3-PM3  19     12       78.0  0.001      1.000
```

Wilcoxon Signed Rank Test: PM2-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
PM2-PM1  19     11       48.0  0.197     0.5000
```

Wilcoxon Signed Rank Test: PM3-PM2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
PM3-PM2  19      6        7.0  0.529  0.000000000
```

Wilcoxon Signed Rank Test: PM3-PM1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
PM3-PM1  19     13       51.5  0.701     0.5000
```

Wilcoxon Signed Rank Test: SE2-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE2-SE1  19     13       70.0  0.093     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE2  19     10       44.0  0.103     0.5000
```

Wilcoxon Signed Rank Test: SE3-SE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
SE3-SE1  19     15       93.0  0.065      1.000
```

Wilcoxon Signed Rank Test: TE2-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE2-TE1  19     13       70.0  0.093     0.5000
```

Wilcoxon Signed Rank Test: TE3-TE2

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon           Estimated
          N   Test  Statistic      P       Median
TE3-TE2  19      6       17.5  0.173  0.000000000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median not = 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-TE1  19     14       85.0  0.045     0.5000
```

Wilcoxon Signed Rank Test: TE3-TE1

```
Test of median = 0.000000 versus median > 0.000000

             N for   Wilcoxon         Estimated
          N   Test  Statistic      P     Median
TE3-TE1  19     14       85.0  0.022     0.5000
```

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