Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula

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ABSTRACT

The Navy M&S Office in conjunction with the Defense Acquisition Modeling and Simulation Working Group presented the Naval Postgraduate School with an enormous challenge in 2006: design and deliver an educational program by 2008, for 20,000 or more acquisition professionals, focusing on the effective use of modeling and simulation in acquisition. The acquisition workforce is central to force transformation, and education is the key to transforming that workforce. This paper describes the processes, lessons learned to date, and assessment plan for this project.

We applied a systems engineering approach to the problem of curricular design. The resulting solution consists of four spirals. The first spiral focused on defining the problem. We developed our analysis based on factors such as our 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, we involved key stakeholders from the acquisition, test and evaluation and training communities. We describe the results of this process.

In the second spiral, our goal was to construct a learning architecture to cover the gaps identified in the first spiral. We describe the course content, scope, and delivery methods that we determined based on those needs from the first spiral.

The results of the first and second spirals, and subsequent lessons learned, will be the focus of our discussion herein. We will also briefly summarize the third and fourth spirals, which are currently underway, that involve course design and testing in the case of spiral three, and delivery and assessment of the curriculum for spiral four.

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INTRODUCTION

The Department of Defense Modeling and Simulation (M&S) and Acquisition communities recognize the need for education and training in M&S across the acquisition workforce (DoD M&S CO, 2006). The desired educational program is different than existing educational opportunities in that it targets *users* of M&S rather than *developers*.

To meet this need, the Naval Postgraduate School applied a systems engineering approach to develop a set of curricula. We submit that this is different from traditional curricular design in that it enables the production of a better suited end product by incorporating systems engineering principles that are not inherent in typical curriculum development projects. In particular, the focus on requirements elicitation from external stakeholders and requirements analysis presents a unique emphasis.

The design process incorporated several institutions that agreed to deliver a common set of curricula to meet the needs of the Defense community. This, too, is an uncommon practice in curricular development.

This paper reports our progress as we near the end of the first year of this multiyear program. It contains a description of the process and of the deliverables produced during the first phase. Further papers will describe the results of the curricular development implementation of later phases of that process.

Herein we will first provide a brief overview of curriculum design and systems engineering approaches. Then we will show how we applied these systems engineering approaches to the design of a set of modeling and simulation curricula. We present the requirements that our process defined. We sketch our future work to complete this project. Finally, we will provide some lessons learned.

CURRICULUM DESIGN

Traditional curriculum design approaches vary from ad hoc construction of materials to systemic Instructional System Design (ISD) approaches that generally follow the ADDIE model: analyze, design, develop, implement, and evaluate (Molenda, 2003). This has been characterized as an inherently linear process (Bell and Lefoe, 1998). Other advocates characterize it as a feedback loop. For example, Don Clark (2006) presents the flowchart in Figure 1 to characterize ISD. Clark also presents a detailed breakdown of the tasks to be performed in each of the five phases of ADDIE.

Iterative design process appears in the literature. Bell and Lefoe propose a feedback loop in their outcomes based on integrative and flexible delivery models. Walkington (2002) proposes a similar feedback cycle. However, most curricular development is sufficiently challenging that institutions settle for a single pass through the design cycle. For example, the Electrical and Computer Engineering Department at Carnegie Mellon spent four years on a single redesign of its curriculum (Director et al., 1995).

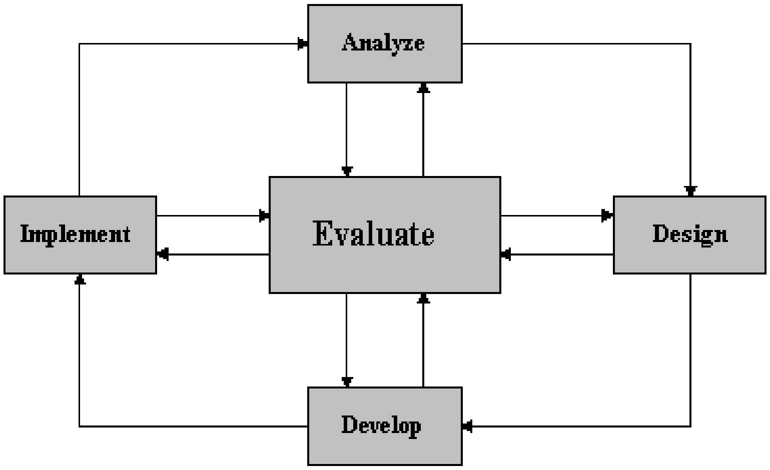


Figure 1: ADDIE model of Instructional Design, as a flowchart. Adapted from Clark (2006).

Engineering accreditation is beginning to demand evidence of involvement from constituents in the design and development of engineering curricula. The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) seeks "high degree of involvement in defining objectives and desired outcomes, assessment, and improvement cycles; (and) sustained evidence of strategic partnership with all key constituents." (ABET, 2002) The ABET is also pressing for evidence of feedback loops in curriculum revision.

At our own institution, curricular design incorporates a strong involvement from constituents (called "sponsors" at NPS) in the services and also a biennial curricular review process involving constituents (NPS, 2003). We have also participated in a multi-school educational franchise, called "Product Development for the 21st Century." This curriculum was jointly developed and delivered by NPS, MIT, RPI, and the University of Detroit – Mercy. All of the partners deliver the same courses, using a common set of syllabi.

Emerging best practices, then, favor strong constituent input, feedback loops, and detailed work breakdown. These desired characteristics lend themselves well to the choice of a Systems Engineering (SE) methodology as a practical approach to curriculum design.

SYSTEMS ENGINEERING APPROACH

As a systems engineering department, we approached this project inside the framework of our traditional SE design models. Several models representing the systems engineering process exist (Blanchard and Fabrycky, 1998). They hold several principles in common. First, take a top - down approach that views the system as a whole. Second, take a life-cycle approach that addresses all the phases of the system life in the design process. Third, get the requirements right at the start of the project. This involves careful coordination with stakeholders. Fourth, iterate using feedback loops. Last, use an interdisciplinary approach. The waterfall, spiral, and Vee methods all have these five points in common.

We use an approach similar to the one developed at the US Military Academy, presented here as Figure 2. We adapted these principles in our approach to the design of these curricula.

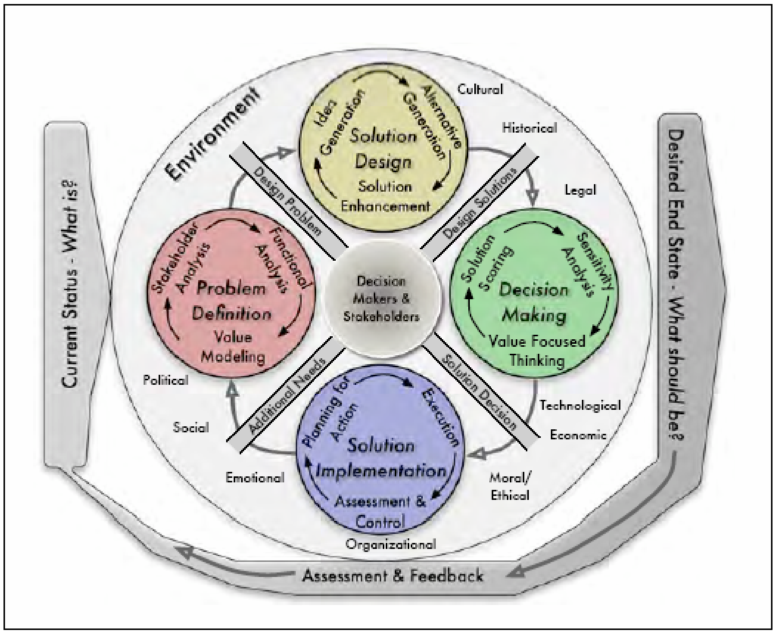


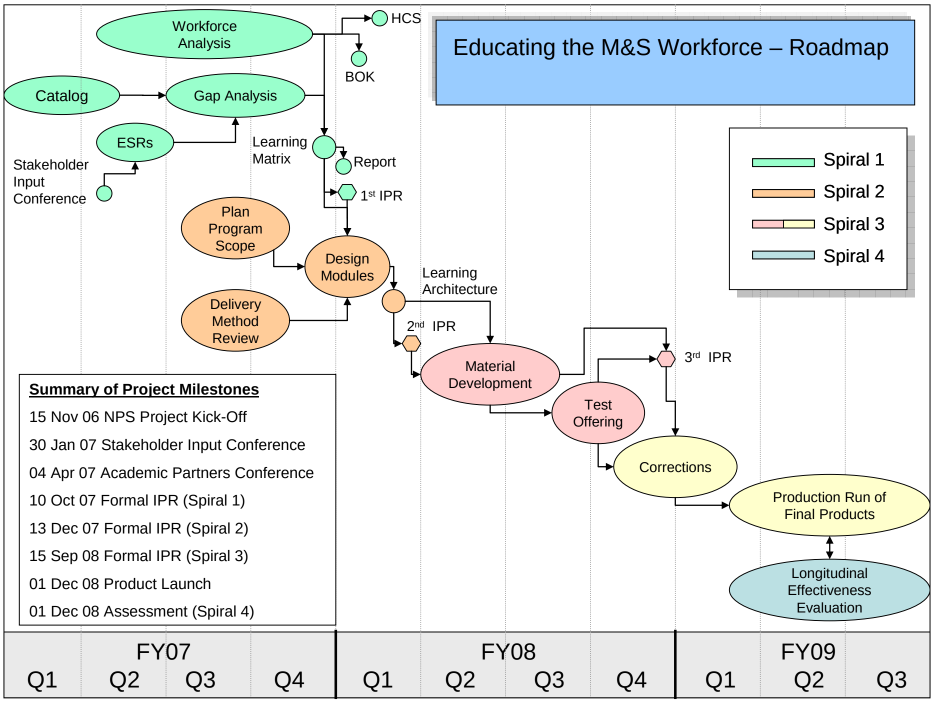
Figure 2: Systems engineering design process. From Parnell, Driscoll, and Henderson (2006).

In keeping with the SE design process concept, we took a top-down look at the problem. We segmented the target student population by career field and level of expertise. Next we scoped the project to address three of the thirteen acquisition career fields. They were program managers, system engineers, and test & evaluators. The three levels of expertise established for each of these career fields were basic/entry, intermediate/journeyman, and advanced/senior. These were also in alignment with the career levels defined by DoD Instruction 5000.52M (DoD, 1995). We determined the educational requirements for each of these nine (three by three) audiences. We examined what was available nationally to meet these educational requirements, and defined the gaps. We then determined the requirements to design various content modules to address those gaps. This differs from a bottom-up approach, which would have assembled existing courses into a program.

We took a life-cycle approach to the design of the curricula, focusing on assessment and feedback mechanisms. We found that designing the business plan to support the delivery of the curricula presented the biggest challenge. This is discussed in the lessons learned portion of this paper. We took great pains to get the requirements correctly defined. This, too, is discussed in detail in a subsequent section. We have planned for iteration in the design of the program, using a test-fix-test paradigm.

Last, we assembled an eclectic team of instructors from many disciplines and institutions, practitioners, educational designers, representatives of the user community, along with representatives of industry. The requirements defined have been reviewed and accepted by this broad-based team.

Next we developed a project plan for the development of the curricula. It is organized into four spirals, presented graphically in Figure 3. The first spiral consists of requirements definition, the second is development of the architecture, the third is detail design and development, and the fourth is delivery and assessment. As of the writing of this paper, spiral one is complete and we are nearly complete with spiral two.



Summary of Project Milestones

15 Nov 06 NPS Project Kick-Off
30 Jan 07 Stakeholder Input Conference
04 Apr 07 Academic Partners Conference
10 Oct 07 Formal IPR (Spiral 1)
13 Dec 07 Formal IPR (Spiral 2)
15 Sep 08 Formal IPR (Spiral 3)
01 Dec 08 Product Launch
01 Dec 08 Assessment (Spiral 4)

Figure 3: Project plan.

How does our approach differ from traditional instructional systems design? In many ways, it is similar. Top-down approach, analysis of requirements, and feedback loops are elements of ISD. What distinguishes our approach is a matter of emphasis on requirements, the interdisciplinary nature of the subject matter and hence of the partners, and the life-cycle planning.

In our SE model, we are now in the Solution Design Phase, having recently completed the Problem Definition Phase, with its emphasis on stakeholder analysis, functional analysis, and value modeling. Since our curricular design answers to and must be approved by a set of external customers, this problem differs from the traditional curricular design where the decision makers reside in the institution delivering the instruction. This, coupled with the necessity for building consensus for design and delivery across a wide set of academic institutions, has driven us to use a systems engineering paradigm over an ADDIE paradigm.

SPIRAL ONE

The first spiral began in November 2006. We assembled a team at NPS from the engineering school, the school of operational sciences, and the business school to explore how we would build an interdisciplinary and inter-departmental team to address the request of the sponsor. Most schools find team building across such a range of disciplines and institutional boundaries challenging, and our school is no different. We agreed on a structure for organization, and agreed to partition the work for parallel development, with a small steering committee responsible for organization and integration.

We set a small team to work collecting data on existing educational programs that might address, fully or partially, the education of acquisition personnel to employ modeling and simulation in their projects. This resulted in a catalog of existing programs in a relational database.

Concurrently, we set up another team to develop the detailed educational requirements for each of the nine market segments. Following terminology used at NPS, we called them “Educational Skill Requirements” or ESRs for short. We identified key representatives from the user communities in government and industry. We also identified a set of potential academic partners for delivery and involved them in the requirement setting. The ESRs were broken into five areas which are presented below.

We compared the results of the ESRs with the catalog, and identified the key gaps extant. Those gaps are presented and discussed below. And finally, we organized the audiences, ESRs, existing programs, and gaps into a “learning matrix.” This single document summarized the requirements for the curricula to address each segment.

Concurrent In parallel with our work, partners at the Air Force Agency for Modeling and Simulation were developing a human capital strategy for the modeling and simulation community, and defining a body of knowledge for that group of professionals. Their work complemented ours by addressing a different portion of the defense workforce.

CATALOG

The catalog contains data from 22 institutions that offer relevant instruction. It contains information about 253 courses. The data is organized into tables, including institution, programs, courses, topics, learning objectives. Cost data and delivery options are included. The catalog allows the team to search for courses that meet the proposed ESRs, and to then refine the search by parameters such as cost, delivery method, duration, and location.

The focus of existing education is on those who develop and analyze models and simulations. There are few courses that focus on those acquisitions professionals who are supported by M&S efforts. Catalano and Didoszak (2007) found “Existing post-graduate modeling and simulation degree programs produce engineers capable of developing M&S, rather than focus on the required knowledge to *use* the M&S for acquisition.” They found 29 courses that had an acquisition focus and that targeted acquisition professionals. These were in most part “short introductory courses of a few days in length providing a basic understanding of the use of M&S” (Catalano and Didoszak, 2007). There were only nine of 188 traditional courses that addressed any of the objectives of the new program. They also found that the average cost per course was $1271.

EDUCATIONAL SKILL REQUIREMENTS

After consulting with our stakeholders, we broke the ESRs into five groups: process, program management, operations and logistics, test and evaluation, and engineering. The first group addressed common M&S issues for the acquisition community, and the last four addressed issues that focused on the corresponding domains of application.

The process ESRs are presented in Table 1. These ESRs have been vetted by users, sponsors, industry, academic partners and other stakeholders. There is wide agreement that they are comprehensive in scope. The rest of our ESR groups focus on the domains of application. Those ESRs are listed in Tables 2 - 5.

Table 1: Process ESRs

P1) Understand the critical decisions in the acquisition lifecycle, the analysis plans to support them, and the information required.
P2) Understand the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps, and to estimate how well new program concepts might address those gaps.
P3) Understand the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.
P4) Know the technical aspects of the domain of application.
P5) Know the taxonomy and hierarchies of models and simulations and be able to select appropriately for a given situation. Understand the types of architectures and role of architectures in tying together and communicating requirements, analysis, modeling and simulation, design, and development planning to all stakeholders. Understand how M&S is deployed in different environments (Live, Virtual, and Constructive). Understand the differences between standalone and confederated M&S applications and when to apply each in various situations. Be familiar with the simulation interoperability standards.
P6) Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of “built to” or “buy to” performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.
P7) Estimate the cost, develop a schedule, and measure the performance of a modeling and

simulation plan. Identify the areas of risk and develop a mitigation strategy.

P8) Know how to incorporate modeling and simulation, through a Simulation Support Plan, into a systems engineering plan and a test and evaluation master plan.

P9) Know and require the best practices and standards in modeling and simulation as developed in key case studies.

P10) Know the models and simulations used in a given domain, their inputs and outputs, and their strengths and weaknesses.

P11) Know the common terminology and high level roles and responsibilities, as well as the underlying philosophy, principles, and methodologies used in VV&A efforts, especially those applied in DoD.

P12) Be able to correctly match the level of detail of a model with that of the information needed to support a decision, and understand the connection between the decision to be made and the estimation of measures from the model.

P13) Understand the trades between using a general model and a custom model, including the VV&A implications.

P14) Design a sound simulation study for a given set of objectives.

P15) Apply appropriate statistical techniques to the analysis of simulation output.

P16) Know how to manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.

P17) Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.

Table 2: Program Manager ESRs

A1) Understand the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with respect to design, testing, training, production, cost estimation, manning, and logistical simulations.

A2) Understand the concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle, in order to reduce the time, resources, and risks associated with the acquisition process.

A3) Be able to discern among M&S proposals, relative to measurable program contributions, and decide on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Distinguish whether custom or off-the-shelf products will be best suited for the program's purpose.

A4) Understand the role of M&S in the contract proposal process, how M&S efforts will be defined and specified, and the value of M&S deliverables under an acquisition contract. Determine their need for continuous improvement, vis-à-vis M&S cost/benefit trades throughout the program life cycle.

A5) Know where to find organizational M&S resources to identify the number and types of models currently in use, best practices from case studies, where they originated, and how they might be leveraged in support of an acquisition program.

A6) Be aware of the Modeling and Simulation Resource Repository as a single source for information about and access to DoD models, simulations, data sources, algorithms, and other M&S resources in order to facilitate reuse and avoid duplication.

A7) Understand experimental design, level of model detail, and M&S application as a pre-test prediction tool. Use M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. Understand the analysis of M&S outputs/measures.

A8) Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E) – particularly operational and live-fire test and evaluation.

A9) Know how to employ M&S to explore reliability and interoperability issues.

Table 3: Test and evaluation ESRs

T1) Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration.
T2) Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent testing decision.
T3) Understand the different types of testing (i.e. unit, integration, interoperability, and operational) and identify the utility, limitations and risks for use of M&S in each.
T4) Understand the potential opportunities for employing M&S in the test planning and execution process.
T5) Be aware of existing M&S T&E facilities used within the DoD.

Table 4: Operational and logistical modeling ESRs

O1) Understand the role of operational and logistical models in the acquisition life cycle and when they are used.
O2) Know the properties of a representative suite of operational models across the services, including required inputs, outputs, assumptions, implementation requirements, costs, time required, adaptability and extensibility, and VVA status.
O3) Know the properties of a representative suite of logistical models across the services, including required inputs, outputs, assumptions, implementation requirements, costs, time required, adaptability and extensibility, and VVA status.
O4) Understand abstractions and lower levels of realism in operational and logistics models.
O5) Understand and be able to model the components of logistics systems, including Supply Chain, Storage systems, Facilities, Production, Inventory management, Transportation & distribution, Replenishment policies.

Table 5: Engineering ESRs

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.

These process ESRs contain several noteworthy tasks. They indicate that the integration of modeling and simulation as a source of data into formal decision making processes remains an important challenge for acquisition professionals. P5 requires the appropriate selection of a model and simulation for a given situation. P6 requires the student to establish and write valid modeling and simulation requirements. P7 requires the student to demonstrate project management skills for M&S activities, including cost estimation, scheduling, performance assessment, and risk identification and mitigation. There was wide consensus that the skills and knowledge identified in the process ESRs were vital, and that it was of great importance to deliver these widely throughout the M&S workforce.

The engineering ESRs in Table 5 also deserve special comment. We observed that many in the acquisition community had a greater familiarity with operational models than with engineering models. Operational models are useful for verifying that the correct set of capabilities is defined in the concept development phase. Engineering models are useful for design, and especially for testing. In fact, if one desires to substitute M&S results for live testing, one is most often contemplating the use of an engineering model.

After long discussion and careful consideration of the audience, we decided that formal survey courses on the principles listed in Table 5 was not going to be palatable to the general members of the acquisition community, who lacked the time and background to complete them successfully.

We decided to address the engineering ESRs through a set of case studies that provide the engineering context as they presented the case. Accordingly, we commissioned preliminary design of eleven case studies. These range from the dynamics and control theory underlying the Segway machine, to the structural mechanics, fluid mechanics, and environmental science behind ship shock simulation models.

RESULTS OF GAP ANALYSIS

The gap analysis revealed two main gaps. First, where there were courses and material that addressed the ESRs, there was no common look and feel to them. In their current state, they cannot be easily integrated into a coherent whole. For example, the Defense Acquisition University has a module on M&S for System Engineering (DAU, 2006) that is delivered on-line. A second short course is offered by George Mason University in a three day, 21 hour short-course delivered in traditional lecture format. These courses cover some of the ESRs but not at the depth necessary for some of the audiences. It is not possible to integrate the two courses as they exist as they were not designed for such integration and since they use different modes of delivery.

The second main gap was that a number of key ESRs had no courses or materials that addressed them at the level desired for the acquisition professionals. This was particularly true of the engineering ESRs. It was also true for several of the program manager and process ESRs.

A detailed report on the gap analysis is available upon request to the authors.

PARTNERSHIP PROCESS

The target audience for these curricula is estimated at 20,000 students. This exceeds the capacity of any one educational institution. To address this, we recruited partner schools from across the nation to participate in the project. Partners as of this writing include: George Mason University, Johns Hopkins University / Applied Physics Lab, Old Dominion University, Stevens Institute of Technology, University of Alabama (Huntsville), University of California (San Diego), and the University of Central Florida. We have divided work among ourselves according to our specific competencies and strengths. For example, the University of Alabama (Huntsville) has a national reputation for its simulation based testing work, and that school volunteered to lead the design work for many of the T&E ESRs previously shown in Table 3.

We developed a metaphor for our approach. We consider ourselves a national food franchise chain. Together with the academic partners, we are designing a menu and a store layout. All the institutions can open their own franchise store, but the layout and menu will be standardized across the chain. Quality benchmarks and standardized syllabi will help assure that the product at one store is the functional equivalent of the product at any another store.

We have broad agreement on this approach, but as we have not yet completed design integration, the level of difficulty in bringing this approach into reality remains an open question.

STAKEHOLDER FEEDBACK

Our panel of stakeholders includes representation across the services. The Navy is represented by staff from the Secretary of the Navy's office, the Naval Air Systems Command, the Space and Naval Warfare Systems Command, and the Commander Operational Test and Evaluation Force. The Army is represented by staff from Headquarters, Department of the Army, and the Future Combat System Program Office. The Air Force is represented by the Air Force Agency for Modeling and Simulation and the Joint Strike Fighter Program Office. The Marine Corps has been represented by staff from the Expeditionary Fighting Vehicle Program Office. Industry has been represented by Boeing.

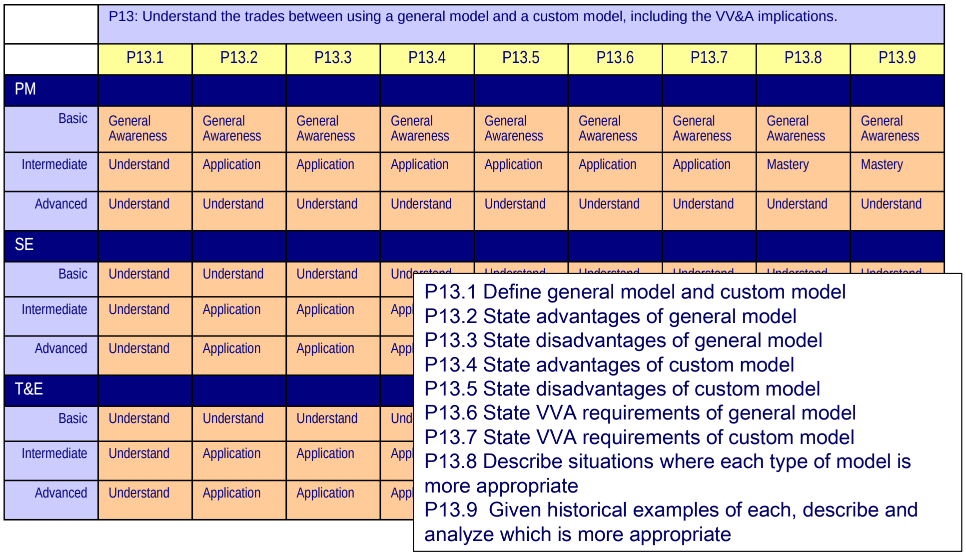
We have iterated the approach and the ESRs several times through the stakeholders to achieve consensus. We have also briefed the senior members of the Defense Modeling and Simulation Coordination Office on progress to date, and we have incorporated their feedback as part of our design process.

Major design reviews are scheduled at the end of each spiral with representatives of the stakeholders and the sponsors.

SPIRAL TWO

Our current spiral takes the results of our gap analysis and develops syllabi for content modules to address those gaps. The majority of this work is being performed by our academic partners and is nearly complete. Much of this work focuses on defining the detailed ESRs which will then in turn create the learning architecture through an index of specific tasks fulfilling the stated educational requirements. An example of what the detailed ESRs might look like for P13, one of the Process ESRs from Table 1, is shown in Figure 4.

Here the overarching ESR is decomposed into sublevel ESRs. The depth of knowledge for each of the career fields, at the accompanying career level, shown as you enter the table from the left, is defined by the general competence levels: General Awareness, Understand, Application and Mastery. Once complete, each of the 50 ESRs will have a corresponding table consisting of detailed ESRs mapped to the appropriate level of granularity. This then forms the consistent and cohesive structure of our learning architecture.



	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	Understand	Understand	Understand	Understand	Understand	Understand
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					

P13.1 Define general model and custom model
P13.2 State advantages of general model
P13.3 State disadvantages of general model
P13.4 State advantages of custom model
P13.5 State disadvantages of custom model
P13.6 State VVA requirements of general model
P13.7 State VVA requirements of custom model
P13.8 Describe situations where each type of model is more appropriate
P13.9 Given historical examples of each, describe and analyze which is more appropriate

Figure 4: Example of Sublevel ESRs and Corresponding Career Level Competencies.

While each module will be developed to the highest level of competency that is required for the subject matter, it may not necessarily be to the Mastery level. By implementing this kind of a methodology in the design of the course modules, portions of content containing more details information can later be extracted to meet lower required competency levels without a major overhaul of the course.

This concept allows for the flexibility in creating courses that are tailored to the target audience, one of the key stakeholder inputs stressed heavily during our early discussions on the deployment of this education program. Any number of desired competency levels, course lengths and delivery methods can then be combined to provide an optimized solution in educating the end user.

As expected, Spiral Two will conclude with a design review where our sponsors will approve the work prior to moving to the next stage.

WAY AHEAD: SUBSEQUENT SPIRALS

Our instructional design team at NPS will complete the templates for the “common look and feel” for the content modules. The engineering case studies that were previously mentioned will be one of the first deliverables and will serve as a first opportunity to “test market” our product. As theses case studies will be used to support the courses created in Spiral Three, we anticipate incorporating this initial feedback in early to make the greatest impact on the course development process.

At present we are planning a mixture of traditional academic courses, short courses, online courses, stand-alone reference material, and collections of case studies. We will confirm with our stakeholders the delivery methods that will be used.

As part of the life-cycle analysis, we will develop a long-term business model with our sponsors. The model will account for delivery, maintenance, and periodic update costs.

Spiral Three includes the actual development of the content modules and supporting materials. It includes a classroom test of the materials, and the generation of feedback on those materials from students, sponsors, and stakeholders. Following that feedback, one quarter is allocated for corrections to address any deficiencies and to disseminate any exceptional best practices.

Spiral Four is the production delivery and the longitudinal assessment of the effectiveness of the material.

A NOTE ON ASSESSMENT

Three separate assessment efforts are underway. The first is to assess student knowledge before and after completion of the content for his or her market segment. This involves a pre-test that will also be used to tailor material to the student. At the end of the curriculum, a post-test will assess the student's mastery of the educational skill requirements. The pre-test and post-test are being developed at NPS for web-delivery.

The second is an assessment of the appropriateness of the educational skill requirements. This will involve long-term surveys of both graduates and their employers for feedback on how useful the ESRs were in the performance of their duties.

The third assessment effort will focus on the effectiveness of the instruction and will be administered to students at the completion of each content module. This will be used to continuously improve the delivery of the information.

LESSONS LEARNED

Lessons learned to date are necessarily preliminary. Nonetheless, we have some initial findings. It has taken longer to build consensus among the wide group of stakeholders represented than we originally anticipated. Thus, the greater the number of partners, the less agile the effort becomes. There is an enormous amount of coordination and synchronization necessary in an undertaking such as this. This requires much greater management than we had anticipated. Obtaining consensus is also difficult when team members have different visions.

The business plan cannot be ignored when building curricula. When we started this project, the initial business plan was that the costs of delivery would be centrally funded. This changed to a customer-funded model as we got underway. The mechanics of that funding and revenue sharing are being worked out. Of greater importance, unless the workforce is presented with incentives to enroll in the curricula, there is a risk of low enrollment. The sponsor bears the responsibility to help create demand in the acquisition workforce, as that is beyond the scope of the project. The sponsor is considering adding the completion of the content of this program to the credentials necessary to advance in the acquisition workforce. This also involves risk, since there are many stakeholders involved in the management of the qualifications of the acquisition workforce, and the M&S CO is but one of them. The risk to the academic partners has been mitigated by paying them the full cost to develop their materials, but there is still risk to DoD; if we "build it, but they do not come."

Integration is emerging as a challenge. The curricula must be vertically and horizontally integrated. We acknowledge that there is risk when there are so many different delivering institutions involved. Our mitigation strategy is to provide detailed templates and regular feedback. This still promises to be a challenge.

CONCLUSION

This project is immensely challenging. We believe that the only way it can be successfully completed is to apply basic systems engineering principles to the design and execution of the curricular design. We are taking a top-down approach, addressing the curricular system as a whole. We are also taking a life-cycle approach. We have diligently worked to establish the educational skill requirements, and we are developing the delivery requirements as of this writing. We have structured feedback loops into the program. Last, we have built a team that is inter-disciplinary, inter-departmental, and inter-scholastic.

The requirements that we have identified are an important step towards the improvement of the acquisition workforce, the better implementation of M&S in acquisition activities, and the continuing transformation of the way the acquisition enterprise does business.

This effort has been noted as a model for other Defense educational initiatives. In particular, the re-engineering of the Navy Systems Engineering training and education strategy is being based on a template derived from this approach.

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