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ACQUISITION-BASED SIMULATION

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ABSTRACT

The Army acquisition community requires high-resolution simulations that represent the dismounted infantry soldier in enough detail to conduct an analysis of alternatives (AOA) for individual weapons and equipment. These models must also be capable of assessing future, proposed capabilities and technologies. Previous work established a detailed, representative set of soldier functions which should be modeled, as well as proposed coordination among three different models. This paper describes the technique used for implementing that coordination on behalf of the acquisition community. It does so in two parts. First, we discuss the methodology used to transforming the needs of the acquisition community into analysis needs. Second, we describe how we integrated the soldier functions into those analysis needs to derive simulation requirements. We will conclude with a discussion of how effective the technique has been in practice.

1 INTRODUCTION

The United States Army has come to rely heavily on modeling and simulation to prove the value of any new item of equipment. This is particularly true in the case of the increasingly technological and therefore expensive new items of equipment. This practice is widely known as simulation-based acquisition. The Army's SMART (Simulation and Modeling for Acquisition, Requirements and Training) program mandates exactly that with the goal of using computer models which "can be saved, altered, deleted, expanded, modified and re-used as the occasion demands, that allows for maximum flexibility to explore alternatives in support of decision processes to modernize the Army." (AMSO 2002)

Unfortunately, the pace of innovation in modeling and simulation has not kept pace with the products themselves. An example of this is the modeling of communication networks. The Army is developing elaborate communication systems. No longer are the platoon and squad leaders the only individuals in a platoon with a radio. Indeed, it is increasingly the case that team leaders and individual soldiers carry radios as well. However, we are just beginning to fully capture that equipment, its distribution, and the related behaviors that are created in combat simulations. This phenomenon is true for many pieces of equipment carried by soldiers. As a result, there is no single simulation that can provide useful analytical results at that detail. One organization within the US Army's acquisition community, Program Executive Office (PEO) Soldier, contracted the Operations Research Center (ORCEN) at the United States Military Academy (USMA) to find or develop such a capability. After conducting a detailed analysis, it was recommended that PEO Soldier could achieve the required detail by coordinating its analysis needs among three separate simulation programs, IWARS, OneSAF and COMBATXXI. A by-product of that research is a detailed hierarchy of functions that a soldier performs on any battlefield. (Tollefson 2004)

In this paper, we discuss the steps taken to implement that recommendation, focusing on how we developed the specific modeling requirements needed by PEO Soldier. By doing so, we are effectively creating an acquisition-based simulation capability. We begin (Section 2) with a short description of the PEO Soldier organization, the three simulations, and the initial steps taken in implementation. Following that (Section 3), we discuss our methodology of defining the analysis needs, compare alternative approaches, and describe in detail our translation of the needs into precise simulation requirements. Finally (Section 4), we conclude with a discussion of how this approach has been received and used in the community, as well as discuss the required steps forward.

2 BACKGROUND

2.1 PEO Soldier

PEO Soldier is the US Army's materiel developer for virtually every item of equipment carried or worn by soldiers around the world. Subordinate to PEO Soldier are three Project Manager Offices: Soldier Warrior, Soldier Equipment and Soldier Weapons. Together, they are responsible for selecting from among candidate systems those new items of equipment which will enhance a soldier's combat effectiveness. (PEO Soldier 2005) However, as mentioned above, advances in combat modeling technology have not matched the pace of advances in equipment technology. This is especially the case for PEO Soldier, because their equipment requires a very-high-resolution simulation.

In December 2003, PEO Soldier contracted the Operations Research Center (ORCEN) to attempt to remedy this lack of specific detail in combat modeling. Their request was that the ORCEN select an existing or under-development simulation, or create a completely new simulation which would provide analytical results at the individual soldier level. Particularly key would be the ability to modify the soldier entity's equipment and observe the changes in performance.

In the ensuing eight months, analysts from the ORCEN studied the problem, using the Systems Engineering and Management Process, a decision-making process taught in the Department of Systems Engineering at West Point. To better support their analysis, the ORCEN created a hierarchy of individual soldier functions, against which the capabilities of various simulations were judged. Their final recommendation was to coordinate the efforts of three separate simulations: One-Semi-Automated Force (OneSAF), Combined-Arms Analysis Tool for XXIst Century (COMBATXXI), and Infantry Warrior Simulation (IWARS). (Tollefson 2004)

2.2 The Three Simulations

One-Semi-Automated Force (OneSAF) and Objective OneSAF (OOS) are combat simulations being developed by the Army's Program Executive Office for Simulation, Training, and Instrumentation. OOS will be represent operations up to the brigade level. It is intended to be used for training as well as analytical applications (Surdu 2004).

The Combined-Arms Analysis Tool for 21st Century (COMBATXXI) is a combat simulation developed by the TRADOC Analysis Center at White Sands Missile Range (TRAC-WSMR) and Marine Corps Combat Development Command (MCCDC). It is an entity-level simulation that models tactical operations at the brigade-level or lower. It has been constructed for use in analytical applications. (TRAC-WSMR undated)

The Infantry Warrior Simulation (IWARS) is a combat simulation developed by the Natick Soldier Center (NSC) and the Army Materiel Systems Analysis Activity (AMSAA). Like COMBATXXI, it is designed for use in the analytical modeling and simulation domain. This model targets "individual and small-unit dismounted combatants and their equipment." (Auer 2004)

2.3 Initial Steps in Implementation

The SEMP is a four-step problem-solving process taught in the Department of Systems Engineering at the United States Military Academy at West Point. As mentioned previously, the recommendation for coordination among three simulations was developed and based on evidence gathered by following the first three steps of that process. The final step, implementation, includes three phases: Planning for Action, Execution, and Assessment and Control. These steps are iterative, as it is often necessary to review or repeat steps as the implementation actually occurs. This paper is focused on planning for action, although we are beginning to execute this coordination.

Implementation of this plan began in earnest in August 2004, when representatives from PEO Soldier, OneSAF, COMBATXXI and IWARS met to discuss the recommendation. The three model developers were aware of the recommendation itself but had never all been in a single forum to discuss its implications. The result of the meeting was an agreement in principle to the decision. Each recognized that they had their own strengths and weaknesses in modeling, and that PEO Soldier would benefit most from capitalizing and coordinating on those points. Further, they recognized that PEO Soldier would be willing to provide funding to improve each of the models. Since the developers agreed in principle on the decision, it became necessary to codify that in a formal Memorandum of Agreement (MOA). This was accomplished largely by electronic mail, telephone conversations, and two meetings over the next four months. While the actual MOA is still working its way through official channels, each of the developers has concurred with its substance and supports it. The remaining question for each is the exact requirements to be provided in the models.

3 PROVIDING THE REQUIREMENTS

3.1 Defining the Analysis Needs

Concurrent to the MOA review process, we in the ORCEN had focused on defining the requirements for the modelers. Recalling that the original purpose of the study was to support PEO Soldier acquisition decision-making, it was important to focus our efforts specifically on those products or capabilities. Chief among those products has been the development of the Land Warrior System, an integrated, very technologically-advanced ensemble of equipment. Land Warrior represents the next step in the evolution of equipment used by the US Army soldier. For that reason, our initial efforts were targeted at that system. Since then, we have taken a broader approach, attempting to widen our field of view and capture the vast array of potential analysis needs of PEO Soldier. To do so, we have relied upon a four-step process, shown in Figure 1 below.

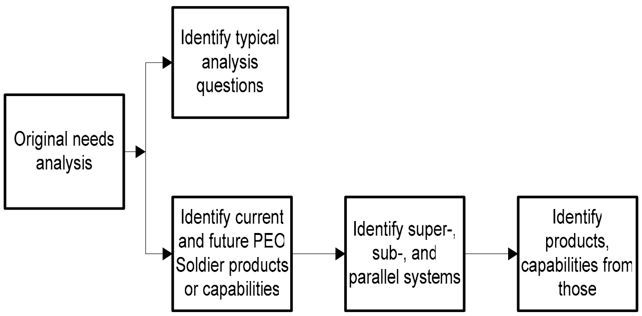

Figure 1: Method to Identify Analysis Needs

The ORCEN analysts who initiated this project provided the information for the original needs analysis. They identified that the original goal of the project was to analytically support acquisition decision-making for PEO Soldier and choose between candidate Soldier Tactical Mission Systems (STMS), such as radios or weapons. This restricted our scope of potential modeling topics to those which would be used or carried by an individual soldier in a combat situation. That point is significant, since it allowed us to prioritize our original list of over 450 products to about 65 products in 7 broad "families."

Based on the realization that this coordinated set of models would be used in the acquisition process, it was important for us to remember that to support any decision, any item of equipment would have to prove its worth by answering certain analysis questions. Further, the modelers stated that knowing these questions would assist them in understanding the modeling detail needed. Those two facts led us try to identify typical analysis questions. Therefore, we have collected several examples of analysis questions used for similar items of equipment.

As we continue in this process, we have changed our perspective toward these questions. While we will provide them to modelers, we have not highlighted them in the requirements for three reasons. First, given the nature of technological innovation, it is impossible for us to claim to capture a representative set of analysis questions for equipment. The questions will change for every new item of equipment, as well as for different studies. Second, while we appreciate the conscientiousness of the modelers, if we provide a question, it could be possible to provide enough detail in the model to answer only a particular question, without regard to a broader set of possible questions. Finally, we originally envisioned that we would provide the questions early in the process, using them as a guide. Instead, we will provide them later, as that will allow us to prioritize the groups of products and therefore have a more specific set of questions. For those three reasons, we have decreased the importance placed on this step in the process.

Returning to the original goal of the study, our next step is to identify current and future PEO Soldier products or capabilities. This is an especially critical, albeit fairly obvious, step in our process. By starting with current products -- those that are already fielded -- we can ensure that the models capture the necessary detail to use as comparative or baseline data. This is important because we also will provide requirements that are based on future capabilities. Only by comparing the future capability to a current item is it possible to prove the value of a new candidate acquisition. We began the study with over 450 products;

We are also considering, as part of a parallel system, the new technologies under development as part of the Future Force Warrior (FFW) program. FFW is the next step past Land Warrior in the evolution of soldier equipment and includes very technologically advanced products. Using both current and future products as our starting point, we will capture the necessary types of equipment and capabilities that PEO Soldier must analyze as part of their acquisition process.

3.2 Translating Needs into Simulation Requirements – Alternative Approaches

After identifying analysis needs in terms of a particular product or capability, the next step is to translate those needs into a specific modeling requirement. Doing so provides the connection between the PEO Soldier organization, their products, and the model developers who have to write the code to perform the simulation. We considered three candidate methods for making this translation, eventually settling on a method that combines the best of the three and provides a concise "task sheet" for each product or capability.

Our first attempt to provide these requirements was solely based on PEO Soldier products and their individual effects. For each of those products, we could define the first and second order effects of the product. By passing along that information to the modelers, they would have a "plain English" understanding of what capabilities a new piece of equipment offered. This could be a fairly simple task, and it would allow the modelers a non-technical description of a potentially very technical object. In effect, it would allow a programmer to see and understand how a soldier would use an item on the battlefield. While that is important, it truly would be too simple, missing the interaction of pieces of equipment, as well as the non-trivial details of modeling such an item.

Our second candidate for translating these needs into requirements was aimed at tailoring our product to the Army acquisition process. That process mandates a detailed analysis of alternatives (AoA), which has the responsibility of proving the worth of any new item of equipment and uses specific questions about a product to do so. Our method would have us define those analysis questions which would be used in such an AoA. For each product, we would attempt to determine a good set of analysis questions that would prove its value. We could then define a level of representation detail that would be required to answer the question. That specification of the detail would become the modeling requirement, delivered to the developers for their action.

While that process would have retained the focus on acquisition decision-making, as well as the emphasis on PEO Soldier products, it would have been too reliant on the analysis question involved. For reasons given above, we are reluctant to tie ourselves to any current idea of what the analysis question could be. Further, that detail needed to answer a particular question may not capture the interactions of various pieces of equipment, a point which is critical to the overall soldier representation.

We considered a third alternative for providing these modeling requirements, one that would have been based largely on a Universal Modeling Language construct. We would begin by considering soldiers as objects, with attributes (physical, mental, etc) and methods (move, sense, decide). Each new piece of equipment would become either an attribute of the soldier or of some other object, or an object itself. This would lead to a comprehensive listing of the equipment to be modeled, as well as its attributes. Based on that, we would define a soldier's method using each of the other objects' attributes. This would capture the interrelatedness of many of the items, and the programmers would be familiar with the format delivered. Additionally, the work completed in the initial part of the study, especially the hierarchy of soldier functions, would lend itself to this quite well. However, this process would be quite tedious and be more detailed than would probably be needed. Also, each of the three simulations has their own UML chart. Creating a fourth could produce confusion as we move forward, not to mention that there would likely have to be a considerable effort to ensure each object in each chart was similarly represented.

In the end, none of these methods by itself would provide the necessary detail while still allowing a modeler to understand the larger environment of the battlefield and how a soldier would employ an item. It was therefore necessary for us to create another process to provide these requirements.

3.3 Translating Needs into Simulation Requirements – Our Approach

After considering each of these candidate methods of translating needs into requirements, we developed a fourth technique. This four step sequence combines several of the steps seen in our candidate methods. It captures enough detail for modelers without creating confusion, and includes a "plain English" description of the product to allow a programmer to visualize the effect an item has on the battlefield. A flow diagram of the process is shown below in Figure 2. I will first describe the steps, then provide an example.

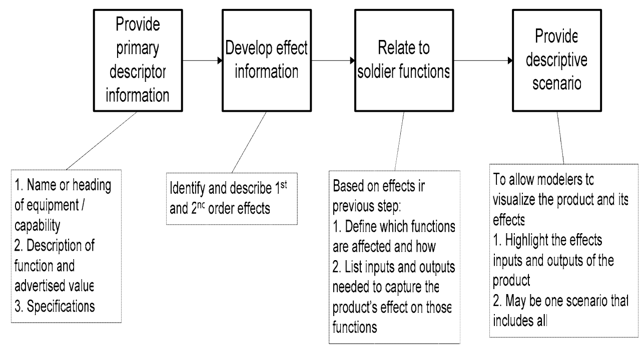

Figure 2: Method to Translate Analysis Needs into Simulation Requirements

3.3.1 Primary Descriptor Information

The process begins with a family of similar products or capabilities. The first step in the sequence is to specify the basic descriptive information about a product or family of products. This is meant as a simple list of the functions and technical specifications of an item. It could include such facts as the dimensions of a weapon, its range, its muzzle velocity, and so on. For a family of products, it would specify which items are in the family and capture the representative facts that are common to the family. For each family of products, we have also prioritized these products and attributes based on their place in the fielding process and their contribution to its performance. This simple method is described in Table 1 as well as an example below.

We have organized some of PEO Soldier's products into an "optics" family which includes viewing, range-finding, and target designation devices. The highest priority products in this family are those that are currently-fielded: PVS-7 Night Vision Devices, as an example. For the PVS-7, the highest priority attribute to model is its field of view, image intensified detection ranges, and any magnification that it possesses – its basic attributes. Including those in a combat model provides an accurate, simple rep resentation of the device. For a more detailed representation, it would be useful for the model to represent its

Table 1: Description of Method to Prioritize Modeling Requirements

1st Modeling Priority	2nd Modeling Priority	3rd Modeling Priority
Basic representation of currently-fielded products	More advanced representation of currently-fielded products	More advanced representation of future products
	Basic representation of future products	

weight, power usage and reflection (to enemy observation). Those advanced topics are the second priority. Also in the second priority are products such as the Small Tactical Optical Rifle Mounted (STORM) Micro-Laser Rangefinder (MLRF), which is still in the acquisition process. It has the added attribute of a rangefinder. Once these attributes have been defined, it becomes the basis for an accounting for the battlefield effects of an item, which is the second step.

3.3.2 Effects

This second step, which is identical to the initial candidate method described above, is quite simple; it is to provide a non-technical, two- to three-sentence description of the first and second order effects of the product. Although simple, this has continued to be significant because of discussions with the modelers themselves. They have maintained that while it is important that they know the engineering-level details of an item of equipment, it is perhaps more important that they understand how a soldier would employ it. We expect it will be necessary to provide more than one of these descriptions for most products, especially those that encompass many functions or related items of equipment.

Returning to the example of the products in the optics family, this requires providing a description of the device's effects on a soldier. PVS-7 Night Vision Devices allow soldiers to see and operate at night or in obscured environments. They also enable more accurate target engagement and allow soldiers to control fires or target with infrared targeting devices. Finally, it also reduces the peripheral vision of the soldier. Providing these simple descriptions gives the modeler an idea of the effect of an item. Using PVS-7s is a simple example; this description becomes more important as the equipment becomes more technologically-advanced or difficult to visualize.

3.3.3 Specific Inputs and Outputs

While that second step will provide the opportunity for the modeler to visualize the piece of equipment on the battlefield, it does not give the required detail to completely and accurately model it. This occurs in the third step, and is very reliant on the work that was done in the initial part of the study. As mentioned earlier, the ORCEN analysts charged with choosing a simulation program developed a detailed hierarchy of functions that a soldier performs on the battlefield. They also identified an initial list of interacting inputs and outputs which would affect or be affected by each of those functions. We use these results in the third step of our process. Specifically, we relate the 1st and 2nd order effects of an item to the soldier function or functions it affects. Doing so also allows us to list the inputs and outputs, and more importantly, to explicitly detail the effect of the equipment on them. By modeling those inputs and outputs and how they interact with the equipment, it is possible to specify the modeling detail needed.

For the example of PVS-7s, it is necessary to first identify the soldier functions that are affected by the equipment – in this case, sense, engage and move. The original hierarchy deconstructed those functions further, leading to the specific inputs and outputs. For the sensing function, a sub-function is to search – manipulate equipment, orient and observe. Clearly the PVS-7 has a great effect on how a soldier performs that function. To correctly model the contribution offered by the device, it therefore is necessary to model the following inputs: a soldier's decision to search, a soldier's METT-TC assessment, the terrain and weather conditions, the symmetric and asymmetric lines-of-sight, the field of view of the device, and the optical contrast of the environment or target. As an output, the model should capture a change in equipment status, reduced ability to focus on other tasks, a change in the equipment orientation, as well as the visual information sensed through the device.

3.3.4 Descriptive Scenario

The final step of the process is to provide a descriptive scenario of how a soldier or squad of soldiers would actually employ the equipment. This complements the description completed in step two, but provides an operational vignette of the effect of an item. It also will be tailored to include examples of many of the inputs and outputs noted in step three. This portion of the translation process is a product of discussions with the model developers. They use a similar tool when modeling operational techniques or tactics, with which they are not generally familiar. We do expect to combine several pieces of equipment into the same vignette, so there will not necessarily be exactly one for each item. Further, while we began with 65 products, we will provide these vignettes for those products which are highest priority and show the most promise for modeling.

Each of these steps produces a result, whether a list of technical specifications, effects, or inputs and outputs. We will collect those results into a task sheet, and have a task sheet for each product or family of products. The next step in the overall process is to deliver those task sheets to the modelers and receive their feedback and proposals to complete the work. Once that is accomplished, we will continue into the execution and assessment phases of implementation.

4 CURRENT PROGRESS AND CONCLUSION

This process has been a work in progress for several months. While it was originally envisioned that the result for each product would be a single task sheet that summarized the results of each step, in practice we have begun with a matrix format. Each family of products has their own matrix. Each matrix contains the prioritized list of products in the family, as well as the attributes and effects of those products. The bulk of the matrix is taken up in capturing the specific inputs and outputs that must be modeled. Using those matrices as a base document has allowed us as analysts to present the requirements to modelers. The modelers then can clearly specify which inputs and outputs they already model, those that they plan to include in their model, and those that they are not planning to include in their model. It also is a allows PEO Soldier to have a tool to determine which modeling gaps they should attempt to address. Once they identify a smaller subset of modeling gaps, we will transition to a task sheet format, one for each product or family of products.

The US Army will continue to rely on modeling and simulation to support their acquisition decision-process. For many items of equipment, it is critical that the acquisition community is able to translate their needs into descriptive, detailed simulation requirements. We have applied the Systems Engineering and Management Process to this need and developed a method of addressing it for PEO Soldier. More broadly, it is possible to use the same analysis method to develop modeling requirements for any acquisition organization. By linking the simulation capability to the needs of the acquisition community, it ensures that the model captures the necessary detail to provide useful analysis for a decision maker. This detail will only increase the realism and effectiveness of any simulation conducted for any other purpose as well. The end result will be an improved modeling capability, valuable for decision-making and training for the next generation of soldiers.

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