Prioritization Framework: A Step Toward Cost-Effective VV&A

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ABSTRACT

VV&A is a four-letter word. Often begun as an afterthought, verification, validation and accreditation (VV&A) efforts for modeling and simulation (M&S) software can be cumbersome, buried in unnecessary detail, and extraordinarily resource intensive. In an effort to assist a sponsor in approaching the verification and validation process, the researchers developed a practical, highly methodical, and generalizable framework for providing a cost-effective approach to the VV&A process. The framework relies on the completion of a viable set of requirements and begins with reviewing those requirements with the sponsor/end user to determine which requirements seem to be primary and which are secondary to the planned use of the simulation. This initial assessment is supplemented by interviews with the end user to determine what scenarios the user intends to simulate with the software and the conditions in which those scenarios will be executed. The scenarios and the conditions for those scenarios are developed into a weighting tree that provides weighting factors that can be applied to the requirements to yield a weighted criticality for each requirement. When sorted using these weighted criticality values, the resultant list constitutes the priorities for validation. The sponsor's assessment of the primary and secondary importance of the requirements provides a means of developing trade spaces for the V&V effort. The sponsor now has a repeatable process, based on the intended use for the simulation, allowing triage of a large number of requirements by placing the emphasis where it is needed. The V&V agent then can approach the problem in a way that places the emphasis on the most critical requirements and helps avoid wasting precious resources on non-essentials.

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INTRODUCTION

Verification, validation, and accreditation (VV&A) is often treated as a four-letter word (though, technically a three-letter-and-a-logogram word) because it is too often done as an afterthought appended to the development process of a simulation at a time when most of the resources for the project have been exhausted. Alternatively, VV&A is done when some higher authority threatens the existence of a program because the simulation tools used have not been subjected to VV&A. Under such circumstances, the VV&A process becomes a tax on already burdened programs and a headache for the program manager. The method discussed in this paper was developed to assist a program manager in performing verification and validation (V&V) on an existing simulation under consideration for use in relevant application areas and to do it within budget and without sacrificing performance. Prioritization based on the intended use of the simulation seemed the most profitable route to performing a cost-effective V&V process.

Prior to launching into a discussion of a prioritization framework for developing a cost-effective approach to V&V, it is useful to begin by defining each term in the VV&A acronym. The following definitions are from the Department of Defense (DoD) *Modeling and Simulation (M&S) Verification, Validation and Accreditation (VV&A) Recommended Practices Guide (RPG)* (Department of Defense 2007):

> Verification – the process of determining that a model implementation and its associated data accurately represent the developer's conceptual description and specifications, or *did I build the thing right?*
>
> Validation – the process of determining the degree to which a model and its associated data provide an accurate representation of the real world from the perspective of the intended uses of the model, or *did I build the right thing?*
>
> Accreditation – the official certification that a model, simulation, or federation of models and simulations and its associated data is acceptable for use for a specific purpose, or *is it believable enough to be used?*

In other words, the purpose of verification is to determine whether the equations or computational models used to represent the entities in the simulation are encoded properly in the software, or that the software does what the model developer intended it to accomplish. In validation, the essential question is whether or not the encoded representation corresponds to the measure of the physical (or real) world it is supposed to represent. The measure of the real world is called a *referent* and encapsulates an understanding of the segment of the real world to be captured in the simulation. That understanding could be measured data, a commonly accepted mathematical relationship, or even the considered opinion of subject matter experts.

The definitions imply that – in order to accomplish V&V of a simulation – the V&V agent must have a viable set of requirements describing what the software is supposed to do, along with referents or acceptable standards of representation for those requirements. These requirements and referents should have guided the development of the model or simulation. Without such guidance, developers have no option but to encode *their* interpretation of what the simulation is actually supposed to represent. In the absence of good referents, any degree of performance could constitute acceptable correspondence to the real world, potentially leaving the model user with software that is inappropriate, inadequate or even unusable.

Nonetheless, the V&V agent, upon initiating the V&V effort, often discovers that the list of requirements is incomplete, failing to cover the user's requirement space and lacking in requisite specificity. Furthermore, referents frequently are not specified for any of the required representations. In a quest for supporting documentation, the

V&V agent is likely to find that there is no conceptual model (thus no record of agreements and compromises between the user and developer), and the documentation on any verification and validation done during development is incomplete at best.

In such cases, the V&V agent must begin the V&V effort by shoring up a weak set of requirements, engaging the user in determining a potential set of referents for the newly refined requirements, and initiating an extended set of discussions with the developer to extract the particulars of verification and validation that were left undocumented or buried in the developer's project notes. Each of these steps is a significant cost driver in both time and dollars.

At a minimum, it will be necessary to refine the requirements to ensure that all of the prospective model user's analytical needs are specified, that the requirements are written in a testable manner, and that a threshold level of performance and a reasonable referent (even if that referent is assessment by a subject matter expert) is given for each requirement. These steps are necessary, but their cost can be reduced if there is a means of determining which requirements are critical to the intended use of the simulation. When working with an existing simulation, the requirements that must be well-specified are those relevant to the user's intended employment of the simulation rather than those associated with the original development effort. A prioritization framework based on the refined requirements and intended mission areas (missions or areas in which the model is expected to be employed) can scope the V&V effort, focusing it on only the most user critical requirements. Prioritization also bounds the effort the V&V agent must expend in recovering and supplementing missing documentation. This paper will describe such a framework, developed and used as part of an actual V&V effort to assess the potential applicability of an existing simulation.

M&S APPLICATION AREA

The user for whom the prioritization framework was developed was concerned with the problem of warehousing and transporting valuable items to distribution points. The major mission areas to be addressed by the simulation include a well-protected warehouse, a protected distribution center and a convoy to transport the high-value items from the warehouse to the distribution center**.** The high-value items could be, for example, ammunition or medical equipment or supplies. Because these are high-value items, they are of potential interest to others who are not the legitimate owners or recipients of the materials. Thus, the warehouse and distribution center are located in protected areas equipped with fences armed with intrusion sensors and defended by a well-trained, armed protection force. The convoy is similarly well-protected with armed defenders and surveillance assets.

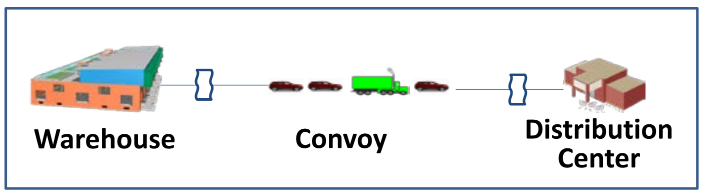

Figure 1 Major Mission Areas of the Simulation

It is assumed that an assault force would be a highly-motivated group, potentially well-trained and equipped with weapons available on the open market. They would have cars, trucks, motorcycles or all-terrain vehicles available to them. The circumstances under which these forces would engage would be the protection of the three mission areas that comprise the problem space: the warehouse, the convoy, and the distribution center. Part of the assessment would focus on overall capability of the physical defenses, but the user was particularly interested in what could be learned by including armed conflict between the assault force and defenders. The simulation would be used for analysis, requiring that the simulation run faster than real time and come equipped with post-processing capability.

All three mission areas require a simulated physical environment including elevation data and physical features, both natural and man-made. The necessary resolution of data used in building the physical environment would be that needed to support the movement of large and small vehicles as well as of humans. Vehicles and humans would be required to perform such actions as fire when fired upon and seek cover in the environment. Interactions among all the representations within the environment would have to be taken into account, including inter-visibility. Motion models for vehicles and humans would have to be sensitive to environmental conditions and normal laws of physics would have to be obeyed; for example, the movement of humans would be blocked by barriers or vehicles.

Vehicles and humans could hide behind structures or in forested or tall, grassy areas. Humans would operate using some type of artificial intelligence that would guide their performance while permitting them to respond to events in the environment. The interactions in the simulation would allow the user to examine the use of sensors, protective defenses of different sorts, the size of defensive forces, and tactics used in the defense of the fixed sites or the convoy.

REFINED REQUIREMENTS

Upon initiation of the effort, the V&V agent found an initial set of requirements that were a combination of items tightly specified in some areas, but with virtually no description in others. The first step in refining these requirements involved the development of a taxonomy to assist in providing adequate description of requirements for all representations in the simulation. The taxonomy included five major categories: environmental representations, platforms, weapons, sensors, and behaviors. Long conversations with highly responsive users and comparison with other simulations provided the needed information to refine the requirement set, determine threshold levels, and identify referents wherever possible.

The V&V process was designed to use threshold levels of representation because these constituted the minimally acceptable representations as specified by the user; however, an objective level – the user's ultimately desired level of representation – was developed as well where appropriate. The user reviewed each requirement and provided an initial assessment as to whether it was of primary or secondary importance to his analytical needs. The final spreadsheet of refined requirements had the following elements:

- Category: from the taxonomy (environment, weapon, sensor, platform, behavior)
- Requirement number: developed later for convenience using the category, requirement number, and subsidiary requirement number (e.g., W1.2, S2.1)
- Requirement: a type of item belonging to the category, for example, a vehicle under the category of *platform*
- Subsidiary Requirement: often expressed as typical behaviors such as movement of specific types
- Threshold Level: the minimally acceptable level of performance
- Objective Level: the ultimately desired level of performance
- Accuracy: acceptable measure of correspondence to the referent, not always available
- User's Assessment: primary or secondary

The prioritization process used the category, the requirement defined at the subsidiary requirement level, the threshold level of representation, and the user's assessment.

PRIORITIZATION FRAMEWORK

When the user has a large set of requirements, it is important to determine a prioritization schema for deciding where to place resources in both developing and validating the simulation. In both instances, establishing a priority list is a means of conserving resources and assuring that the final product meets the user's needs. The concept of developing some form of prioritization is not new. A body of literature in the modeling and simulation domain has been growing over the past ten years seeking a criterion upon which to base prioritization schemas. Early efforts were based on the development of a validation maturity process akin to the maturity model used for software development (Harmon and Youngblood 2005). Subsequent refinements in the US and among NATO nations (see, for example, NATO Science and Technology Organization, Modeling and Simulation Group 2015) seek to tie the processes more closely to the intended use of the simulation. The M&S Use Risk Methodology (MURM), in which risk associated with use of a software to inform decisions, is influenced by insufficiencies in software representations in addition to the degree to which the user will rely on simulation to achieve stated goals (Youngblood, Pandolfini, and Pace 2011). The approach used in this study draws upon some of the analytic approaches found in MURM, but focuses on critical requirements rather than any stated or estimated risk.

The prioritization framework that follows was developed to support V&V efforts, but could equally well be used to guide the development of a new simulation product. The framework orders the requirements based upon the way the user intends to employ the simulation. The process is simple, logical, and repeatable should the user need to establish new goals or directions for the use of the simulation. It is a documented process that can be used by an accreditation agent, and it begins with having the user provide an initial evaluation for each requirement as being of primary or secondary importance (P/S). This assessment will be used again at the end of the process.

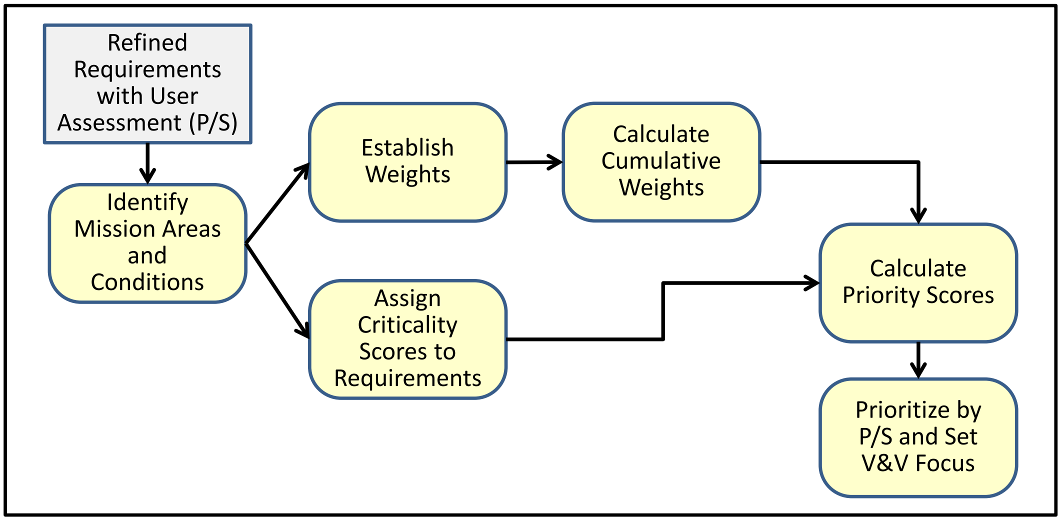

Figure 2 Flow Chart for Using the Prioritization Framework

The flow chart in Figure 2 traces the steps in using the prioritization framework. Once a strong set of requirements have been developed, the prioritization process begins with identifying a set of circumstances or conditions under which the simulation is to be used – conditions that can be used to differentiate the demands of the mission areas and can be consistently applied to each mission area. The conditions are such that they can be layered onto the mission areas. The conditions and tiers chosen for this application area were as follows:

- the first tier contains the set of mission areas to be examined by the user;
- the second tier considers using the simulation for daytime rather than nighttime operations;
- the third trier accounts for dominant weather conditions (clear, rain, or snow).

The conditions described above were selected on the basis that they are easily understood by the user and can readily be used to distinguish the circumstances under which the simulation is to be used. They are also present in all scenarios and have an impact on a large number of entities represented, thus providing a means of distinguishing among the requirements. For example, day and night operations have a strong effect on sensor performance, while weather can influence such things as sensor performance and movement. That said, the prioritization need not use the environmental conditions illustrated in this example; however, whatever factors are used must provide a set of parameters that are pervasive across all potential mission areas and form a well-understood set of conditions that the user can easily specify for the mission areas. The identification of appropriate conditions is both art and science. Conditions are specific to the application area and must provide sufficient differentiation among the requirements to permit a prioritization meaningful to the sponsor or end user's purposes for using the simulation. For the mission areas involved in this study, environmental conditions provided the needed differentiation.

Once these tiers are established, the user examines the first tier and assigns weights to the relative importance of each mission area with respect to the others, then normalizes the weights across the mission areas so they sum to one. The weights could be based, for example, upon the most often requested set of analyses, the condition under which the majority of data is available from live exercises for comparison, or the conditions corresponding to the most likely occurring scenarios in the real world. This process is repeated for the remaining tiers. The tiers of weighting factors form a weighting tree from which composite weights can be computed by multiplying the weights. An example weighting tree is shown for a case with two mission areas in Figure 3. The bracketed notation [0, 1] indicates that the value along that segment can assume any real value from 0.0 to 1.0 including the endpoints.

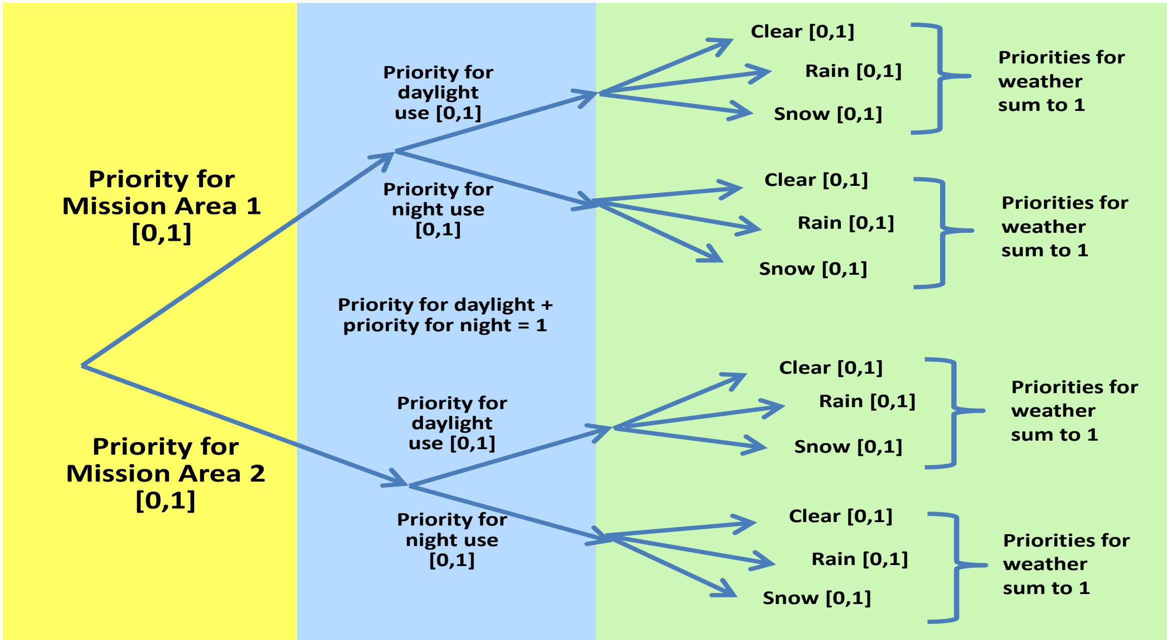

Figure 3. Weighting Tree Based on Mission Area Priorities

As an example of how to compute a composite weight, consider a weight of 0.4 for mission area 1, a weight of 0.8 for daylight in mission area 1 and a weight of 0.3 for snow during daylight in mission area 1. Then the composite weight for snow during daylight in mission area 1 is 0.4 * 0.8 * 0.3 = 0.096. Note that the composite weights will necessarily sum to one because the weights in each tier sum to one.

Once the weighting tree is developed, the V&V agent's technical experts examine each requirement based on the conditions specified along each of the branches of the weighting tree to determine whether the representation is critical, useful or not important under the conditions represented by that branch. The V&V agent will deem each representation as

- critical to that condition and give it a value of 2;
- occasionally used under that condition and give it a value of 1; or
- not needed under that condition and give it a value of 0.

Once these assignments have been made, the cumulative weighting factor is multiplied by each criticality score and the results are summed across all combinations of mission areas and conditions. The result is a priority score for each requirement. These scores can then be ranked in order to obtained a prioritized list of requirements based upon the prospective user's intended use of the model.

EXAMPLE

The following examples taken from the set of refined requirements serve as an illustration of the process diagramed in Figure 2.

Identify Mission Areas, Conditions, and Weights

Figure 1 illustrates the mission areas to be addressed using the simulation. The similarity among the representations required for the distribution and warehouse mission areas led the user to confine the analysis to the warehouse and convoy. The user determined that for the initial set of evaluations, the warehouse mission area would be exercised about 60% of the time relative to the convoy mission area. Attempts to attack at night represented the most significant threat to the warehouse, leading to a weighting of 0.7 for the warehouse mission area at night. Convoys, on the other hand, were rarely planned for night; however, should there be extenuating circumstances, it might be necessary to extend the duration of the convoy into hours of darkness. Thus, some weighting was placed on night operations for convoys (0.2). The weighting values for weather conditions were also dependent upon whether the operations were to take place during day or at night. At the warehouse, the propensity of clear weather led to weighting that environmental factor at 0.5 during daylight hours with rain and snow conditions being of lesser importance (0.3 and 0.2, respectively). At night, however, the more dangerous conditions at the warehouse were operations during rain when the effectiveness of some of the sensors protecting the site would be reduced. In this case, therefore, rain was assigned a weighting of 0.5, while clear weather and snow were assigned lesser values (0.3 and 0.2, respectively). In this manner, the user was able to provide values for the weighting tree shown in Figure 2 by considering the circumstances under which the simulation would be used to provide assessments.

Assigning Criticality Scores

The next step was conducted by the V&V agent's technical experts and involved the assignment of a criticality score (2, 1, or 0) to each combination of mission area and conditions. To illustrate this process, we have selected requirements from several different categories of representation. From the environmental representations, we chose three: berms, vegetation in the form of grass, and precipitation. Note that precipitation here refers to the model requirement to represent precipitation and its effects, while rain and snow are the precipitation conditions under which the model is expected to be used. We also include two entries from sensors: light intensification devices and passive IR devices.

Berms are man-made features built into defended sites as a barrier against incursion by unwanted visitors. They are not likely to be found along a convoy route, but might be present as artifacts of prior events. For example, shore batteries built along coastal roads on both the east and west coasts of the U.S. have defensive features in common with berms and could be represented as berms. Thus berms have a criticality rating of 2 for warehouse and 1 for convoy, across all conditions. Grasses are found around both warehouse sites and along the roadside; however, during snows, they are likely to be weighted down and, hence, less important as potential cover for threats. Criticality for grasses is rated as 2 for clear and rainy weather, but 1 for snow for both warehouse and convoy instances. Precipitation is irrelevant for clear days or night and thus rates a 0 under clear weather conditions. Light intensification devices are used during low light conditions and are thus rated as irrelevant during the day and critically important at night; while IR devices may have some use during the day, but are critically important at night as reflected by the scores of 1 and 2 for those circumstances.

Apply Cumulative Weights and Compute Priority Score

With the criticality factors established for each of the requirements, it is time to apply the weighting factors. This is done by multiplying the cumulative weights at the rightmost point in each branch of the weighting tree shown in Figure 3 by the criticality score for each requirement just computed. The result is shown in the lower part of Table 1, where the combined weighting factor computed from the three-tiered tree is multiplied by the criticality factor to provide the weighted criticality for each of the requirements shown. The desire is to find the importance of the requirement across all mission areas; therefore, the values are summed across all the rows – all the potential mission areas and conditions – to find the overall importance of that requirement. The last column in the lower part of Table 1 is a measure of the overall importance of the requirement as represented by the sum.

Using the rightmost column in Table 1, one can determine which of the requirements are more important given the two scenarios – warehouse and convoy. In the category of environmental factors, of those shown in the table, the representation of grasses is of higher priority than berms and precipitation. This is reasonable as the berms are of only marginal importance for convoys and the bulk of the analysis covers clear weather, thus reducing the need to represent precipitation and its effects. The same logic is true for the sensors. Light intensification devices are of lesser importance because they are useful only during nighttime operations, while passive IR devices have utility for both day and night operations.

The process outlined above was applied to each requirement and for all three mission areas and associated conditions. The abbreviated set of requirements serves to illustrate the application of the criticality factor. Two mission areas were shown to preserve legibility. The sum will always fall within the range [0,2] with the highest scores going to the requirements with the highest priority. Each requirement category was kept separate under this process. There were no extreme changes in prioritized values when different weighting factors were applied. As would be expected, since the discriminating factors were environmental, the environmental representations and sensors which are most sensitive to environmental conditions were those most affected by the choice of different weighting factors.

The initial sense on the part of the user for what was of primary and secondary importance was then checked against the prioritization, making sure that when a requirement was listed as primary, any requirement on which it depended also bore the categorization of primary. This provided the opportunity to revisit the list of requirements with the user and to account for interactions not specifically exposed in the list of requirements themselves.

Table 1 Example of Prioritizing Requirements

		Warehouse = .6						convoy = .4						
		day = .3			night = .7			day = .8			night = .2			
		clear	rain	snow	clear	rain	snow	clear	rain	snow	clear	rain	snow	
		0.5	0.3	0.2	0.3	0.5	0.2	0.6	0.3	0.1	0.8	0.1	0.1	
Category	**Requirement**	**0.09**	**0.054**	**0.036**	**0.126**	**0.21**	**0.084**	**0.192**	**0.096**	**0.032**	**0.064**	**0.008**	**0.008**	
Environment	Berm	2	2	2	2	2	2	1	1	1	1	1	1	
	Vegetation: grasses	2	2	1	2	2	1	2	2	1	2	2	1	
	Precipitation	0	2	2	0	2	2	0	2	2	0	2	2	
Sensors	Light intensification devices	0	0	0	2	2	2	0	0	0	2	2	2	
	Passive IR devices	1	1	1	2	2	2	1	1	1	2	2	2	
														SUM
Environment	Berm	0.18	0.108	0.072	0.252	0.42	0.168	0.192	0.096	0.032	0.064	0.008	0.008	1.6
	Vegetation: grasses	0.18	0.108	0.036	0.252	0.42	0.084	0.384	0.192	0.032	0.128	0.016	0.008	1.84
	Precipitation	0	0.108	0.072	0	0.42	0.168	0	0.192	0.064	0	0.016	0.016	1.056
Sensors	Light intensification devices	0	0	0	0.252	0.42	0.168	0	0	0	0.128	0.016	0.016	1
	Passive IR devices	0.09	0.054	0.036	0.252	0.42	0.168	0.192	0.096	0.032	0.128	0.016	0.016	1.5

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USING THE PRIORITIZATION RESULTS

The prioritization framework is intended to produce a means by which the user can review a large set of requirements and combine his knowledge with the results of the prioritization to determine the best use of his resources. It is not meant to replace the user's judgement, but to provide the user with a formal, logical, and repeatable process to capture and use that judgement. Comparing the results of the prioritization process with the user's initial assessment offers another opportunity to adjust prioritization as needed. In most cases, the users chose to raise or lower (change to primary or secondary) the initial assessment. This additional comparison is also useful in exposing interactions among requirements not recognized during the initial assessment. Once all adjustments were made in collaboration with the user, the numerical results were ready to be used to focus the V&V process.

The requirements were originally listed by category (environment, weapon, platform, sensor, behavior). Retention of this separation throughout the prioritization process was found useful in exposing interdependencies not obvious in the overall listing of requirements. The initial approach was to select a numerical prioritization score and use that as the dividing point for requirements to be covered during the V&V process. It quickly became evident that not all categories are created equal and a more rational selection of requirements was afforded by choosing different scores for different categories. For example, the initial approach might select all requirements with a priority score of 1.2 or greater. For platforms, the ability of a wheeled vehicle to sense and respond to terrain of different types including soil and mud fell above 1.2, into the high priority category. To exercise this functionality, it would be necessary to have environmental effects that produced either dry soil or mud; however, precipitation effects in the environmental category had a priority score of less than 1.0. If the user wanted to simulate having the vehicle drive through both hard soil and mud, the effects of precipitation would have to be included in the set of requirements selected for V&V even though the prioritization score was less than 1.2. The interdependence between these two factors is logical, but not obvious in the list of requirements. The user could choose to include the effects of precipitation in the environment or not include the effect of mud on the trafficability of wheeled vehicles. This is an example of the trade space open to the user when employing the prioritization scores. A second means of examining the prioritized requirements would be to use the user's initial assessments. In at least one case, the user had set the priority of a particular sensor to primary, but in the ratings it fell below the score of 1.2. Upon consideration, the user determined that the particular sensor should be included in the validation effort in spite of its lower score. The prioritization framework provided the overall estimate of what should be included in the V&V effort, allowing the user to concentrate on fine details only. At the end of the decision process, the user has a documented record of the prioritization schema and the decision made for the expenditure of resources.

This prioritization framework is readily understandable from the perspective of the user and technologist, and it allows the user to establish needs in very clear terms. The user can explore the effect of choosing different conditions easily. Changes in weighting factors can be applied in a matter of minutes and the resultant set of prioritized requirements listed for immediate examination. The framework gives the user the ability to provide rational, repeatable, and documented evidence for his decisions concerning where to focus his V&V resources; thereby providing increased confidence that the simulations selected adequately portray the conditions appropriate to the intended use.

CONCLUSION

Employing some type of prioritization is an effective means for limiting the resources needed for VV&A while providing some assurance that the resulting assessment is adequate for the intended purpose. The framework presented in this paper is easy to implement and is based on the user's needs and intended use of the simulation. While it was developed to support a V&V effort directed toward potential acceptance of a simulation developed for other users, this method can be adjusted for use in managing the investment in any new simulation tool.

Prioritization is not a definitive assessment, but a triage that can help the user/sponsor determine the final selection of requirements to be validated for a given model. It also provides a rational, defensible, and repeatable process for choosing what to validate and what to leave out of the V&V process.

REFERENCES

Department of Defense, (2007). *Modeling and Simulation Verification, Validation and Accreditation Recommended Practices Guide*, Waskington, DC: Office of the Secretary of Defense.

Harmon, S. Y., & Youngblook, S. (2005). "A proposed Model for Simulation Validation Maturity Process." *Journal of Defense Modeling and Simulation* 2, 179-190.

North Atlantic Treaty Organization (NATO) Science and Technology Organization, Modeling and Simulation Group, (2015). *Generic Methodology for Verification and Validation (GM-VV) to Support Acceptance of Models, Simulations and Data*, Neuilly-sur-Seine, France: NATO Science and Technology Organization.

The Johns Hopkins University Applied Physics Laboratory, (2011). *Risk Based Methodology for Verification, Validation, and Accreditation (VV&A) M&S Use Risk Methodology (MURM)*, Laurel, MD: Johns Hopkins University Applied Physics Laboratory.

Youngblood, S., Pandolfini, P., & Pace, D. (2011). "Not Your Mother's Programmatic Risk -- M&S Use Risk Methodology (MURM)." *Fall Simulation Interoperability Workshop*, Simulation Interoperability Standards Organization.