

THE USE OF ADVANCED WARFIGHTING EXPERIMENTS TO SUPPORT ACQUISITION DECISIONS

Kenneth Strayer, Thomas Hoivik, and Susan Page Hocevar

This article summarizes research conducted to determine the use of Advanced Warfighting Experiments to support material acquisition decisions. Specifically, the research evaluated the effectiveness of the Army Task Force XXI Advanced Warfighting Experiment (TF XXI AWE) objective of providing information to support investment decisions and refinement of requirements for emerging technology initiatives. Data were collected from appropriate program offices and user representatives to determine the perceived utility of the recommendations and level of implementation. Subjective data detailing why specific recommendations were or were not implemented were used to determine the contributing factors to a program's ability to benefit from participation in the experiment.

From March 1996 through October 1997, the Army conducted the Task Force XXI Advanced Warfighting Experiment (TF XXI AWE), culminating with a live exercise at the National Training Center, during Rotation 97-06, March 1997. The purpose of the AWE was to provide sufficient data to validate digitizing the battlefield and support credible assessments on which to base future procurement decisions. The TF XXI AWE was meant to be a tool for resolving issues and reducing risk early in the program development process and determining the

adequacy of requirements, design, and new system capabilities before committing major resources. A total of 93 TF XXI emerging technology initiatives were initially included in the AWE.

The stated TF XXI AWE objectives include experimenting with advanced technologies and providing information to support investment decisions on the most promising initiatives (Department of the Army, 1996). The AWE was also meant to help the U.S. Army Training and Doctrine Command (TRADOC) refine requirements and develop solutions for Force XXI. The

final Live Experiment Assessment Report, prepared by the U.S. Army Operational Test and Evaluation Command (OPTEC), included full assessments of most participating TF XXI initiatives. OPTEC provided observations and specific developmental recommendations for each initiative (Department of the Army, 1997).

AWE AS A FORMATIVE EVALUATION PROCESS

Advanced Warfighting Experiments are limited in their ability to predict real-world outcomes, since experimental data generally comes from single or few unrepeatable events. Safety restrictions, lack of realism, and unknown composition of future threats make AWE's weakly predictive at best. But experimentation is not limited to the rigorous demands of summative testing; it includes discovery learning. Experiments can be viewed as "formative exercises to see what works and what doesn't" (Lickteig, 1996, p. 15). The U.S. Army Research Institute recommended that the Army implement a formative evaluation method that focuses on exploration, explanation, and improvement. Formative studies are defined as "evaluative activities undertaken during the design and pretesting of programs to guide the design process" (Rossi, 1993, p. 104). Formative evaluations are conducted in developmental stages to help form or improve the system for the user (Lickteig, 1996).

Researchers at the RAND Corporation have demonstrated that the "credible uses" (CU) framework (Dewar, Bankes, Hodges, Lucas, Saunders-Newton, and Vye, 1996), based on a decision-to-experiment ladder

(DEL), can improve the experimental results from an AWE (Lucas, Banks and Vye, 1998; Lucas, Moore, and Vye, 1998). This approach requires significant up-front analysis to link the experimental design to critical programmatic decisions. The decision-to-experiment ladder includes: issues, decisions to be made, argument to support the decisions, hypotheses to be adjudicated, experiments to resolve hypotheses, and analysis and measures to implement decisions (Lucas, Banks, and Vye, 1998). Examples of the ways in which the DEL can support formative assessments follow:

- The CU process requires that specific decisions be identified that can be resolved by experimentation. Specificity in stating focal issues is an initial requirement to experimental design (Lucas, Moore, and Vye, 1998).
- Through understanding the decisions to be made, analysts know exactly the strength of the argument needed to make the decision. This identification of arguments to support decisions is critical in the design of the experiment and is much more productive than conducting the experiment and then deducing what can be inferred from the evidence (Lucas, Banks, and Vye, 1998).
- For the experiment to be used credibly, it must be designed to support decisions. Because of the limited data gathered from AWEs, there must be an "objective and traceable link from experimental results to decisions on important issues" (Lucas, Banks, and Vye, 1998, p. 16).

Rossi (1993) provides additional support for the importance of the formative component of experiments. He argues that, no matter the complexity or integrity of the scientific process of the exercise, the worth of evaluations must be judged by their utility. To achieve maximum benefit from experiments, the actual evaluation must be tailored to the specific program, the stage of activity in the program, and the needs of the stakeholders in the program. Rossi (1993) outlines five factors that affect the utilization of evaluation findings: relevance to the problem, communication between researchers and users, information processing by users, plausibility of research results, and user involvement or advocacy.

The assessment of the utility of data from the TF XXI AWE to Army program managers is the central point of investigation in this research. In particular, OPTEC provided specific recommendations for each participating emerging technology initiative in its Live Experiment Assessment Report. These recommendations detailed changes to user requirements, desired technology improvements, and integration issues. This research evaluates the utility of the AWE to program managers by investigating the levels at which these recommendations were implemented. Specific factors affecting utilization are identified to improve the formative benefits of future AWEs.

RESEARCH METHODOLOGY

The research methods were designed to evaluate the effectiveness of the TF XXI AWE objective of providing information to support investment decisions and

refinement of requirements for information age technologies. The methodology included: creation of tailored surveys for each program initiative and dissemination to each applicable program office and user, and followup interviews of pertinent program managers, users, and test officials. The primary research questions addressed were:

"...no matter the complexity or integrity of the scientific process of the exercise, the worth of evaluations must be judged by their utility."

- Were the specific recommendations derived from the Task Force XXI AWE used to support investment decisions and to refine requirements of participating initiatives?
- What were the contributing factors to a program's ability to benefit from participation in the AWE?
- What are the characteristics of programs that are best positioned to gain valued investment and requirements information from participation in AWE?

A statistical analysis of collected data was conducted to evaluate implementation of initiative recommendations and to identify contributing factors to a program's ability to benefit from participation in the AWE. Additionally, a summary description of the characteristics of a program that is best positioned to participate in future AWEs was developed.

The scope of this research was limited to the 1997 TF XXI AWE. The research primarily concentrated on material acquisition issues, the immediate use of OPTEC recommendations for initiative development, and the contributing factors behind

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the use or non-use of those recommendations. Of the 93 emerging technology initiatives included in the experiment, 36 initiatives were in-

cluded in the research. Certain initiatives were excluded from the research for the following reasons:

- the initiatives were not evaluated by OPTEC during the AWE;
- OPTEC did not provide any substantive recommendations by which to measure implementation;
- the initiative was a doctrinal or organizational change with no material program; or
- the program was subsequently terminated after the AWE and no representatives could be found to provide input towards the research.

Two representatives from each of the 36 emerging technology initiatives were sought for participation. First, program managers were identified based on their direct experience with the AWE and their ability to provide programmatic insights into the process and results of the AWE.

Secondly, a user representative was identified, in most cases the combat developer responsible for the program. Of the 72 possible representatives, 67 were actually selected to participate in this study.

SURVEY DESIGN

The survey was designed to collect both objective and subjective data. The objective survey items assessed the specific level of implementation of recommendations made in the Live Experiment Assessment Report. Subjective items were included to gather perceptions and opinions from specific program offices and user representatives. The subjective items were structured from the RAND Corporation’s CU framework (Dewar et al., 1996) and the decision-to-experiments ladder (DEL) that directly links experiments to decisions (Lucas, Moore, and Vye, 1998). Specific survey items were framed on the decision-to-experiment ladder to allow participants to demonstrate through their responses the extent to which this decision ladder was implemented during the AWE.

SURVEY INSTRUMENT

The survey instrument utilized a combination of ordinal measurements reflecting the level of implementation achieved for each OPTEC recommendation and factors affecting implementation, as well as open-ended questions designed to gain subjective perceptions about the AWE process. The survey contained four sections.

Section 1 asked respondents to rate the level of implementation of the specific recommendations made for their program initiative by the Army OPTEC’s Live Experiment Assessment Report. Participants

were asked to indicate the term that best described the extent that the recommendation was implemented: fully, mostly, limited, not at all. Participants were also asked to provide narrative comments explaining the factors that influenced the degree of implementation.

Section 2 contained questions about the program's experiences in the 1997 TF AWE that were derived from the decision-to-experiment ladder (Lucas, Moore, Vye, 1998). The questions covered all of the applicable components from issue development to analysis and implementation. Participants were asked to rate the following three questions using a five-point scale (with 1 being low, 5 being high):

- To what extent were you able to tailor or influence your program's specific activities in the AWE to relate to the issues and decisions you faced as an acquisition manager?
- How valuable were the data and recommendations gained from participation in the AWE in making decisions as an acquisition manager?
- To what extent did your program benefit from participating in the AWE?

Respondents also were asked to give a brief narrative explanation of each rating. In addition to the objective ratings, the following three open-ended questions were included to gather contributing factors and characteristics of programs best positioned to benefit from AWEs:

- What were the specific developmental ISSUES being addressed on your program at the time of its participation in

the AWE and what decisions were to be made from gathered data?

- What were the contributing factors to your program's ability to benefit from participation in the AWE?
- Based on your program's experience in the 1997 AWE, describe the characteristics of a program that would best be situated to benefit from participation in a future AWE.

Section 3 gathered respondent opinions on reasons why recommendations made by the 1997 AWE were or were not fully implemented. The questionnaire attempted to include an exhaustive list of potential impediments or positive factors for implementation. Participants were asked to rate each of the items on a five-point scale (1, not significant; 5, highly significant). Examples of reasons for less than full imple-

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mentation included: lack of money; lack of time; questionable validity of test data and recommendations; and technical feasibility. Examples of factors supporting implementation included: high priority by users, high priority of program office, available funding.

Section 4 asked respondents to provide any additional comments on their program's participation in the AWE, including any information that might assist acquisition managers in gaining maximum benefit from participation in future

experiments or that would assist planners in tailoring future experiments to better benefit participating programs.

INTERVIEWS

Finally, interviews were conducted with nine program representatives in order to solicit more detailed information addressing some of the questions in the survey. Examples of questions included in the interview are:

- How did your program benefit from participating in the AWE?
- What kind of specific feedback did you receive on your program's performance in the AWE? Was it valid? Could you take advantage and utilize the feedback?
- How did the maturity of your program affect its performance at the AWE?
- Were you able to tailor the analysis plan for your program with OPTEC?
- What risks were involved with participating in the AWE? How were those risks mitigated?
- How would you characterize a program that would stand to significantly benefit from participation?

RESPONDENTS

Sixty-seven surveys were administered to both program managers and user representatives of 35 different AWE initiatives. A total of 38 respondents returned completed surveys for a response rate of 56.7 percent. Military respondents ranged from major (O-4) to colonel (O-6) and had

an average of 1.9 years experience on the program in question. Civilian respondents ranged from GS-12 to GM-15 and had an average of 7.5 years experience on their programs. The minimum amount of time any respondent had with their program was 12 months. Also included were four civilian contractors who directly supported program offices or user agencies.

ANALYSIS STRATEGY

The analysis methodology included a review of the respondent surveys to identify the following:

1. The average level of implementation of all included initiative recommendations.
2. The overall perception of the program's ability to tailor or influence the initiatives specific activities in the AWE.
3. The overall perceived value of the data and recommendations gained from participation in the AWE as acquisition managers.
4. The overall perceived benefit gained from participating in the AWE.
5. The relationship between degree of implementation of recommendations and factors such as program maturity, program tailorability, perceived value of the data and perceived benefit received from the AWE.
6. A hierarchy of reasons why recommendations were or were not fully implemented.

To address these analytic questions, arithmetic means, medians, and modes were computed for each rated question to determine relationships and effects. A confidence interval was computed that should include the true value of the parameter 95 percent of the time. For most analyses, medians were used for comparison so that outliers would not have a significant impact on results. Median results for the various collected factors were compared against one another and analyzed to determine trends and overall effects on the ability to benefit from the AWE. The Kruskal-Wallis method was used to test the equivalence ($p < .05$) of the various factor medians. Finally, the collected subjective comments were analyzed to draw conclusions to answer the primary and secondary research questions and develop a characteristic description of programs that are best positioned to gain valued investment and requirements information from participation in AWEs.

RESEARCH FINDINGS

USE OF RECOMMENDATIONS TO SUPPORT INVESTMENT DECISIONS

The specific recommendations derived from the TF XXI AWE were used to support investment decisions and to refine requirements of participating initiatives in some cases. Overall, programs reported that 52 percent of the OPTEC recommendations from the AWE Live Assessment Report were either fully or mostly implemented. Thirty percent of recommendations were not implemented at all. Respondents indicated only a moderate benefit from participating in the AWE and that

the data and recommendations received were only somewhat valuable. The most cited reason for recommendations not being implemented was a lack of funding. The recommendation was most likely to be implemented if it was a high priority of the user. Participants considered data valuable in making decisions when the data met at least one of three requirements. First, the data provided actual user feedback on specific user requirements. Second, the data contributed to the development of tactics, techniques, and procedures. Third, the data were provided at a time when it could be instrumental in refining requirements and design.

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CONTRIBUTING FACTORS TO A PROGRAM'S ABILITY TO BENEFIT

The survey data showed that the level of recommendation implementation and the perceived level of benefit from the AWE were generally related. It cannot be concluded, however, that the implementation of AWE recommendations was solely responsible for a respondent's perception of benefit. A wide range of confounding factors effected an initiative's ability to benefit from the AWE.

In determining the contributing factors to a program's ability to benefit from AWE participation, a program manager must first define the term benefit, as it relates to his program. Program managers reported the following potential benefits from their TF XXI AWE participation:

- marketing and exposure of program;
- early user feedback;
- refinement of user requirements;
- development of tactics, techniques, and procedures (TTP);
- follow-on support for funding and production decisions;
- information on integration, interfaces, and interoperability; and
- exposure of developers to the user's environment.

Linkage Between AWE Design and Program Issue or Decision. Survey results found that those program managers who could provide a detailed explanation of the specific programmatic issues being addressed by their participation in the

“Survey comments indicate a substantial risk to programs participating in an AWE.”

AWE or the decisions to be made from gathered data, generally reported a much higher level of perceived benefit from the experiment. Those programs that specifically developed test objectives and measurement processes for the AWE that were linked to specific acquisition decisions, were better positioned to benefit from participation.

Tailoring of AWE Participation. The extent a manager was able to tailor or influence a program's specific activities in the AWE to relate to the program's

acquisition issues and decisions directly contributed to the extent that the program benefited from participation. Those initiatives reporting a high level of ability to tailor or influence generally reported much higher levels of perceived benefit from participation in the AWE. Both program managers and user representatives agreed that to achieve maximum benefit from AWEs, acquisition managers must be able to participate in the planning process.

Program Maturity. Program maturity has an impact on an initiative's ability to benefit. While programs at all levels of maturity can gain from AWE participation, initiatives in the mid-range of development are best positioned to benefit. These programs are sufficiently mature and rugged enough to tolerate the harsh environment of AWEs, have architectures that are not yet finalized, and can make the most use of information derived from participation.

Risk Assessment. Survey comments indicate a substantial risk to programs participating in an AWE. Program risks include factors beyond the costs of participation, to include a poor return on investment, potential negative exposure, and extensive changes in requirements. The factors contributing to risk include: maturity, ruggedization and maintainability, funding availability, equipment availability, and status of program and production decisions.

RECOMMENDATIONS

As a result of the research analysis, we make the following recommendations for acquisition managers and AWE planners.

ACQUISITION MANAGERS

Formulation of Objectives and Measurements. To maximize the potential to benefit from AWE participation, acquisition managers should develop objectives, measurement processes, and data documentation and analysis strategies for the AWE that will inform product improvements and areas for future investment. The results of AWE participation should be adequately documented to allow the use of AWE derived information and findings throughout the developmental life cycle of the participating program.

Participation in the Planning Process. To achieve maximum benefits from the AWE, acquisition managers should actively participate in the AWE planning process and tailor their program's activities in the AWE to relate to the issues and decisions facing the program. Data collection and analysis plans should also be tailored to ensure that the information derived from AWE participation is of value to the program.

Risk and Benefit Comparison and Analysis. Acquisition managers contemplating participation in future AWEs should conduct a detailed analysis of the risks associated with AWEs and consider their tolerance for risk as a factor in making a decision to participate. Potential risks should be compared to potential benefits from participation and interpreted to determine the best course of action for the program. Active measures should be identified to mitigate the specific risks associated with AWE participation. Methods to mitigate risk include:

- early budgeting of funds for the AWE;
- marketing to the user;

- assuring AWE users are adequately trained in the focal technology; and
- direct participation in the AWE planning process.

AWE PLANNERS

Acquisition Manager Involvement.

For the Joint Contingency Force (JCF) AWE, OPTEC representatives should meet with program managers to determine issues that are linked to AWE objectives (Department of the Army, 1998). Planners for future AWEs should allow acquisition managers to actively participate in the development of AWE goals and objectives, scenarios, and data collection and analysis plans

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so that the information derived from AWE participation is of value to the program.

AWE Funding. The Army should consider providing funding for AWE initiatives so that acquisition managers can increase the benefits derived from participation. Participation in AWEs requires expensive prototyping, manning, fielding, training, and transportation costs that must be drawn from existing research and development accounts. Program managers cannot increase their roles in the AWE process and ability to tailor activities without dedicated support from the Army's budgetary process.

AWE Program Selection Criteria. The following factors should be considered when evaluating a program's potential to

gain valued investment and requirements information from participation in AWEs:

- **State of the Technology and Goals of the AWE.** Programs positioned to receive the most benefit from AWE participation will fit within the published goals, objectives, and focus of

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the AWE as stipulated by the planning officials. Also, the AWE must address the issues facing the initiative. As demonstrated in the TF XXI AWE, those programs that

are not a high priority of the analyzing agency may not receive adequate feedback. Additionally, initiatives that are new concept technologies without established current tactics, techniques, and procedures are best positioned to benefit from the integration of multiple systems in an experimental environment.

- **The Ability to Tailor Program Participation.** The extent a manager was able to tailor or influence a program’s specific activities in the AWE to reflect the program’s current acquisition issues and decisions had a direct impact on the extent to which the program benefited from participating. Those initiatives reporting a high level of ability to tailor or influence generally reported much higher levels of perceived benefit from participation in the AWE.

- **Program Participation Objectives and Strategies.** The data suggest that those program managers who develop detailed experiment objectives and expected outcomes, systems for data documentation and analysis, and strategies for implementation of AWE data and recommendations will receive more valued data and will experience more benefit from AWE participation.

- **Program Maturity.** Program maturity effects the ability of a program to perform adequately as well as the ability of the initiative to implement recommendations derived from the AWE. Programs in the mid-developmental phases of acquisition are best positioned to benefit from AWE participation. Programs in early in development are high risk because of their unpredictability and vaguely defined roles and requirements. Programs late in development or in production are medium risk because they may be too far in development to capitalize on recommendations.

Additionally, programs with no pending production or funding decisions are best positioned to benefit from AWE participation. Programs that have secured approval and funding for production prior to participation in an AWE but have not yet begun production, face the added risk of poor performance and loss of support. Those initiatives with imminent production decisions are medium risk, in that AWE performance can significantly influence the survivability of the system.

- **System Ruggedization and Maintainability.** Systems participating in AWEs should be ruggedized and easily maintainable. A system that is highly rugged is able to withstand the stresses associated with operational use in harsh environments. A system that scores low in ruggedization has sensitive components with maintenance procedures that are difficult to conduct in a field environment. Low ruggedization may be associated with early prototype systems.
- **Program Data Needs and Requirements.** Programs with extensive need for data on integration, interfaces, interoperability, and user requirements are best positioned to benefit. Those programs early in Concept Exploration would have the added benefit of receiving early data and user feedback to refine system requirements. Those programs with sufficient feedback from other sources, or not in a position to implement any recommendations from the feedback cannot take full advantage of AWE results and data.

CONCLUSION

The conduct of AWEs has provided unique insights into the future of Army

Warfare and the potential acquisition of participating programs and weapon systems. However, the use of the data and recommendations generated to support acquisition decision making can and should be increased. The findings of this research strongly reinforce the principles of formative evaluation as outlined by Rossi (1993) and the Credible Uses Framework (Lucas, Banks and Vye, 1998) that links experimental design to explicit programmatic decisions.

Key factors were identified that can enhance the utility of AWE to programs responsible for the acquisition and development of technical systems. AWE planners can enhance the utility of resulting data to program managers by attending to specific criteria for program participation, involving program managers in the experimental planning, and providing financial support for AWE participation. Program managers participating in AWE can also take steps to increase the utility of results through specification of issues and decisions that can benefit from data generated by the experiment, a clear assessment of both benefits and risks, and active engagement in the design of measures. Future AWEs should focus on programs that can utilize the information most effectively. Additionally, appropriate funding should be provided to program participants to increase their ability to benefit from AWEs.



Kenneth Strayer, Captain, USA, was commissioned as an officer in 1990. He has served in a variety of combat arms assignments including service at the National Training Center (NTC), Fort Irwin, CA, and in the 25th Infantry Division (Light), HI. He holds a BS in Mechanical Engineering Technology from the University of Dayton, OH (1990), and an MS in Management from the Naval Postgraduate School (NPS), Monterey, CA (1999). He is currently serving in the Army Acquisition Corps with the Tank-Automotive and Armaments Command (TACOM), Research, Development, and Engineering Center (TARDEC).
(E-mail address: strayerk@acom.army.mil)



Thomas H. Hoivik, Captain, USN (Ret) is a professor of Operations Research at the Naval Postgraduate School (NPS) in Monterey, CA, specializing in high technology program management, systems engineering, and test and evaluation. A former experimental test pilot, he has been a Navy aircraft Program Manager, Director, U.S. Naval Test Pilot School, commanded a major Naval Air Base and Squadron, and was a Federal Executive Fellow at the Center for Strategic and International Studies (CSIS). He has over 30 years of Technical Program Management, Testing, and Systems Analysis experience, and has been teaching at NPS since 1983.
(E-mail address: thoivik@nps.navy.mil)



Susan Page Hovevar received her Ph.D. in Business Administration from the University of Southern California. She is currently an Assistant Professor in the Department of Systems Management at the Naval Postgraduate School in Monterey, CA. There she teaches courses in organization and management to military officers earning a graduate degree. Her research and publications are in the areas of organization change, high involvement organizations, reward systems, organizational culture and team-based organization design. Her current work is with an Office of Naval Research sponsored research effort in Adaptive Architectures for Command and Control.
(E-mail address: shocevar@nps.navy.mil)

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