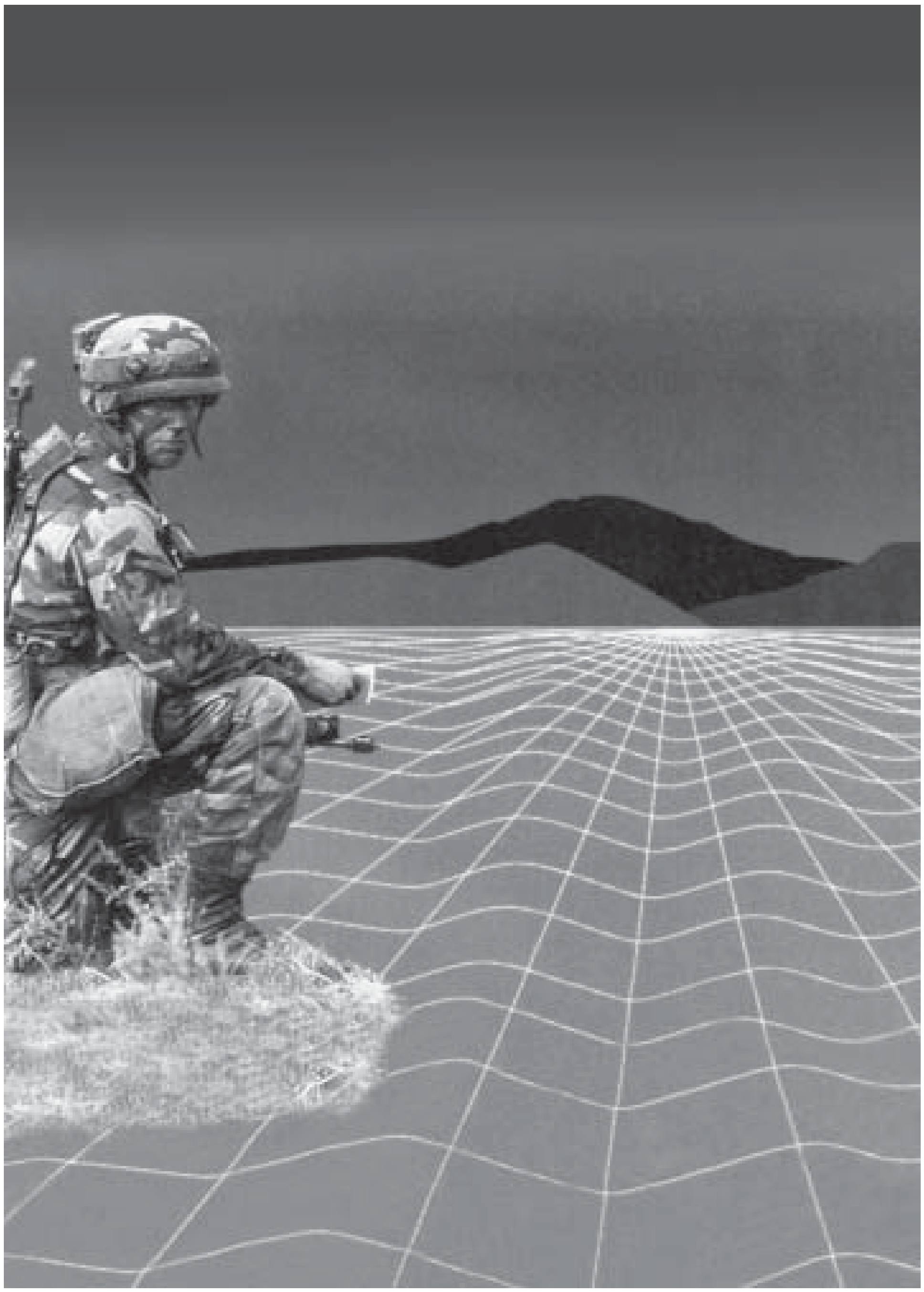

# WHY THE "T" IN SMART
# *A CONSTRUCTIVE SYNERGY*

**LTC Michael D. Proctor, USA (Ret), Amy Posey-Macalintal, and Dennis Kulonda**

Department of Defense (DoD) simulation-based acquisition (SBA) is widely discussed in literature. The Army offers a broad vision of SBA concept in the form of Simulation and Modeling for Acquisition, Requirements, and Training (SMART), accenting not only the Acquisition process but also essential contributions from the Requirements and Training communities. This research highlights how organizational training simulation has significantly helped the acquisition process beyond the confines of post-acquisition training.

Training is essential to the successful fielding of any new weapon system. As a part of the system life cycle, the value of training is well established. Further, the training community is well known for their ability to contribute to the development of training packages for new materiel acquisitions. This research reveals that with increased realism, training simulations may now provide a significant and credible resource useful to acquisition managers, which goes beyond training packages.

The research investigates the hypotheses that an organizational training simulation may support materiel acquisition and, likewise, materiel acquisition may support organizational training simulation development. Using a case study methodology, the research reveals how the Close Combat Tactical Trainer (CCTT) training simulation played a critical part in the Battlefield Combat Identification System (BCIS) acquisition as well as how the BCIS advanced the CCTT.

This paper presents archival record, experimentation, cost, interview, and survey highlights from the case study as well as discusses the Simulation and Modeling for Acquisition, Requirements, and Training (SMART) approach to acquisition. The SMART approach, in part, advocates an explicit strategy to integrate training simulation in acquisition where appropriate. Additionally, this paper also identifies tenets that may promote a synergistic and mutually beneficial relationship between training simulation and materiel acquisition. Finally, the case study identifies process mechanisms that may help insure up-to-date-training systems are available when new equipment systems are fielded or possibly tested.

## EMPLOYING TRAINING SIMULATION IN THE ACQUISITION PROCESS

Simulation-based acquisition as pursued by Department of Defense (DoD) is widely discussed in literature and conference activities. The use of simulation in the system life cycle continues to grow. Managers report gains in terms of quality, productivity, and performance as well as reductions in cost, cycle time, lag time, and risk. This success has not come about by chance, but rather by planned and deliberate actions by astute acquisition managers. A few examples are referenced below (Zittel, 2001; Brantley, McFadden, & Davis, 2002; Garber, 2001; Johnson, McKeon, & Szanto, 1998; Sanders, 1997).

The Army and its simulation action agent, the Army Modeling and Simulation Office, promote a version of simulation-based acquisition called SMART (Ellis, Kern, & Hollis, 2002; Lunceford, 2002). SMART is more than semantics. SMART emphasizes not only the essential acquisition process, but also the quality enhancing contributions of the training and requirements communities to that process.

For the Army, a key vehicle for success has been the Simulation Support

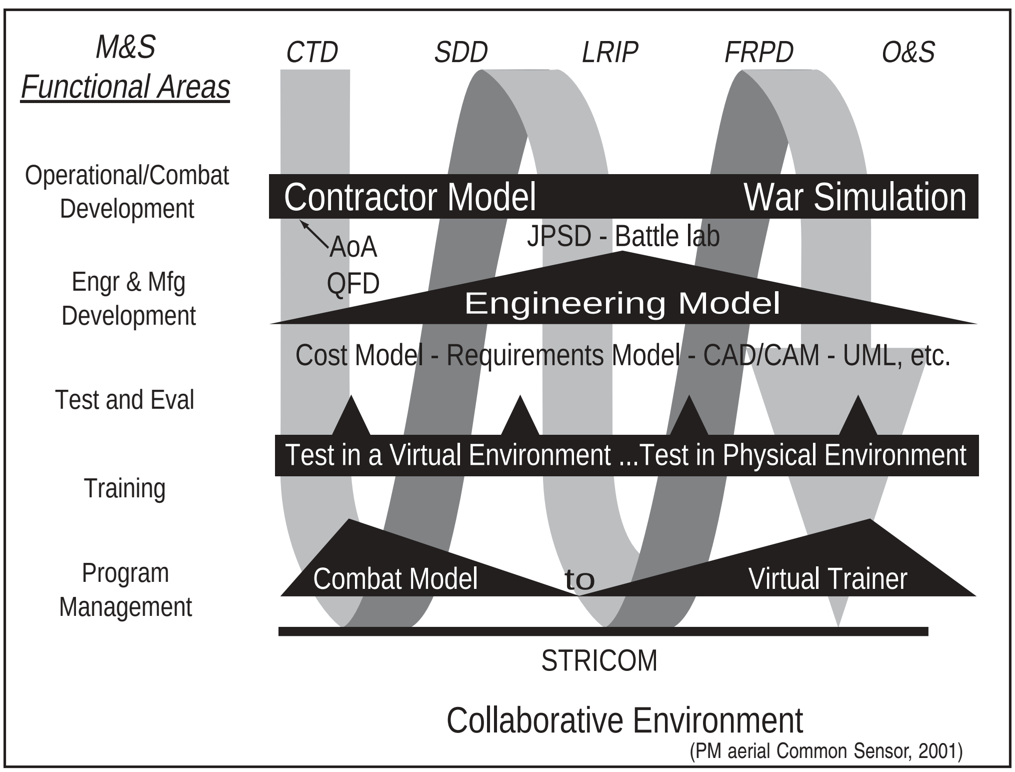


**Figure 1. Selected Program Events and Levels of Modeling and Simulation from Functional Areas**

Plan, (Ellis, et al., 2002). A Simulation Support Plan provides a means of developing a *roadmap* of simulation integration within the life cycle of a system acquisition.

> The Simulation Support Plan is the plan identifying utilization of models and simulations over the lifecycle of an acquisition program from concept and technology development to system disposal. It is a document that evolves as the system matures. Because SMART is an enabler to ~~the~~ meeting Army Transformation objectives, the Simulation Support Plan will discuss how SMART is implemented in the program. (Ellis, et al., 2002, p. 69)

One notional representation of the source and level of simulation contribution across the system life cycle is shown in Figure 1. Some key events in the life cycle are also noted for reference purposes. In the SMART concept, the Integrated Concept Team and the Integrated Product Team, under the leadership of acquisition managers, interweaves the use of models and simulations into the system life cycle. The team plans and schedules activities that lead to successful materiel acquisition.

## THE HYPOTHESES OF MUTUAL BENEFIT

Not clear in the literature is the contribution that organizational training simulations may make to the acquisition process or the contribution the acquisition process may make to organizational training simulations. By the term organizational training simulation, we are referring to a composition of various simulation systems that attempt to represent a military organization for organizational training purposes. For the Army, the CCTT is one example. The Distributed Mission Trainer is an example for the Air Force.

What is significant is that organizational training simulations go beyond stand-alone simulators to encompass a composite of the various systems found in the organization. Simulation of an organization potentially enables savings based on scale rather than simply savings gained through direct one-to-one, simulator-to-system simulation.

Our hypothesis is that not only can these organizational training simulations help, primarily through the advantages of scale, a weapon system development during its life cycle, but also outflow from the weapon system development may advance model fidelity within the organizational training simulation.

## SYNERGY BETWEEN THE TWO

From a theoretical perspective, simulation success hinges on software development factors identified by McCabe (1980) and listed below.

**Fidelity**: the accuracy of the representation when compared to the real world for the applications that it was intended.

**Modularity**: allowing a program to be created from individual modules.

**Expandability**: allowing the expansion of requirements for storing data and scalability in computing.

**Self-Descriptiveness**: clarity in terms of explaining how a system works through easy to use Graphical User Interfaces (GUIs) and tools, visibility of behaviors and models, documentation, and self-descriptiveness of code.

**Self-Explanatory**: ability to understand model output.

**Software System Independence**: shows how much a program depends on its computational system as well as reduces the burden on human support personnel.

**Interoperability**: allowing the use of standard communications protocols so that it can work with other simulations.

**Data Commonality**: allowing the representation of data in a standard form that is applicable across all domains and promotes reuse.

Our formal research survey, of selected (from industry and government) simulation professionals identified by the Director of the Army Modeling and Simulation Office, revealed that of the above factors Self-Descriptiveness, Interoperability, and Data Commonality were statistically ranked higher in importance in terms of creating capable and reusable models and simulations (Wilcoxon Signed Rank Test, $p = .1$).

**"From the acquisition perspective, interoperability and data commonality may prove very helpful."**

That is to say, leading simulation professionals view interoperability and data commonality along with self-descriptiveness as the most significant factors in terms of simulation capability and reusability. Further, funding priorities within the simulation community reflect that importance. For example, over the past decade, the Defense Modeling and Simulation Office funded and created: (1) the High Level Architecture for simulation interoperability and (2) Synthetic Environment Data Representation and Interchange Specification toward data commonality.

From the acquisition perspective, interoperability and data commonality may prove very helpful. For example, a Program Manager of a new system development may leverage interoperability and data commonality investments by taking advantage of the scale implications. Specifically, interoperability and data commonality enable composition of simulation systems involving scores, if not hundreds, of synthetic entities.

While emphasizing interoperability and data commonality, the simulation community, based on our survey, may not emphasize model fidelity as strongly as they do other simulation attributes. This may result in the acquisition community having models of new systems that are of insufficient fidelity to realize the benefits and savings of the SMART approach to system acquisition. From an acquisition perspective that infers, with the advent of a new materiel system, the burden of model development for the new materiel rests with the acquisition manager.

Compounding the possible fidelity shortfall of models for new materiel in an organizational training simulation is the need for increasing fidelity of the new model. This is brought out in part by the data evolution phenomenon identified by Ellis, et al. (2002) and shown in Figure 2. As systems develop over time, data requirements experience increasing need for higher fidelity and greater breath

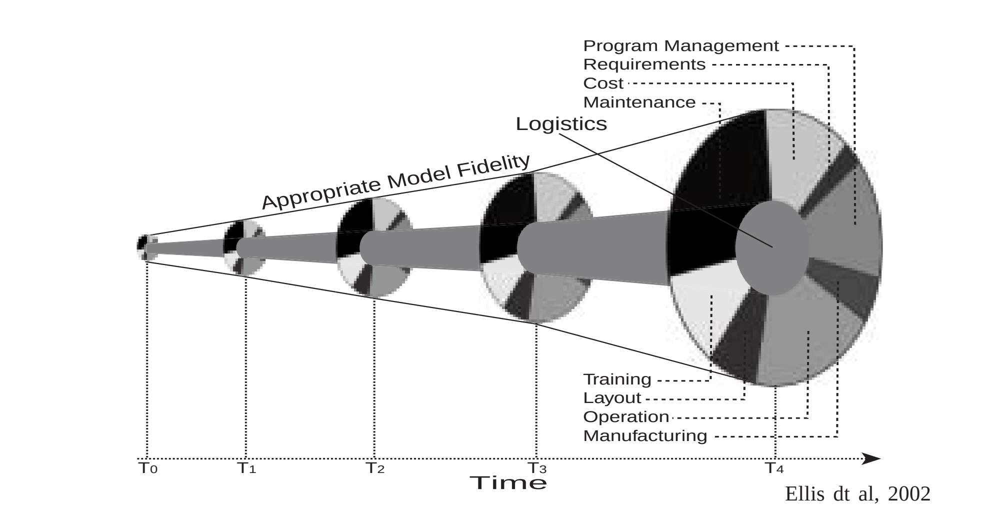


**Figure 2. Growing Requirement for Fidelity and Breath in the Distributed Product Description**

while expanding to more activities distributed within an organization and across organizations. Therefore, existing models of new materiel acquisitions sufficient for stand-alone analysis may need further refinement to be suitable in an organizational context.

The U.S. Army Program Executive Office for Simulation, Training, and Instrumentation maintains that synthetic environment enhancements can occur concurrent with weapon system development. This may happen as model fidelity enhancements are funded so as to enable representation of a new weapon system phenomenon. Hence the state of simulation may advance along with weapon system development as implied by the *Snake Chart* in Figure 3. The key elements of this chart are the two development lines (simulation environment and weapon system) interwoven by a line that *snakes* from one development effort to the other. The winding of the Snake represents the flow of insights, deliberately common databases, algorithms, software routines, architectures, processes, etc from one development effort to the other over time. The flow emphasizes the feedback into simulation development that can be accrued during the materiel acquisition (weapon system) development and vice versa. For example, modeling of a weapon system in a simulation may yield insights that advance the state of the weapons system development. Likewise, weapon system development may create new reusable weapon system models and simulations for future simulation system development, thereby promoting synergy between weapon system development and synthetic environment development.

## PROGRAM DESCRIPTIONS

To examine the hypothesis of mutual benefit, a case study needed to have an

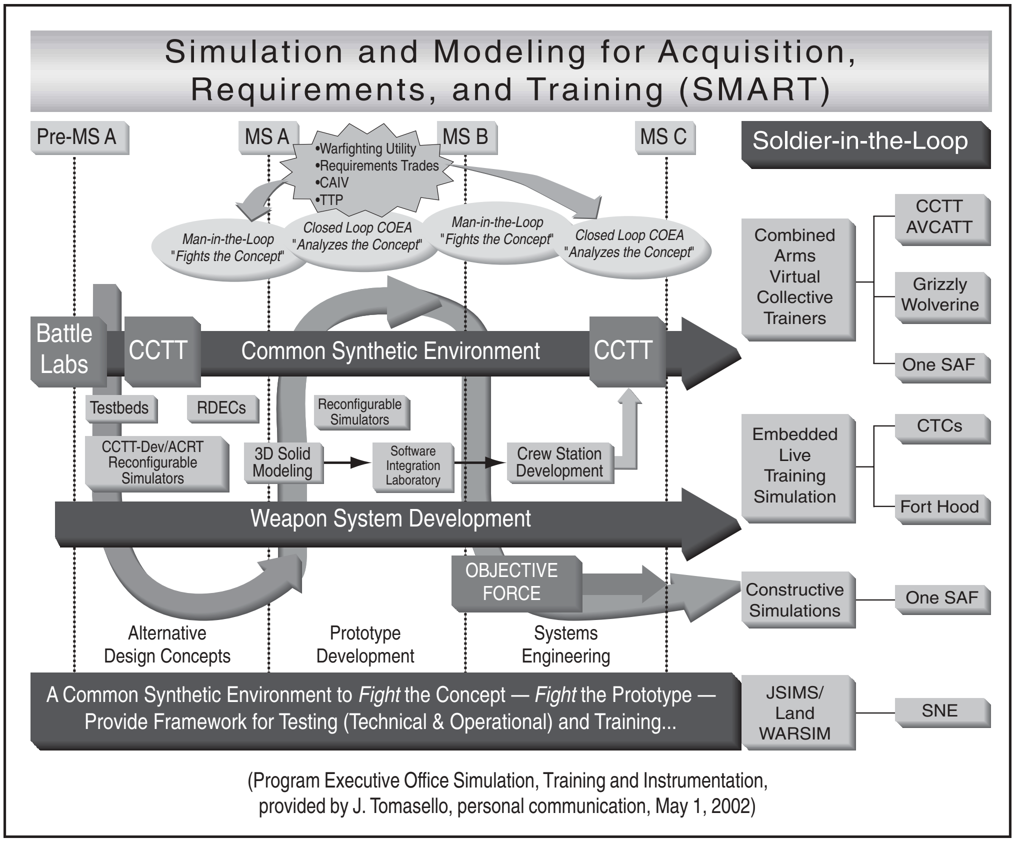


**Figure 3. "Snake Chart"**

organizational training simulation and a materiel acquisition system interact as described above (Yin, 1994). For this research, the materiel system called the BCIS managed by Product Manager, Combat Identification was identified as the acquisition program. The CCTT simulation was identified as the organizational training simulation system. These two systems interacted with each other during the BCIS acquisition.

The CCTT is the first virtual simulation training system developed under the Combined Arms Tactical Trainer (CATT) program (Figure 4). The CATT is acquiring a group of high-fidelity, interactive, manned simulators for training. The CATT program provides command, control, and communications workstations, and exercise control stations. After Action Review systems and the Virtual Combined Arms synthetic environment to support virtual training organizations up to battalion/task force level.

Using interoperability and data commonality, the CCTT system trains tank and mechanized infantry organizations from platoon to battalion task force, including cavalry scout platoons and heavy cavalry troops on collective tasks. The CCTT system offers commanders the opportunity to develop and tailor structured exercises based on mission, enemy, troops, terrain, and time available to meet the training

Courtesy of Lockheed Martin Corporation

**Figure 4.**
**Training in the Close Combat Tactical Trainer Virtual Environment**

plan and objectives of the organization (Figure 5). CATT virtual synthetic environment includes large-scale virtual terrain representation with natural synthetic environment effects (e.g., weather effects), accredited computer generated forces replicating adjacent, supporting, and opposing forces (Barlow, 2003).

Part of the Combat Identification program, theBCIS, is a millimeter wave device that is integrated into the vehicle subsystems to aid in target identification. The intent of the device is to reduce fratricide (friend on friend combat engagement). The BCIS attempts to reduce fratricide by identifying at the gunner's sights contacts as *friendly* if the contact is equipped with the BCIS or *UNKNOWN* if otherwise. The BCIS works effectively through smoke, dust, sand, rain, fog, and beyond visual range. A typical BCIS event occurs with Abrams or Bradley platforms interacting with other friendly and opposing combat vehicles as well as noncombatant vehicles (Maddux, Kwiecien, & DeChiaro, 2001; J. Tomasello, personal communication, May 1, 2002).

## Mutual Benefit

Operational testing of the BCIS was needed in order to assist the U.S. Army in making an acquisition decision. A traditional approach to such testing would be to conduct a live exercise in the field using real vehicles equipped with BCIS. Because of the investments of the simulation community in interoperability and data commonality, an alternative to live field-testing existed in the Close Combat

Courtesy of Evans & Sutherland

**Figure 5. Screen Shot from Close Combat Tactical Trainer Simulator**

Tactical Training system. Using an organizational training simulation to replace an operational test is innovative as well as not typically considered at this stage of the system life cycle. Yet, due to a creative approach, this alternative was allowed to develop.

J. Tomasello (personal communication, May 1, 2002), winner of a SMART 2002 award for his efforts (Lunceford, 2002), clarifies the two choices:

> The goal was to determine if Battlefield Combat Identification System made a greater contribution than other situational awareness equipment choices. For the operational component of the assessment, [Program Manager] PM Combat Identification had the choice of: (1) going to the National Training Center and standup a battalion force of combat vehicles with the equipment to be tested or (2) utilizing the Close Combat Tactical Trainer facility at Ft. Hood, Texas for the operational evaluation. (J. Tomasello, personal communication, May 1, 2002)

The estimated cost of pursuing a live field-operational test was approximately $20 million (J. Maddux, personal communication, n.d., 2003). For case study research, Yin (1994) indicates that archival records are a source of evidence to explain or provide context for such case evidence. As such, General Accounting Office (GAO) reports can provide some insight as to the validity of this $20 million dollar estimate. While recent GAO estimates do not delineate actual exercise costs at the National Training Center, they do indicate that the Army spends *more than a $1 billion annually* to provide training for 123 battalion at its three Combat Training Centers (Schuster, 1999). This includes far less expensive, non-mechanized battalion rotations at the Joint Readiness Training Center. Nonetheless, that is still approximately $8.1 million per battalion in FY 1998 dollars or $8.8 million in FY 2001 dollars.

The last reported GAO cost estimates for unit costs for mechanized battalion training at the National Training Center is $4 to $6 million per unit for 1983 to 1985 ($7.1 to $10.6 million 2001 dollars using the Bureau of Labor Statistics Inflation calculator http://www.bls.gov/cpi) (Conahan, 1986). These figures do not include National Training Center operating and instrumentation costs, which would be prorated across the number of units training on an annual basis. The GAO reports that those costs ranged from $62 to $90 million annually for the 1983 to 1985 period (Conahan, 1986). Additionally, the GAO estimates do not include low rate production costs, equipment upgrades, and other associated costs necessary to actually implement a field test using BCIS equipment. In this context, a $20 million estimate for BCIS testing does not appear to be unreasonable.

On the other hand, the total cost for conducting BCIS testing in CCTT actually came to approximately $2 million. That cost included related modeling efforts, incorporation of models within CCTT environment, expanding the data collection and reduction capabilities, and performing data analyses (J. Maddux, personal communication, n.d., 2003). The same level of testing was achieved without imposing on the National Training Center. Further, the potential for conducting additional scenarios and events not possible in a live setting due to safety and environmental restrictions was possible. J. Tomasello (personal communication, May 1, 2002) explains the advantages.

> Even though configuring the Close Combat Tactical Trainer and designing the evaluation to replicate the different options took a year and involved the cooperation of the Army Test and Evaluation Command and the Army Materiel Analysis Activity (this would have had to been done anyway), the saving from not having to modify equipment, operate it in the field, or endanger personnel during real operations all were savings that could be identified in real time. Further, the collaboration between Developer, Tester, and Trainer yielded additional benefits in quality improvements to Battlefield Combat Identification System that may not be as easily quantified. The results were part of the test. The data were actually used. General Kern could say Battlefield Combat Identification System does reduce the incident of fratricide. That was all done in the simulation as part of

> the operational evaluation. We could readily do night, fog, and rain, etc. on demand that National Training Center could not. (J. Tomasello, personal communication, May 1, 2002)

With estimates of a 90 percent cost savings, lead-times within the planning cycle, and with increased flexibility and capability, J. Maddux (personal communication, n.d., 2003), Product Manager for Combat Identification, funded the modeling efforts to represent the BCIS in the CCTT. One essential aspect for this funding required that the BCIS simulator code, called the Battlefield Identification System Environment and Performance Simulator, be put in the CCTT code. J. Tomasello (personal communication, May 1, 2002) indicates how that was done:

**"One of the key lessons learned from this case study is the SMART approach taken by the key leaders."**

> Georgia Tech Research Institute developed the Battlefield Identification System Environment and Performance Simulator, initially a server based application that replicated what happened when you probe somebody with the Battlefield Combat Identification System millimeter wave system. We took the Battlefield Identification System Environment and Performance Simulator off the server and embedded Battlefield Identification System Environment and Performance Simulator into Close Combat Tactical Trainer code. We designed the software so it was distributed to the manned modules and removed the server as a single point of failure. (J. Tomasello, personal communication May 1, 2002)

This enabled the CCTT to support testing of the Battlefield Combat Identification System. Trials were conducted and the Army Test and Evaluation Command and the Army Materiel Analysis Activity utilized the accredited, simulated battle trials generated in theCCTT in their test and evaluations plans, replacing the live simulation trials that were avoided.

## A SMART APPROACH TO ACQUISITION

One of the key lessons learned from this case study is the SMART approach taken by the key leaders. Elements of that approach include innovation, leadership, collaboration, and an active involvement of the Integrated Product Team with the goal of wisely using all possible simulation alternatives. PM innovation and creativity was paramount to taking on the risk of providing resources to pursue the unproven route of using organizational training simulations to replace operational field testing. In essence, PM Combat Identification took advantage of the opportunity by being open to this non-traditional approach.

Leadership was essential by both the PM Combat Identification and PM CATT in order to capitalize on the opportunity. Collaboration was the means by which things were accomplished. PM Combat

Identification and PM CATT cultivated collaboration across their organizations and participants from the Army Test and Evaluation Command, the Army Materiel Analysis Activity, III Corps, Lockheed Martin, Science Applications International Corporation (SAIC), DSCI, Pulau Electronics, and Georgia Tech Research Institute through their leadership of the Integrated Product Team. In the words of Mr. J. Tomasello (personal communication, May 1, 2002):

> The SMART process changes are major. What SMART does is break barriers down giving everyone a common goal. Collaboration is of the utmost importance. For a process team, you have got to agree from the start, what your objectives are, what your requirements are. (J. Tomasello, personal communication, May 1, 2002)

Expanding on these insights, cooperation between the acquisition community and the training system development community also makes for faster, more efficient and effective transition of high-fidelity, software updates for materiel systems. J. Tomasello (personal communication, May 1, 2002) explains one process mechanism that has reduced training simulation software lead-times.

> Scratching the surface of reuse and SMART is our basic program for our M2A3 Bradley Fighting Vehicle and M1A2SEP Abrams Tank. We take the vehicle software and have it modified with a wrapper around it so that it runs in Close Combat Tactical Trainer. When General Dynamics (system manufacturer) puts out an update, we have a third party — OASIS — … deliver the code with the wrapper to CCTT as well as Advanced Gunnery Training System, the Maintenance Trainer and the Driver Trainer. It is a library they deliver that we take and drop into our systems, Close Combat Tactical Trainer, manned modules, everything. The big advantage of this process is that the tank commander, gunner, loader, etc. sees the latest version of the software in Close Combat Tactical Trainer. You don't want one version of the interface software being fielded with the weapons systems and another version of the software in the Close Combat Tactical Trainer. (J. Tomasello, personal communication, May 1, 2002)

This cooperation between the materiel developer and the organizational training system developer enables training systems to be up-to-date when new materiel system updates reach the field. This process mechanism may also make it possible to conduct future operational testing in organizational training simulations in an even more rapid fashion then occurred in this case study.

For this case study, leadership found traction through creativity, collaboration, capitalization, and cultivation — all of which may be considered key tenets of SMART. Future acquisition managers may consider promoting cross-domain collaboration, cultivation of a life cycle perspective among team members, and capitalization of Modeling and Simulation (M&S) assets in order to achieve program benefit.

## CONCLUSION

With increased realism and the benefits of scale made possible by interoperability and data commonality, organizational training simulations may now provide a significant and credible resource useful in the successful and cost-effective management of a materiel acquisition. This paper identifies key findings from a case study of the use of an organizational training simulation in support of acquisition. A brief overview of the possible mutual beneficial relationship between organizational training simulation and the materiel acquisition system is presented. Examples of explicit strategies of employing training simulation in acquisition and tenets to accomplish these benefits are proposed.

**"The acquisition manager is key to achieving synergy between training simulation and acquisition models...."**

PM Combat Identification effectively collaborated with PM CCTT and other organizations to create benefit for both programs. Essential to the success was their willingness to take advantage of the inherent attributes of the systems themselves. They capitalized on the scale capabilities of the CCTT to represent a large force of live systems. Using one composite system to represent many resulted in significant cost savings. Secondly, they reused the BCIS existing simulator code in CCTT. This action saved both time and money. Accompanying the resulting cost savings and feedback to BCIS was a synergistic flow of insights, deliberately common databases, algorithms, software routines, architectures, processes, etc. to CCTT.

Also essential to the success of this case study was the *roadmap* of simulation integration created by the Integrated Product Team. Planning is necessary not only for the purpose of coordination, but also to accommodate lead times for simulation integration. In particular, this case study indicates successful planning includes: creating new opportunities by innovate thinking and risk taking; cultivating a total life cycle perspective so as to maximize the potential to create benefit throughout the life cycle; emphasizing collaboration within Integrated Concept Team and Integrated Product Team, and capitalizing on existing models and simulation systems within these communities, to include the training community.

Simulation of a large-scale field exercise was made possible through training simulation strengths in interoperability and data commonality. The acquisition manager is key to achieving synergy between training simulation and acquisition models by addressing the need for increasing model fidelity over time as it relates to the materiel development. Organizational training simulations may not have the priority or perspective that materiel acquisition managers have to develop high fidelity models of new materiel. Thus, the responsibility rests with materiel acquisition managers to develop models of sufficient fidelity for analysis. Existing process mechanisms that currently speed the transfer of model data from materiel acquisition systems into the training simulations may also help speed acquisition model data into training simulations for operational testing purposes.

Given the numerous other simulation systems identified by the earlier references, the use of organizational training simulation is only one set of tools in the acquisition community arsenal. The CCTT is one of those tools. Raising the awareness of the capabilities of the training simulation community to the acquisition community is important for the war fighter, who will reap the benefit from these successes.

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