ADDRESSING EMERGING OPERATIONAL REQUIREMENTS WITH LEGACY MODELS

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ABSTRACT

Today's training simulations are only marginally able to address emerging operational requirements. Operations other than war, small unit operations, and countering weapons of mass destruction are a few examples of training challenges facing our forces. Unfortunately, wholesale rework of legacy models to look at new requirements is too time-consuming and expensive and usually requires new hardware platforms. Recent funding cuts from the Services' modeling and simulation budgets are further exacerbating the problem. This paper describes the integration of adjunct models with legacy models to provide an evolutionary approach to address emerging training requirements. The Army's Corps Battle Simulation (CBS) is used as an example to explain the concept and highlight the recent integration of an adjunct model to address battle drill for ballistic missile threats.

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INTRODUCTION

Today's military forces are faced with a myriad of operations. Operations other than war, small unit operations, and countering weapons of mass destruction are a few examples of training challenges facing our forces. Unfortunately, most training simulations address only a limited number of military tasks.

In fiscal year 1996, 200 million dollars were cut from the Services' modeling and simulation budgets which is exacerbating simulation deficiencies. Some hard choices must be made for allocating scarce resources. Regardless of the allocation, the bridge from the current to the future generation of models must support the weight of the Services' operational requirements.

Clearly, some enhancements to current models will be necessary. However, wholesale rework of legacy models is too time-consuming and expensive and usually requires new hardware platforms. A practical approach is to look at the immediate needs of the training audience and modify the current models to interact with adjunct models rather than attempting major changes to particular models.

This paper addresses the "evolution" of the current generation of command and staff training models to keep pace with the needs of the training audience. The paper briefly describes the current generation of training models and discusses an affordable way of extending these training models to address emerging operational requirements. This approach allows new capabilities to be reflected in a legacy model without major redesign. An application of this approach is discussed which added increased fidelity to the Corps Battle Simulation by interfacing it with the Extended Air Defense Simulation.

CURRENT STATE OF CONSTRUCTIVE MODELS

Over the last ten years there has been a natural friction between the live exercise proponents and the modeling and simulation community. As the cost of conducting large training exercises continued to increase, the use of modeling and simulation for training commanders and staffs became more attractive.

In Reforger 1992, the military used theater-level models to stimulate command decision processes and reduce the costs associated with deploying a large force as training aids for the leadership. Since that early success, the military has embraced the use of models as an integral part of its training programs. This success naturally lead to the identification of shortcomings in the models and subsequent revisions to address the highest priority needs. Unfortunately, due to the nature of the perceived threat and current computing capability, the basic models, and subsequent revisions, primarily focused on the "big picture" types of problems. This was satisfactory given industrial-age command and control tools. However, the introduction of information-age systems and their continued proliferation require entity-level representations now to stimulate precision-based operations.

The current generation of training models was designed for large-scale conflict against a well-trained force. The exercises primarily involve theater, corps, and division participants [1]. The adversary's doctrine, organization, training methodology, equipment, and in some cases leaders, were well known. The individual services built their own models to ensure their training requirements were met, and joint models focused on large operations. The computing resources available at the time these models were built, in many cases, bounded the amount of interaction that was possible for a given level of training audience and scenario. Programming languages also varied from model to model. Given the current state of the practice these current training models are referred to as legacy models.

Limited computing resources and major confrontation orientation fostered the notion that only aggregate-level combat interactions were necessary. Details of the engagement were primarily to show trends and weaknesses in the execution of command decision processes. The training focus was on the strategic or operational level of combat. The big issues were staff functions that enabled proper execution of the tactics, techniques, and procedures for a given level of command and staff participation.

Thus, current models are designed to prosecute ninety days of war in about a week. This means that the models are more planning oriented and favor speed over detail and general trends over specific deficiencies in the application of combat power. For example, the Army's Corps Battle Simulation uses a hex-based representation of terrain; this eases computation but obscures the details about an engagement (*i.e.*, was the target missed because the shooter lacked line of sight on the target). In addition, legacy models churn out results of combat based on a force-on-force algorithm vice a one-on-one engagement.

EMERGING OPERATIONAL REQUIREMENTS

The prospect of large-scale conflict in the near future, while possible, is far less likely than it was before the fall of the Berlin Wall. Far more likely is the application of military power in smaller, more lethal, tailored force packages. The prospect of Joint operations in geographic areas other than ones the military has anticipated is real. Consider Haiti and Somalia as examples. Given today's most likely military operations, the training focus is much less campaign plan oriented and more focused on one-on-one or few-on-few engagements. Even for large-scale operations, the commander will be interested in critical operations conducted by small units or special operations forces.

Perhaps more pressing is the prospect of deployment to a theater where the threat of the use of Weapons of Mass Destruction (WMD) via ballistic missiles is very real [2]. Even conventional munitions on ballistic missiles poses a considerable threat, especially when only a small military force is in theater or when the use of missiles against civilians and their homes is possible. This requires the development of entity-level representation to create the necessary conditions required for precision strikes. While the operational command decision process focuses primarily on aggregate problem solving in general, the challenge of defeating a force prone to using WMD requires a concurrent entity representation. This need arises because of the time-critical nature of striking WMD targets. Present legacy models lack this capability. The military must train in anticipation of just such missions. The dilemma is how to train today for these missions? How to maintain the edge?

The military recognized the need for better modeling and simulation support to the warfighter and is beginning the development process for the next generation of models. The Army has already awarded a contract for its model — WARSIM 2000. The Air Force issued the Request For Proposals (RFP) for the National Air and Space Model (NASM), and the contract for the Joint Simulation System (JSIMS) is scheduled for award in the January 1997 time frame. That's the good news. The bad news is these models are not scheduled to reach Full Operational Capability (FOC) for at least five years. How will the military bridge the gap from today's needs and recognized shortfalls to the fielding of the new systems?

The Synthetic Theater of War-Europe (STOW-E) and the Aggregate Level Simulation Protocol (ALSP) initially focused on creating conditions meant to get beyond theory to help shape the next generation of models. An opportunity continues today to instantiate legacy models with capability designed to help refine and clearly define functional requirements for the new models. Theater missile defense operations are a case in point because they are not represented well in legacy models today.

APPROACHES FOR USING CURRENT MODELS TO ADDRESS EMERGING NEEDS

There are many approaches for addressing training deficiencies through the use of modeling and simulation. At the Joint level of training, one approach is to link existing service models to provide a common environment for the training audience. This approach is currently being used in the Joint Training Confederation. This approach has been very successful in stimulating some aspects of the training program.

Another approach is to augment the training event with a seminar to talk the audience through the training objectives that were not executable in the particular model. This can be effective, but it does not flow with the normal sequencing of the training event.

A third approach is to augment the training event with a separate model or simulation to overcome the deficiencies of the base-level model or Confederation to ensure some exposure to selected training objectives. This can be effective too, but this method also lacks the goal of achieving all training objectives in a common simulation environment with dynamically interactive play in proper operational context. The common simulation environment is essential for capturing significant events in a single data collection effort. The data is then used to prepare and present a holistic After Action Review (AAR) to the training audience. This AAR provides the positive feedback necessary to reinforce the proper accomplishment of the training objectives and examine negative aspects of performance [3].

Finally, augmenting the base model used for a training event with an adjunct model — one that provides the added capability missing in the base model — is the approach advocated and discussed in this paper. The basic concept is to carve out the modules within the base model that are inadequate for a given training event and logically replace this functionality with a more capable module. At times, it may be necessary to write a new module to perform the needed functions. If this is the case, then the new development should be done in a manner consistent with the newer models and an application programming interface developed to allow the base model to call the new software. Frequently, the shortcomings of a particular base model are well known and understood, and another existing model or simulation may already possess the needed capability. In this case, the interface is the critical software to be developed. The integration of the Extended Air Defense Simulation with the Army's base model is an example of this technique.

MODERNIZING THE ARMY'S BASE MODEL — CORPS BATTLE SIMULATION

Corps Battle Simulation (CBS) development began in 1983 at the Jet Propulsion Laboratory and was originally called JESS (Joint Exercise Simulation System). The Corps Battle Simulation has been the Army's base model for training commanders' and their staffs at division level and above since 1987. It is used by the Battle Command Training Program (BCTP) to train division and corps commanders and their staffs during Army Warfighter Exercises. In this application, CBS is used in the stand-alone mode. This means that it is not connected to other service models, and hence all combat outcomes are decided in the CBS model. In the Joint environment, CBS serves as the common ground model for the Joint Training Confederation (JTC). In the JTC mode, CBS is linked to the other services models using the Aggregate Level Simulation Protocol. Over the years, additional functionality has been added to CBS to "fix" identified training shortfalls. In today's environment, funding constraints make any further major revisions very unlikely.

CBS is a discrete event, aggregate-level simulation. It is a constructive model where objects are groups of entities, like an armor battalion, rather than individual entities, like tanks and artillery pieces [4]. It can run faster than real time, and is hosted on DEC equipment. Senior commanders using this model are able to conduct joint training in a theater or train a single division commander and his staff. The training audience is primarily operating at the operational level of combat while practicing the tactical application of the operational art. For a corps commander, maneuver units are typically represented as icons. The organizational level of detail is two units below that of the unit being trained as opposed to focusing on entities where precision is required. So for a corps commander, the maneuver units are at the brigade level. At this level of aggregation, one-on-one detail is absent. To handle this shortcoming, two modules were added to CBS — COBRA and COAST.

Combat Outcomes Based on Rules of Attrition (COBRA) module is a rule-based model that enables force-on-force attrition algorithms to be weighted by additional combat factors such as mission, enemy, terrain; and simulates the human dimension — fatigue, etc. This provides an added degree of realism to be included in determining the results of combat engagements. Rather than having an "aggregated" combat power rating, COBRA enables weapon system capability and requires a thought process as to employment. From the human perspective, the adjunct model considers such things as length of time in "combat" as a way to determine combat capability.

The Controller's Assistant (COAST) module was added to CBS to handle infiltration missions. It is both a manual and an automated controller that can manage battalion-sized infiltration missions. It breaks the battalions into smaller unit elements, manages the infiltration operations, and then merges the smaller units back into a single unit and passes control back to a human controller [4].

In 1995, the lack of adequate fidelity in Theater Missile Defense (TMD) operations was identified as a high priority deficiency in both large-scale Army exercises and in the CINC-level arena. The most important aspect of using modeling and simulation to train for TMD operations is that actions must happen on the same time line that they would in a real operation [2]. This was an interesting problem to address, since the deficiency surfaced for two training environments. The fidelity of TMD play had to be increased in both the CBS stand-alone mode and in the JTC mode. However, both continue to perpetuate the aggregate level of detail rather than an entity representation to address the shortfall noted earlier.

In the basic CBS model, when a theater ballistic missile or "SCUD" (opponent's missile) is fired at a target location, an impact event is scheduled in the model. The training audience is sometimes informed that a missile is in flight, but the missile is not visible in the model and the impact point is unknown to the training audience. If appropriate air defense assets are available and prepared for Theater Ballistic Missile (TBM) engagements, then a ground-to-air engagement occurs. If the engagement is successful, then the impact event is canceled. If not, then at the scheduled time the impact occurs, an internal common mission space (CMS) algorithm assesses damage by doing a hex-based search in the vicinity of the impact point, determining which units are affected, and assessing damage, if any.

When used in the JTC mode, CBS relinquishes its ability to fire SCUDs and to engage them with appropriate Air Defense Artillery (ADA) assets. Instead, the Air Warfare Simulation (AWSIM), the Air Force model, controls the firing and engagement of SCUDs. Before March 1996, the launch and engagement sequence in AWSIM was invisible to the CBS model. The most recent change to CBS provides launch and engagement information to CBS. (The full capability is still not used because the engagement process resides in AWSIM. Future use of this capability is under review by the JTC Working Group.)

An initiative by the Army's Space and Strategic Defense Command (SSDC) to add a missile object to the CBS model has provided the opportunity for the training audience to train for TMD operations. This capability is being exploited to conduct realistic, dynamically interactive, play in "real-time" by the training audience.

An essential element for providing TMD play in a training event is a close correspondence between exercise events and operational context. This includes adequate representation of sensors, communications delays, and system engagement capabilities [5]. The Extended Air Defense Simulation (EADSIM) satisfies this correspondence criteria. EADSIM is an entity-based model used by all the services for analytic purposes [6]. It is Distributed Interactive Simulation (DIS)-compliant and has been used for one-on-one and few-on-few engagements. While EADSIM can perform traditional air warfare modeling, it also uses approved, detailed algorithms for TMD purposes. It is the TMD functionality that was harnessed to enable proper battle drill for the training audience and to make realistic assessments of the planning function for ADA employment vis-à-vis the TBM threat for a given scenario, and to ensure realistic engagement results. Using EADSIM as an adjunct to CBS allows the stimulation of real Command, Control, Communications, Computers and Intelligence (C4I) systems and processes. In short, it creates a simulation environment to look at the battlespace, query, and synchronize time-critical operations.

The TMD mission has four pillars — Passive Defense, Active Defense, Attack Operations, and C4I [7]. The C4I pillar, as shown in Figure 1, is pervasive and is an essential part of, and integrates, the other pillars.

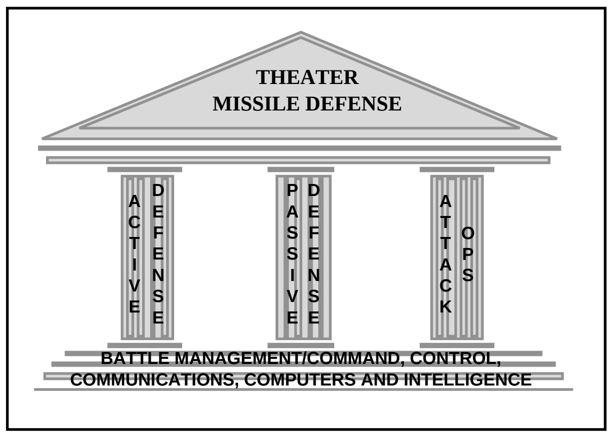

Figure 1. TMD Mission Pillars

For Passive Defense, the critical information needed by the commander is early launch notification and timely refinement of the predicted impact point. Given this information, he can take appropriate action to notify the forces in the impact area to take appropriate protective measures. These measures normally include appropriate changes to the Mission Oriented Protective Posture (MOPP) status for protection against chemical and biological munitions. If the commander cannot pinpoint the impact location, then all forces must increase their MOPP status. This will have a temporary detrimental effect on the forces. Moreover, the early notification of a launch provides the appropriate stimulus for the training audience. It puts the commander and his staff on a real time line. In many cases, the entire sequence of events from launch to impact is less than ten minutes. This immediacy of action to properly exercise the appropriate alert/warning procedures is totally absent from the current CBS experience. But the impact of a ballistic munitions with a chemical warhead could devastate a small force. Thus, the requirement to enable precision operations to stimulate and train the task of synchronizing these operation in a one-on-one basis.

The Active Defense pillar requires not only early launch notification, it also requires information about the ballistic trajectory. With this information, the commander must alert the appropriate ADA units and successfully manage a ground-to-air intercept of the threat TBM. In CBS, this process is normally done internal to the model. The appropriate ADA training audience receives little or no training benefit. Worse, if overlooked as part of the commander's function, negative training occurs. For proper exercise of this pillar, the planning and placement of ADA assets is critical. In addition, a realistic model of the engagement process is critical — launch detection, launch dissemination, proper radar coverage, accurate ADA launch procedures and timing, and repeated attempts to destroy the SCUD if the first volley fails. An approved model that puts the training audience in an operational context is essential. EADSIM provides this realism. Figure 2 shows the concept for a requirement to enable both Active Defense and Attack Operations.

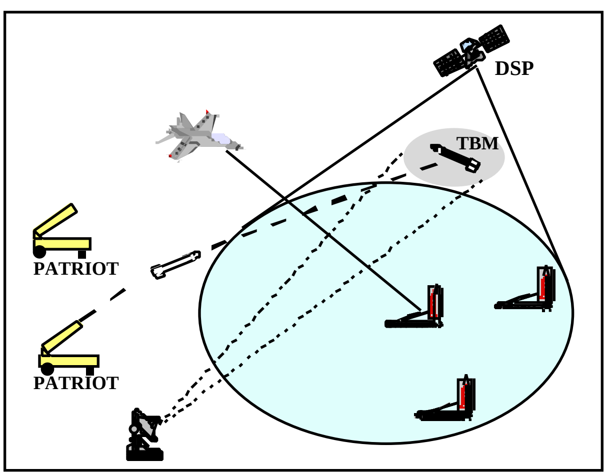

Figure 2. Active Defense and Attack Operations Concept

Attack operations is a more aggressive pillar and requires the proper orchestration of a number of battlefield operating systems. Key to the proper exercise of this pillar is a short sensor-to-shooter timeline. In addition, prosecuting attack operations is a complicated process requiring precision and a great deal of detail at the entity level. Basically the commander must establish his critical information requirements and use his intelligence assets to find the Transportable Erector Launchers (TELs) before they launch a SCUD; or failing that, find the TELs immediately after launch, and destroy them. This aspect of TMD operations is totally absent in the CBS environment. Since CBS icons are groups of TELs, the individual TELs are not directly targetable. Even if an intelligence model like the Tactical Simulation (TACSIM) is linked to CBS to allow templating of individual TELs in a grouping, correlation problems still exist. Individual TEL locations provided by TACSIM do not correspond exactly to CBS icon/object locations [8].

The solution is to replace the functionality of the CBS Anti-Ballistic Missile module with a more detailed representation of TMD operations. Major redesign of CBS to add this functionality was too costly, and waiting for the next generation of models did not satisfy the immediate training need. But a cost effective solution was found by adding EADSIM's TMD capabilities as a CBS module through an Application Programming Interface (API).

To allow for later additions to the CBS model, a DIS-compliant API was designed. This permits additional high fidelity, detailed, entity-level models to add tailored capabilities to the CBS training audience as the needs of the training audience expands to address emerging operational requirements. This capability is not meant to focus on expanding the legacy model, but rather to provide a "lab" to instantiate functionality to better understand new model functionality.

IMPLEMENTATION OF A COST-EFFECTIVE SOLUTION

Using EADSIM as the TMD module in CBS has a dramatic impact on the training audience that uses information-age command and control tools such as the Army Space Command's (ARSPACE) Army Theater Missile Defense Element (ATMDE) Tactical Operations Center (TOC). The capability stimulates the battle drill of engaging an incoming threat TBM and meets the conditions required to measure task performance against standards.

Savings accrue in terms of hardware needed to effect the capability. The CBS-EADSIM link is passive and works as a "technical control" station. As such, there is no need to learn a new model because the CBS order structure initiates the requisite action in CBS. This, too, negates the need to have both a CBS and an AWSIM terminal when used with the JTC. The most substantial savings are realized from not having to: run additional models, train personnel on additional models, and employ staff to operate and maintain the models.

The methodology used to create the link makes the capability extensible to adding other adjunct models. As an example, there is a need to stimulate processes such as precision strikes to support detailed attack operations. The simulation must create the conditions where the operational synchronization tasks can be measured empirically.

Perhaps the most significant result of this approach is that it costs very little to develop and maintain. This creates the "lab" for refining and defining requirements for high fidelity functionality such as TMD in future models like WARSIM 2000 and JSIMS.

PROOF OF CONCEPT

In May 1996, the Army sponsored its annual Prairie Warrior (PW96) exercise at Fort Leavenworth, Kansas. The network loads that one could expect during a major exercise, combined with the significant TMD play, made this a great opportunity to prove the concept of integrating CBS with EADSIM using DIS PDUs. It was also the first use of high fidelity play for the TMD community to conduct Active Defense and Passive Defense. The ATMDE TOC participated in the exercise so real-time battle drill was conducted in an operational context. The Joint Training Confederation provided the simulation environment. The member models of interest to this paper are AWSIM and CBS. The logical configuration of the exercise environment is shown in Figure 3.

During PW96, AWSIM launched the TBMs. This information was broadcast using the ALSP. The broadcast information received by CBS from AWSIM was entered into its data base and then sent through the DIS API which translated this information into DIS PDUs which were received by EADSIM. EADSIM processed the information and did two things. It used this information to provide a high fidelity fly-out and engagement of the TBMs by Patriot missiles, and forwarded the launch information to the ATMDE TOC.

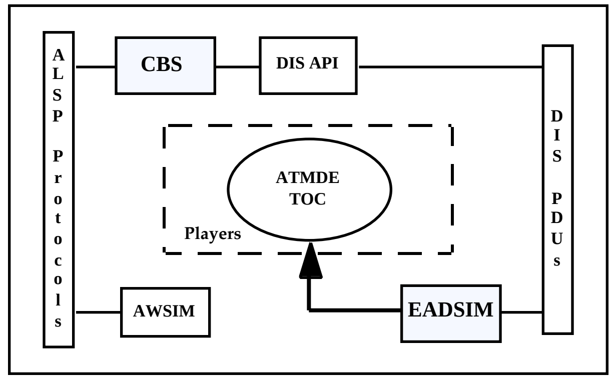

Figure 3. Logical Configuration of Models at Prairie Warrior

The DIS API managed the translation of unit information from CBS to entity information for EADSIM use. For PW96, this meant keeping a consistent view of just US Air Defense Artillery (ADA) batteries and opposing force transportable erector launchers. The DIS API handled the mapping of the batteries to individual fire units. As the exercise unfolded, the ADA assets were periodically moved and experienced attrition and reorganization. The DIS API managed this mapping as well. The aggregation and disaggregation technique and the handling of the launch information using DIS PDUs during PW96 met the users' expectations.

The results of the ground-to-air engagement by EADSIM were derived by detailed one-on-one algorithms, provided an accurate count of munitions expended for the engagement, and provided a realistic determination of which SCUDs were not engaged. In TMD paralance these are "leakers". Even one leaker can have a devastating effect on US forces since it may be carrying a weapon of mass destruction.

The ATMDE TOC received the launch information from EADSIM in its go-to-war systems and conducted real-time battle drill. The ATMDE TOC interacted with the other exercise participants and provided synchronized TMD play for the entire exercise.

At the conclusion of the exercise, the National Simulation Center sponsored testing of the two-way link with CBS in the JTC and in stand-alone mode. Both modes were tested successfully without any observed error or significant latency. The logistics update information was translated from DIS PDUs to CBS Supply Update Orders, and the CBS log files were examined to verify the success of the operation.

As a result of the PW96 participation, the concept of providing high fidelity TMD play in CBS through the use of an adjunct model was proven for Active and Passive Defense.

LESSONS LEARNED FOR FUTURE MODELS

Distributed Interactive Simulation protocols and the Aggregate Level Simulation Protocol are the two primary means for communicating between independent simulations. The next generation mechanism will be the High Level Architecture (HLA) and its Run-Time Infrastructure (RTI). These are sponsored by the Defense Modeling and Simulation Office and will eventually replace the DIS and ALSP interfaces. The work being done today to interface various models (*e.g.,* CBS and EADSIM) from separate domains (training and analytic) will provide significant insights into timing and fidelity issues and should help provide a more complete specification of the required interactions between models to stimulate training audiences.

The line between command and control systems and simulation systems is blurring quickly. The Army intends to "embed" an "A-B switch" capability within future command and control systems to allow the use of go-to-war tools for training, too.

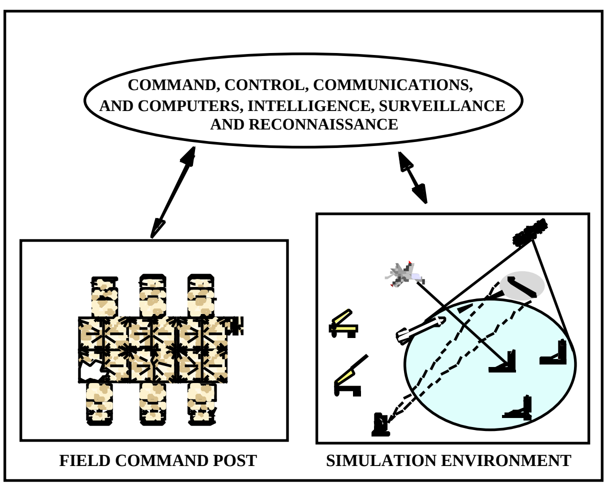

Figure 4. Command Post-C4ISR-Simulation Concept

Figure 4 shows an example where functions in a Command Post (CP) link to the Command, Control, Communications, and Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) architecture which also links to a simulation. Each functional area of responsibility within the CP must know its own operational status regarding a battle (real or virtual) and provide its input to the command decision processes.

The specific work on-going with the CBS-EADSIM interface is providing early identification of operational deficiencies in terms of command and staff procedures and proper employment of ADA assets in the TMD role. To date, Active Defense and Passive Defense have been incorporated into the CBS environment. The addition of Attack Operations is in the requirements specification phase.

CONCLUSIONS

CBS was designed for the classical large-scale, force-on-force conflict expected during the Cold War. It addresses operational context. Today, tailored joint-force packages must address operational and tactical context, so timelines based on both days and minutes must be blended to accomplish training objectives. By interfacing EADSIM with CBS, these disparate time scales are being included in large-scale training exercises.

CBS (a constructive, aggregate model) has been interfaced with EADSIM (an entity-based, high fidelity, analytic model) to enable the training audience to conduct appropriate battle drill for Passive and Active Defense operations against ballistic missile attacks.

In addition, by using a DIS interface, additional entity-level models can be incorporated into the CBS environment without the costly and time consuming process of re-engineering CBS. This methodology is providing valuable lessons learned for the next generation of models.

ACKNOWLEDGMENTS

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