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RAND

The Army After Next

Exploring New Concepts and Technologies for the Light Battle Force

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Prepared for the
United States Army

Arroyo Center

Approved for public release; distribution unlimited

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PREFACE

This document summarizes our initial year's work on the project "Assessing Advanced Concepts and Technologies for the Army After Next (AAN)." At the request of TRADOC, Deputy Chief of Staff for Doctrine (DCSDOC), the Arroyo Center began work on this project about halfway into FY97. The overall intent of the effort was to provide force-on-force simulation-based analytic support to the AAN initiative and to the series of wargames. The effort involves the use of high-resolution constructive simulation to explore both operational concepts and technology options for the *light* battle force concept associated with the AAN initiative. This research should be of interest to defense policymakers, concept and materiel developers, acquisition executives, and technologists.

The research was conducted in the Force Development and Technology Program of RAND's Arroyo Center, a federally funded research and development center sponsored by the United States Army.

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SUMMARY

BACKGROUND

As uncertain as they are, current projections of the military-political environment are used to help dictate and define the demands likely to be placed on U.S. military forces in the far future. Developing new concepts to meet these future needs and, in turn, positioning technology and materiel development to enable these new concepts to be carried out by future forces represent a key challenge and a common area of interest for many in the defense community. Those responsible for shaping the future U.S. Army through the Army After Next (AAN) initiative represent a major cross-section of the defense community; they fully recognize the challenge that they face. The need for long-range planning is articulated by their mission statement:

> Conduct broad studies of warfare to about the year 2025 to frame issues vital to the development of the U.S. Army after about 2010 and provide those issues to senior Army leadership in a format suitable for integration into TRADOC combat development programs.[1]

As it has been carried out so far, the AAN initiative is an evolutionary process that will allow the U.S. Army to continually and systematically explore new concepts and capabilities for warfighting in the future. It has been emphasized that “AAN is a journey, not a destination.” Thus, it is a process that is envisioned less to resolve a specific problem than to produce a set of potential solutions for a range of evolving future challenges.

In addition to exploring long-range needs, the AAN community acknowledges the need for modernization continuity. For example, Army XXI systems that are being developed and produced now will likely be part of the U.S. Army 30 years from now and, by default, will be part of the AAN force. However, the belief that Army XXI, by itself, will not be able to meet the demands of ground warfare 30 years from now is driving recognition that additional capabilities will have to be developed—something referred to as a “potential” force that offers greater

[1]“Army After Next” briefing, TRADOC, 1997.

overall military responsiveness and flexibility. As a result, the long-range planning for such a force would need to be integrated with systems currently in the acquisition process for Army XXI.

RESEARCH CONTEXT AND SCOPE

A number of current concepts have been identified by TRAC as candidate "potential forces." They include: (1) a variant of the mobile strike force, (2) an advanced assault force, (3) high- and low-risk air-mechanized battle forces, and (4) a light battle force. Although most of the current AAN focus has been on the exploration of the air-mechanized battle force, our research began this year with an assessment of the light battle force.[2] This force shares several key characteristics with DARPA's small unit operations and the Marine Corps Hunter-Warrior concept.

In the past, RAND has used high-resolution constructive simulation as a tool to explore the military utility of new concepts and technologies. For this project we extended our earlier work, which focused on near- and medium-term improvements for light forces, to encompass farther-future AAN concepts. This research was a natural follow-on to research on small dispersed forces conducted by the Arroyo Center for the Defense Science Board, 1996 summer study.[3]

For this research we focused on a single scenario from a large array of possible ones. Generally, scenarios can vary in terrain characteristics, threat sophistication, and environmental conditions, among other factors, resulting in highly varied results. The scenario we selected for this analysis, which was developed with input from TRADOC, constitutes a very rapid defense against a highly advanced attacking armor/mech force[4] over a relatively large region (consisting of mixed terrain). Light battle units were deployed to defend against the attack.

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[2]"Battle force," here, is used in the general sense. More literally, we examined only one and two battle units in our analysis; an entire light battle *force* by definition contains six battle units.

[3]See J. Matsumura, R. Steeb, T. Herbert, M. Lees, S. Eisenhard, and A. Stich, *Analytic Support to the Defense Science Board: Tactics and Technology for 21st Century Military Superiority*, Santa Monica, CA: RAND, DB-198-A, 1997.

[4]The threat consists of a modified version of Red force as defined by SAIC for AAN analysis and wargaming. The threat in this scenario contains 1,500-plus threat vehicles, including 200 attack helicopters.

Unlike its heavy unit counterpart, a light battle unit uses its advanced airframes for intertheater mobility. Once deployed, it is a stationary force. It is equipped with a tiered architecture of RISTA assets, and it employs a combination of direct and indirect fire assets for lethality. Indirect fire comes in the form of (1) weapon pods that contain anti-armor artillery, advanced fiber-optic missiles, and air defense missiles, and (2) very-long-range or "reachback" weapons that are launched from afar and can reach different depths on the battlefield. Also, because this is a relatively small, dispersed force, no single part of it represents a critical target.

The current straw man organization of the light battle unit, as defined by TRADOC, is shown in Figure S.1.[5]

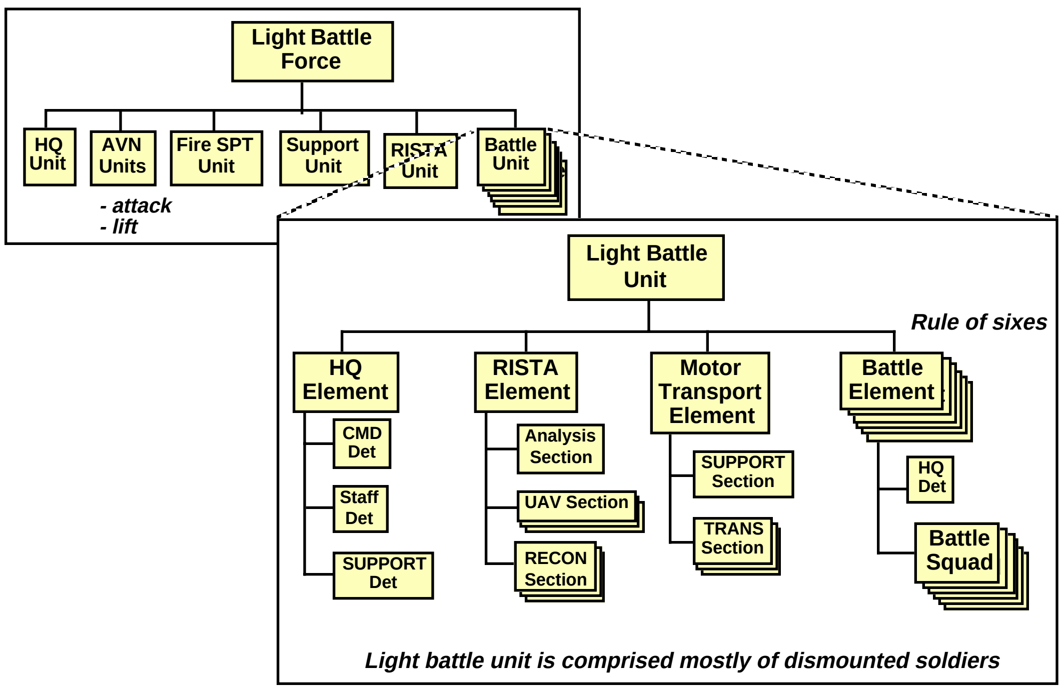

Figure S.1—Light Battle Unit Organization

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[5]From "AAN, Air-Mechanized Battle Force," briefing charts by TRADOC.

The force organization follows the rule of sixes: six battle units in a battle force, six battle elements in a battle unit, and six battle squads in a battle element. Our simulation-based analysis is conducted at the battle unit level, where each combat entity in the unit is modeled individually. The battle unit was augmented with aviation, fire support, RISTA, and other assets.

INITIAL INSIGHTS

One of the key capabilities required of the light battle force is an ability to hide and wait for the right opportunity and then create a "virtual ambush," resulting in a shock or disintegration of the enemy. This kind of defeat, to some extent, is a contrast from more traditional attrition in that it greatly compresses the time in which lethality occurs.[6] Essentially, the concept envisions that an advancing threat is allowed to penetrate, and then the battle force unleashes massive simultaneous fires from afar and closer in. To accomplish this, unprecedented amounts of survivability (possibly in the form of stealth) and lethality (in the form of precision-guided weapons) would be required. Thus, as a starting point, we examined those two critical aspects of the light battle force concept via our simulation and modeling.

Survivability

To explore the issue of survivability, we began with the most detectable and vulnerable aspect of this force: the organic weapon pods.[7] We examined four levels of preparation—deployment in the open, deployment in defilade (which reduces the pod's critical dimension by two-thirds), deployment in defilade with camouflage (which further reduces its signature by half), and deployment in defilade with a level of signature control that might correspond to a "low observable" condition (which further reduces the signature yet another half). Each of these

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[6]This sudden and rapid lethality may not be comprehensive in nature, but it does entail defeating an enemy's command structure, cohesiveness, organization, and, possibly, will to fight.

[7]In addition to the weapon pods, the battle squads would be another entity to examine for survivability; however, they have an ability to move into hide locations.

represented a parametric level of reduction rather than one directly correlated to a physical performance level attained via testing.

Simply deploying pods in defilade offered some reduction in their overall vulnerability to fire, but it did not have a dramatic impact on their detectability (the large number of Red systems constituted many “look” opportunities). The addition of camouflage reduced the detectability substantially, but it was not until the highest level of signature control was used that the force could remain undetected. One other way to increase pod survivability was to allow them to fire first rather than wait for an ambush. While this was seen to provide some additional survivability, it would sacrifice the element of surprise associated with the engagement.

Because of their small numbers and very low density, the soldiers associated with the battle unit were generally not vulnerable to indirect fires. More specifically, because of their laydown or placement to cover the terrain, battle squads were typically separated by several kilometers. Even within a squad, there was additional separation along with a fair amount of redundancy. Thus, no single squad constituted a lucrative (high-density) or, for that matter, critical target. To some extent, the enemy’s ability to engage was governed by the battle force laydown itself. Nonetheless, because the battle squads were required to maintain some degree of line-of-sight to the attacking force for target acquisition purposes, even though they maintained cover, some of the squads became vulnerable to direct fire. In some cases, where the simulated battle was allowed to continue to its completion (where the enemy continued to attack regardless of accumulated losses), as much as one-third of a battle unit was attrited. In the event that an attacking force continues, even with high numbers of casualties, an exploitation capability such as maneuver would be useful to further neutralize the attack.

Lethality

In ideal conditions, and assuming that stealth could be achieved at least to the defilade/camouflage level, the application of one battle unit was seen to be able to attrit a large percentage of the enemy units leading the attack. The addition of the reachback weapons, in this case U.S. Army long-range fires (could also include USAF or Navy air support), dramatically increased the total number of kills. However, the most notable effect of the reachback contribution was in kills with respect to time. Specifically, all kills by these systems occurred in the first 30 minutes. If enough “compression” of kills occurs (kills within a relatively small period), a “shock” effect can be created; this shock effect can temporarily disrupt or even stop the momentum of the attack. If this is followed up or exploited quickly by a subsequent attack, perhaps a limited direct fire engagement, one can argue that even greater, synergistic levels of damage can be attained and the battle can be decisively terminated (referred to as a disintegration-defeat mechanism) . However, this light battle unit, because of its lack of ability to maneuver, was not able to capitalize on this opportunity.

Also, as effective as the force was seen to be, there was no guarantee that one light battle unit with reachback weapons would entirely succeed with its mission to stop the attacking force, for two key reasons. First, it was unclear how much attrition will be required to succeed in stopping an attacking force. Second, after advancing as little as 15 km, the enemy force had the option of seeking refuge and creating a defense in the many urban areas instead of continuing its attack. For these reasons, we deemed that a single battle unit was not enough to ensure mission success, even with the other ideal scenario conditions assumed.

As a next step, we employed an additional battle unit, heavily armed with direct fire weapons, around the urban areas. The effects of this “point defense” capability were quite compelling. In the case where this direct fire was added, nearly all the lead elements of the attacking force were destroyed (with or without the use of reachback systems).[8] This suggests that given the three key methods for force lethality to provide a defense in this scenario—organic pods, reachback weapons, and direct fire—reachback systems were the least necessary system for accomplishing the battle units’ fundamental objectives.

However, it is important to highlight that such reachback systems were instrumental for creating the shock effect, which greatly influenced the *way* in which the attrition was obtained. Also, the reachback systems provided a means for conducting the deeper attacks, well into enemy territory.

[8]With some increase in the number of battle units’ losses.

Mission

Much of this research suggests that with key technologies—such as an advanced tiered RISTA network, a seamless C3 system, a wide range of multifunctional long-range, medium-range, and close-range precision guided weapons, advanced low-observable capabilities, and other technologies—over time and distance, a small, well-positioned force can attrit a much larger attacking force.[9] However, attrition alone represents only one means for accomplishing the larger mission of defending an ally's territory. Further, because of the secondary objective of protecting the intermediate urban areas in our scenario, the context of attrition can change. It was quite evident that the necessity of protecting these urban areas greatly altered both the shape of the force, its equipment and laydown, and the overall outcome of battle. *Thus, the mission to both stop an attack and preclude entry into intermediate urban areas influenced battle force performance, representing a dramatic difference over simply attriting the enemy force as it advanced.*[10]

FUTURE WORK

As for future research, we plan to continue our examination of the light battle force. Most of the research to date has concentrated on performance of the battle force in near-ideal circumstances. Future work will now ask the question: "What can go wrong, and what will its impact be?" Additionally, we are currently planning to shift our focus to help the AAN community assess the effectiveness of the heavy battle force. To date, there have been several analyses examining the performance of a heavy battle force. We hope to leverage these and perform detailed force-on-force combat analyses to further quantify the effects of such a force.

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[9]Because of the exploratory nature of this research, the question posed is, "If these technologies are available, do they make a difference?" From a more practical side, the key question might now be, "What is the likelihood that such technologies can be fielded and sustained throughout the course of battle?"

[10]Some emerging concepts suggest that attrition alone can be an effective means for defeating an attack. In this scenario, many of the weaknesses of these concepts were seen.

ABBREVIATIONS

AAN	Army After Next
AD	Air Defense
ARI	Army Research Institute
ARL	Army Research Laboratory
ARO	Army Research Office
ASP	Acoustic Sensor Program
ATACMS	Army Tactical Missile System
AWACS	Airborne Early Warning and Control System
BAT	Brilliant Anti-armor submunition
C3	Command, Control, and Communications
CAGIS	Cartographic Analysis and Geographic Information System
COE	Corps of Engineers
DARPA	Defense Advanced Research Projects Agency
DCSDOC	Deputy Chief of Staff for Doctrine
DFAD	Digital Feature Attribute Data
DTED	Digital Terrain Elevation Data
EFOG-M	Enhanced Fiber Optic Guided Missile
FDC	Fire Direction Center
FSE	Fire Support Element
LER	Loss-Exchange Ratio
LO	Low Observable

MADAM	Model to Assess Damage to Armor with Munitions
MOE	Measure of Effectiveness
MRMC	Medical Research Materiel Command
NDRI	National Defense Research Institute
NVEOD	Night Vision Electro-Optical Division
OOTW	Operations Other Than War
RDEC	Research, Development, and Engineering Center
RISTA	Reconnaissance, Intelligence, Surveillance, and Target Acquisition
RJARS	RAND’s Jamming Aircraft and Radar Simulation
RTAM	RAND’s Target Acquisition Model
SARDA	Secretary of the Army for Research, Development, and Acquisition
SEMINT	Seamless Model Interface
SMDC	Space and Missile Defense Command
SUO	Small Unit Operations
TOC	Tactical Operations Center
TRAC	TRADOC Analysis Center
TRADOC	Training and Doctrine Command
UAV	Uninhabited Aerial Vehicle

THE ARMY AFTER NEXT

Exploring New Concepts and Technologies for the Light Battle Force

This document summarizes our initial year's work on the Army After Next project at RAND Arroyo Center. This project started about halfway into FY 97. The intent of the effort was to provide analytic, simulation-based support to the Army After Next (AAN) initiative. The effort focuses on use of high-resolution construction simulation to explore technology options and operational concepts for the *light* battle force component of AAN.

Project Objective

- **Explore and assess new operational concepts and technology options for the Army After Next (AAN)**
  - **Team with user and developer communities**
  - **Integrate explorations of operational concepts**
  - **Incorporate assessments of technology**

Our primary research objective was to examine candidate technologies and concepts conceived for AAN by the user and developer communities. This was an integrative process and involved coordination of our high-resolution simulation work with analytic studies being pursued by other agencies such as TRAC and ARL.

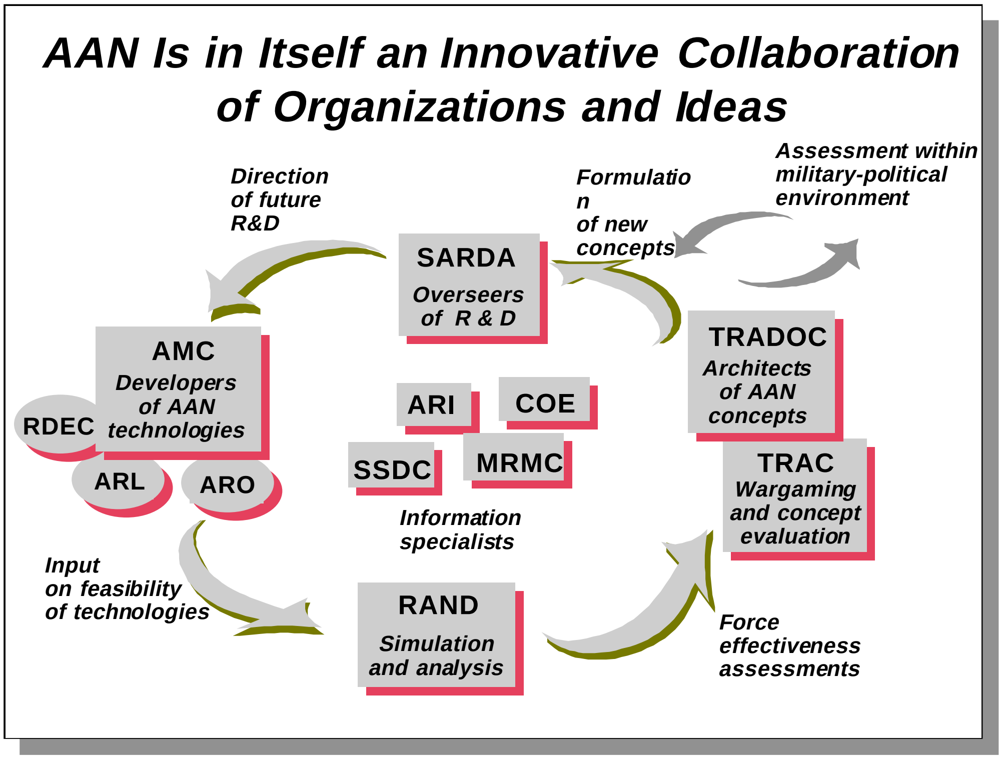
AAN Is a Key Initiative That Will Shape the Army of the Far Future

- **AAN mission statement (TRADOC)**
  - ***"Conduct broad studies of warfare to about the year 2025 to...***
  - ***Frame issues vital to the development of the U.S. Army after about 2010 and...***
  - ***Provide those issues to senior Army leadership in a format suitable for integration into TRADOC combat development programs"***
- **AAN is an iterative process that will "experiment with and study [different] potential future Army forces" (TRAC)**

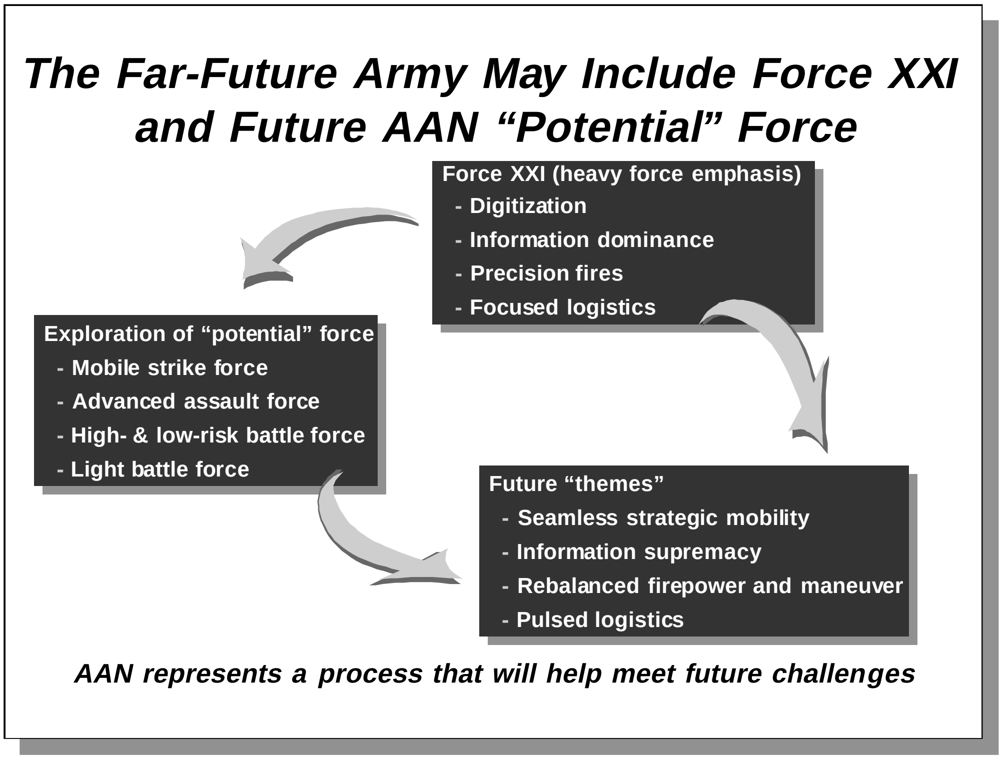
To provide the overarching context for this research, the AAN mission statement as defined by TRADOC is provided here.[1] A key point to note is that even though the studies focus on the time period of the far-future Army, they articulate the need to leverage these studies earlier so that they can be integrated into development programs.

TRAC also points out that AAN is envisioned to be an iterative process that explores different types of potential future forces.

[1]"Army After Next" briefing, TRADOC, 1997.



Our interpretation of AAN is that it is an evolving, innovative collaboration of organizations with many centers of interaction. This chart diagrams some of the relationships. For example, TRADOC, which was assigned as the Army lead by the Chief of Staff of the Army (on the right) is seen to formulate new concepts, while AMC proposes and characterizes new technologies that can carry out those concepts. SARDA oversees the R&D process, and Arroyo Center uses inputs in its simulation and analysis process from users and developers, along with specialty centers such as the Corps of Engineers and Army Research Institute. RAND Arroyo Center is also secondarily involved in higher-level military-political assessmentsent between the participants.



It is currently envisioned that the AAN-era force (focused on year 2025) will contain a Force XXI component and will also include a "potential" component with greater force flexibility and lethality. Some of the key characteristics desired for the Force XXI force generally include: digitization; information dominance, precision fires; and focused logistics. This force, made up largely of legacy systems, will likely have an emphasis on heavy forces and combat systems. Some candidate "potential" AAN forces, identified by TRAC, tend to be much more deployable and currently include a variant of the mobile strike force, an advanced assault force, both high- and low-risk air-mechanized battle forces,[1] and a light battle force. It is interesting to note that some of the general characteristics desirable for Force XXI are also carried to the next step in the AAN potential force.

[1] Differences between the high- and low-risk air-mechanized battle forces include: numbers of tilt-rotor aircraft, presence of multifunctional ground and air vehicles, and performance specifications of combat systems.

Outline

→**Methodology**

- **Light battle force**
- **Scenario**
- **Initial findings**
- **Future work**

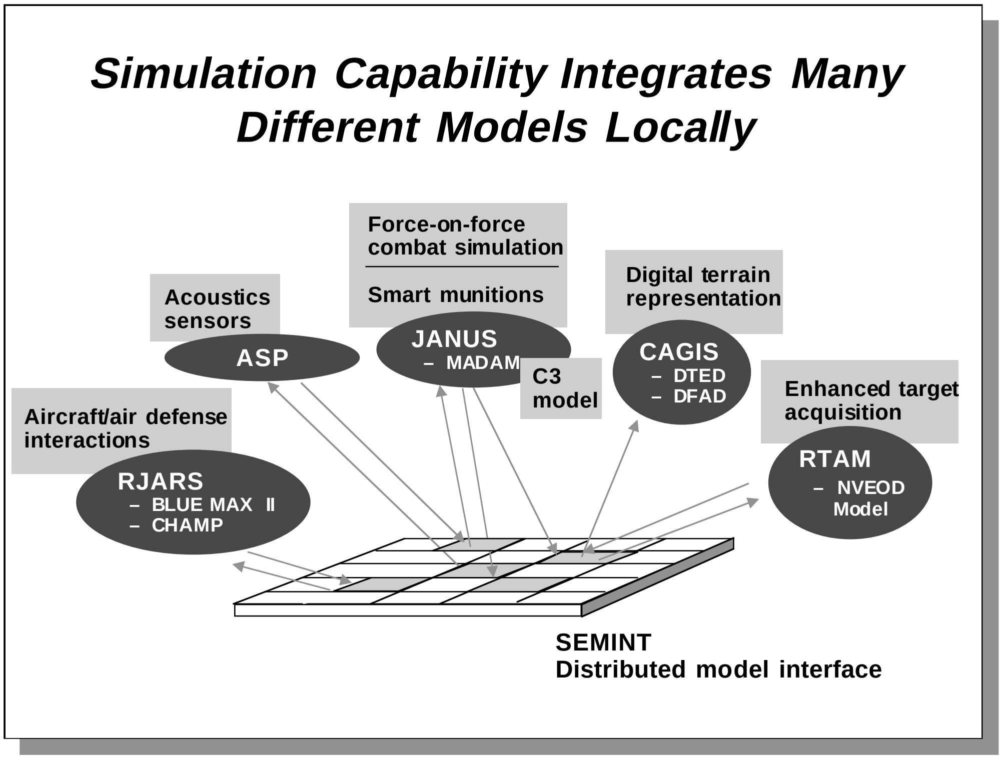
This document is organized into five sections. The first section describes our methodology and simulation models. The second section describes the salient aspects of AAN, lists specific characteristics of the light force component, and discusses how the participating organizations are anticipated to interact. The third section describes the scenario we used to examine AAN light force excursions. The last two sections close with a discussion of initial findings and future directions respectively.

Research Approach

- **Use high-resolution simulation to explore the combat effectiveness of the light battle force**
  - **Across different scenarios**
  - **Under different environmental conditions**
  - **Against different threat capabilities and tactics**
- **Apply a variety of evaluation methods**
  - **Traditional MOEs of lethality, survivability, deployability, supportability, robustness**
  - **New MOEs on area coverage, shock, and disintegration-defeat criteria**

In the past, RAND has used high-resolution constructive simulation as a tool to explore the military utility of new concepts and technologies. In this project we are extending our earlier work, which focused on near- and medium-term improvements for light forces, to encompass farther-future AAN concepts. This year, we started with a single scenario and set of environmental conditions with some minor variations of the battle unit capability. We expect to continue this work to include a wider range of excursions, possibly spanning different scenarios, environmental conditions, and assumptions of threat levels and capabilities, to quantify the improvements resulting from new concepts. We also hope to examine deployability and supportability issues at some point in the future.

In this effort, we process the simulation output to determine both traditional measures of effectiveness (MOEs), such as kills, losses, and movement, and new MOEs, such as shock and disintegration effects from massed fires. Several of these new MOEs were developed from discussions with TRADOC colleagues.



A portion of our research was devoted to modification and development of high-resolution models capable of representing the performance of far-term advanced-technology AAN systems. We started with our existing distributed simulation environment for modeling ground combat, developed over the course of several years on other projects. The structure of this distributed environment is diagrammed above.

The RAND version of Janus serves as the primary force-on-force combat effectiveness simulation and provides the overall battlefield context, modeling as many as 1,500 individual systems on a side. The combination of the RAND Target Acquisition Model (RTAM) and the Cartographic Analysis and Geographic Information System (CAGIS) allows us to represent, as needed, detailed detection/acquisition phenomenology, including those associated with low-observable vehicles. RAND's Jamming and Radar Simulation (RJARS) provides a means to simulate the detection, tracking, flyout, and fusing of air defense missiles. The Model to Assess Damage to Armor with Munitions (MADAM) enables us to simulate the effects of smart munitions, including such aspects as chaining logic, multiple hits, and unreliable submunitions, among others. The Acoustic Sensor Program (ASP) provides a detailed simulation of acoustic phenomenology for such systems as air-delivered acoustic sensors and wide-area munitions. The Seamless Model Integration (SEMINT) allows all of these locally distributed simulations to communicate while running on separate processors.

Scenarios Create Multidimensional Challenges for Light Battle Force

Rapid deployment, mixed terrain

- **Massed force invasion**
- **Very little warning time**
- **Intermediate objectives (towns)**
- **Sophisticated enemy**
  - **Mech-armor forces**
  - **Helicopter-based air support**

Research should involve examining force effectiveness in different situations

We are currently using one scenario from a large array of possible scenarios that vary in their terrain characteristics, threat sophistication, and environmental conditions. This scenario involves a very-rapid-deployment mission to defend a large region from encroachment and takeover by a neighboring power. The scenario takes place on mixed terrain, which includes both open areas and hilly, vegetated regions (e.g., in this study we chose a LANTCOM scenario). With minimal warning time, the light battle unit is transported and then deployed over several hours during the night. The enemy launches its combined force attack at first light using mech-armor and helicopters.

The primary mission of the light battle unit is to defend the region from being taken over by the enemy invasion. This suggests that the light battle unit must either repel the attack or slow it enough such that additional forces can be positioned to repel the attack. In lieu of a complete takeover, the enemy’s intermediate objective is advancement into towns, some of which are as little as 10–15 km from the international border. Political constraints do not allow the battle unit to either deploy across the international border or conduct any preemptive actions.

Outline

- **Methodology**

→**Light battle force**

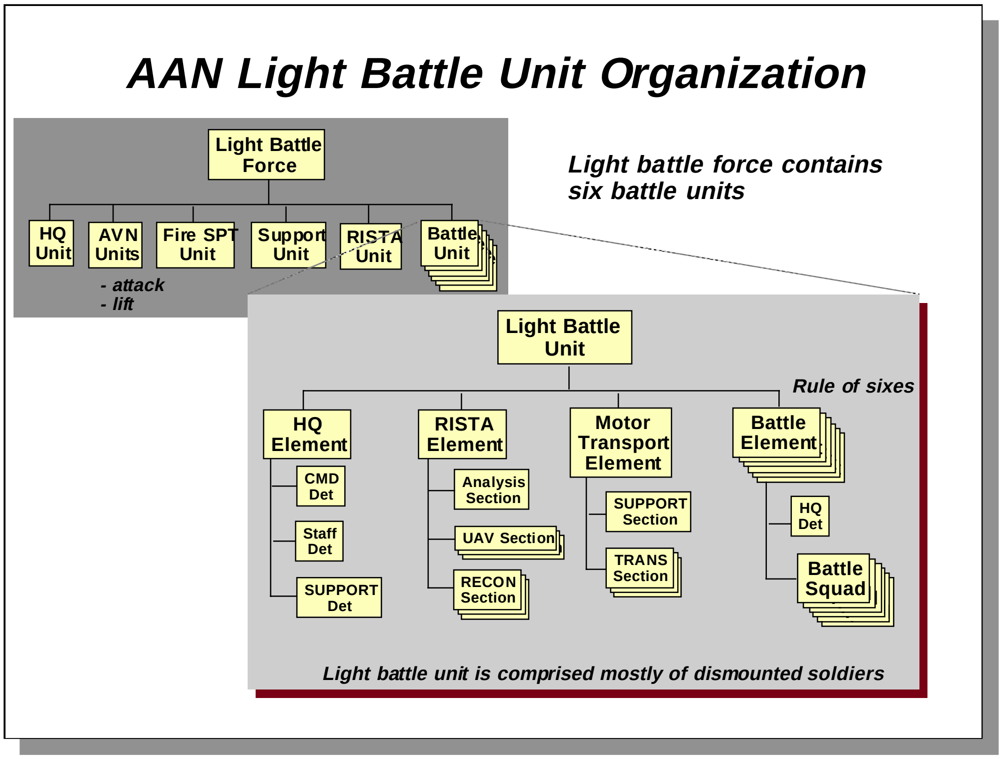
- **Scenario**
- **Initial findings**
- **Future work**

In this section we describe the light battle force, which was the focus of this year's work.

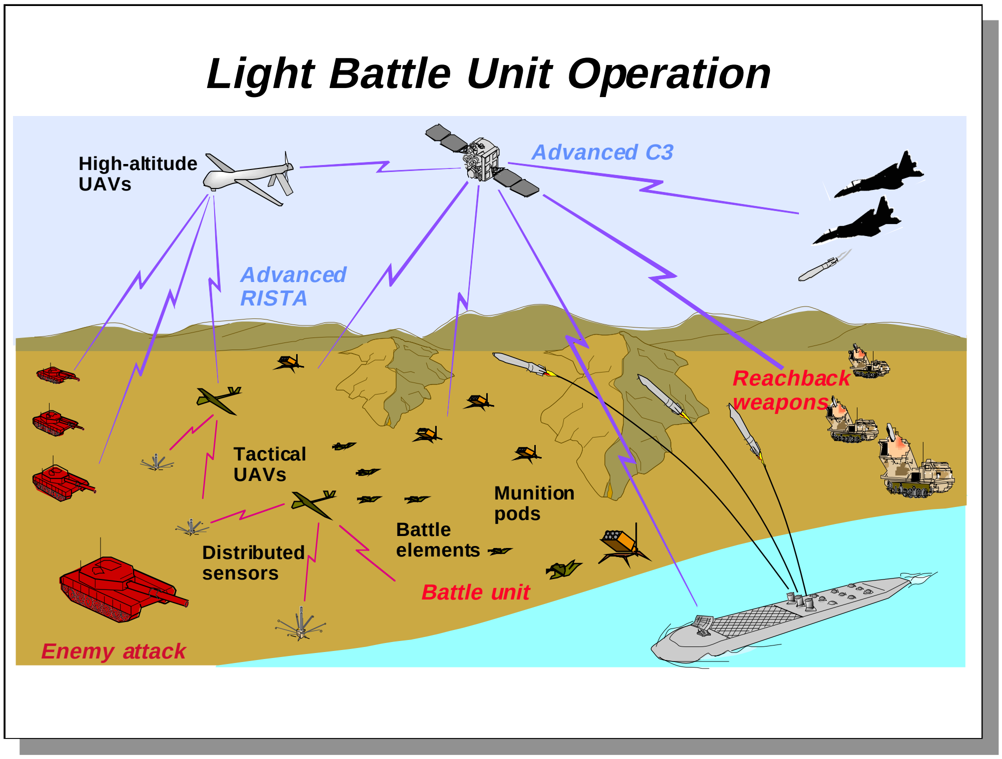
Our Current Research Focused on AAN Light Battle Force

- ***Speed*—excellent intertheater mobility, inserted very rapidly; however, limited intratheater mobility**
- ***Knowledge*—information dominance created by tiered network of ground, air (and space) based RISTA and C3 and denial of enemy situational awareness**
- **Current vision includes dismounted infantry**
  - **Equipped with direct fire weapons**
  - **Supported by dispersed, organic indirect fire weapons pods**
  - **Has direct access to “reachback” weapon systems (long-range firepower)**

Generally, the AAN initiative is recognized as synergistically capturing and harnessing two critical elements for future warfare—speed and knowledge. With respect to intertheater mobility, the light battle force is envisioned to be an extremely responsive, deployable force. This light battle force shares many characteristics with the Marine Corps Hunter-Warrior concept and DARPA’s small unit operation (SUO) force. This light battle force, however, is not confined to littoral regions and is not envisioned to require a port or airfield to establish itself. While advanced airframes play a critical role in deploying the force, once deployed, the light battle force is not envisioned to have significant tactical mobility. This force relies heavily on information supremacy and advanced precision-guided firepower (to include USAF and USN integration) to repel an attacking force.



The light battle unit has been specified by TRADOC according to the rule of sixes: six battle units in battle force, six battle elements in a battle unit, and six battle squads in a battle element. Our simulation-based analysis employs a battle unit or more, with each combat entity in the unit being modeled individually. In addition to the battle unit, a slice of the larger battle force—aviation, fire support, RISTA, and other assets—was attached to the battle unit.



The light battle force concept is notionally pictured here. Enemy armor is detected by high-altitude and tactical UAVs and forward observers from the battle element itself.[2] The contacts are communicated back through airborne and terrestrial relays to the battle unit and to higher echelons of command. Calls for fire are made to organic assets such as artillery, EFOG-M, and air-defense pods and to external assets such as arsenal ship, MLRS launchers with ATACMS missiles, and Tac Air.

Not shown are additional assets such as Army aviation, airborne radar platforms, and GPS satellites.

[2] Distributed sensors such as the air-deliverable acoustic sensor, shown in the image above, can also be used to provide additional information to the force.

Concepts and Technologies for the Light Battle Force

- Employs predictive planning techniques
- Deploys rapidly with minimal presence and support
- Creates "virtual" ambush with information dominance
- Coordinates precision fires at all levels (reachback, local indirect, and direct fires)

- Advanced RISTA and situational awareness systems
- Advanced C3 network
- Advanced weaponry (reachback and local)
- Signature reduction capabilities
- Weight reduction methods

Our work focused primarily on the AAN light battle force, although many of the technologies and concepts also apply to the air-mechanized battle force. The underlying concepts of AAN that we will try to examine include information dominance and predictive planning, rapid and very light deployment, creation of virtual ambushes (massed, quick-strike precision fires at a time when an enemy is vulnerable and not expecting an attack, which is planned and executed with information supremacy), and coordination of a variety of different standoff weapons. Each of these is enabled by specialized technologies which can be modeled either in absolute terms or parametrically.

Outline

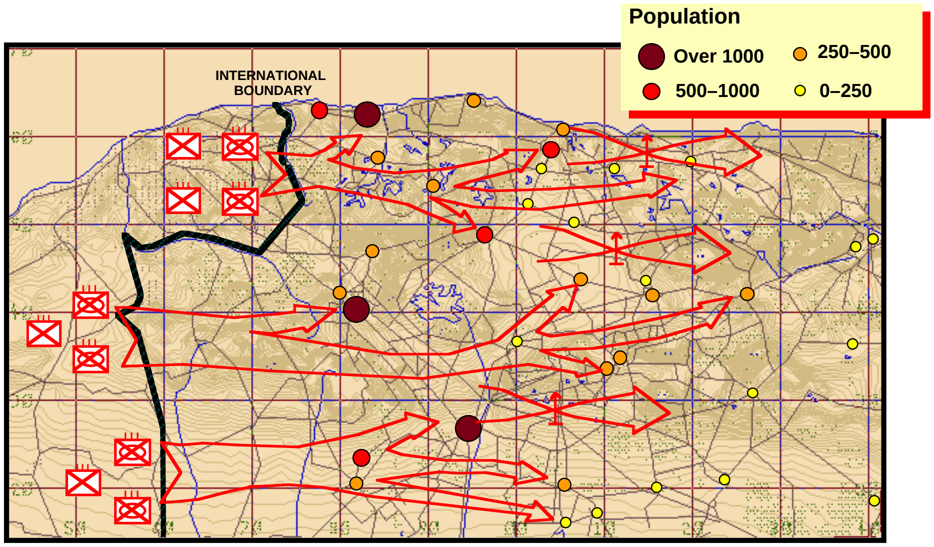
- Methodology
- Light battle force

→Scenario

- Initial findings
- Future work

This section describes the scenario we used for the analysis.

Initial Scenario Puts Light Battle Unit in Rapid Defense Against Enemy Invasion



The Red plan of attack is shown here. Red intends to make three thrusts across the international boundary with two advanced heavy brigades each. The region shown is approximately 60 km north-south and 100 km east-west. The terrain is mixed in nature—some open areas and other areas with hills and foliage. Although there is an extensive road network, for the most part it is not used because of the broad nature of the attack. Nonetheless, the attack moves quickly due to the cross-country mobility of the enemy vehicles (55 kph). Many small towns act as intermediate objectives as Red moves quickly east. Red has approximately 1,500 systems, 200 of them advanced helicopters that move in three waves with the ground forces. Although air-based firepower can potentially respond rapidly to this enemy attack, tactical mobile air defenses preclude overflight with impunity (air supremacy has not yet been established). Additionally, the combined urban areas, weather, and foliage can reduce the ability to find, engage, and destroy targets from afar.

Key Assumptions

- **RISTA support**
  - **3 UAVs per battle element (2 FO-FAC per squad)**
  - **6 airborne radar systems cue air defense**
  - **HAE UAV cues all reachback weapons**
  - **No distributed sensors used**
- **Squad organization, 7-man in 2-2-3 configuration**
- **Pod configuration**
  - **60 artillery pods, 25 MLRS missiles per pod**
  - **24 advanced EFOG-M pods, 8 missiles per pod**
  - **30 air defense pods, 10 missiles per pod**
- **ATACMS Block II used as primary reachback system**

Because the Blue force is a light force equipped with only a few vehicles (primarily for the fire direction centers and fire support elements), most of the AAN forces remain stationary during the roughly 150-minute battle. There are 114 pods, consisting of three classes of munitions— anti-armor artillery, advanced EFOG-M, and air defense. Each battle element has six seven-man squads, along with three tactical UAVs for acquiring tactical-level information. The light battle unit additionally has six airborne radar systems (similar to AWACS in capability) and a high-altitude endurance UAV for generating higher-level situational awareness information, and in our scenario these are used to target air defense and reachback systems.[3] These systems are assumed to be unjammed and invulnerable. No distributed ground sensors are used in this set of runs, in order to determine the coverage performance of the base set of AAN sensors.

Since this is a division-level combat effectiveness model, lack of robustness in organizational structure is not tested, e.g., ability to conduct 24-hour operations.

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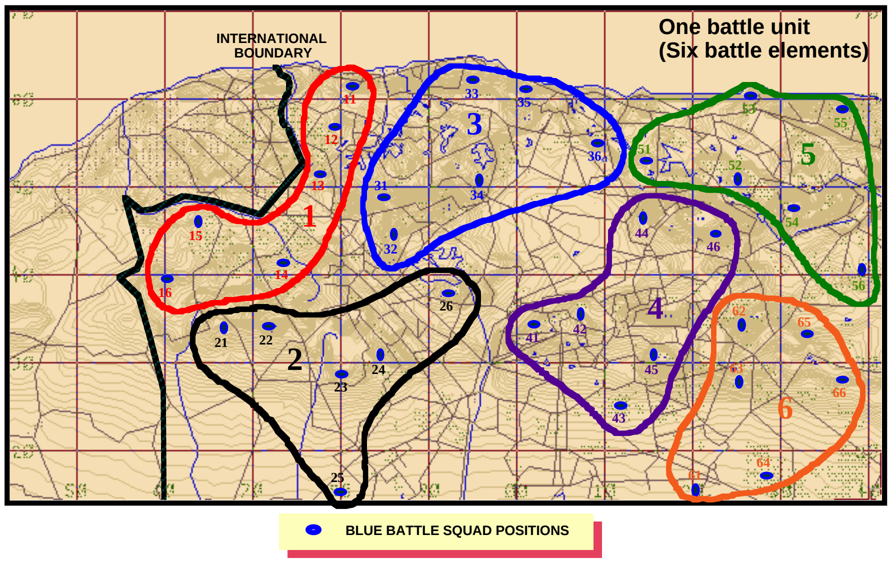
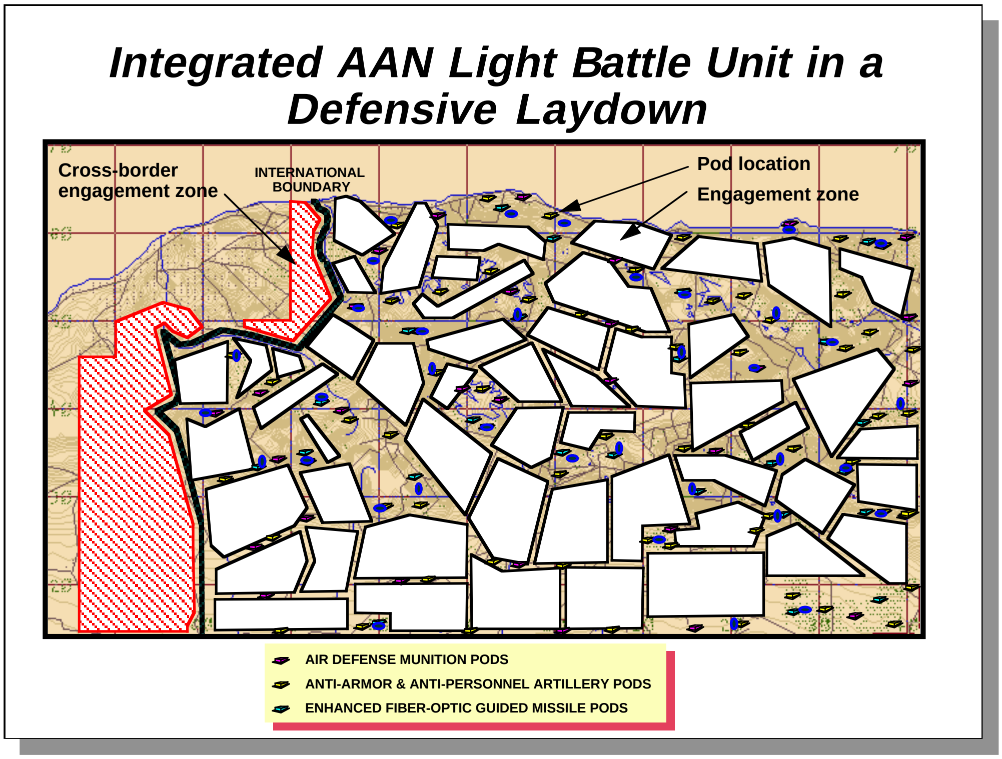
[3] Reachback weapons and air defense systems can be cued by a number of different intelligence assets.

Laydown of Battle Unit Divided into Elements and Squads

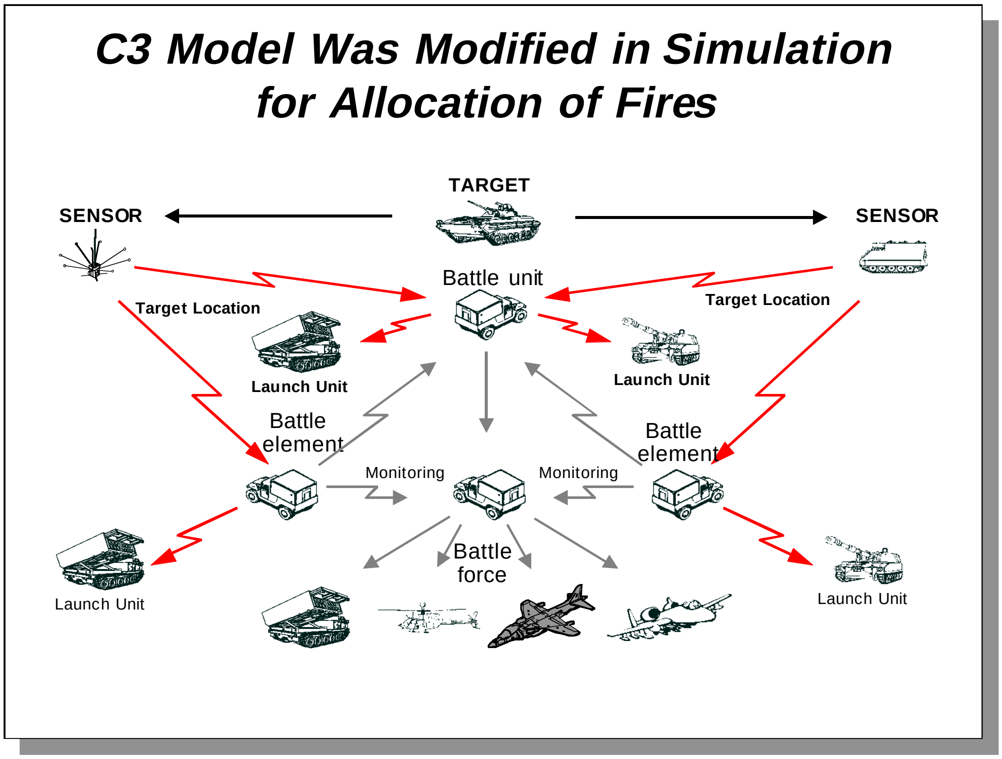


The organizational structure of the deployed battle unit is shown above. As noted earlier, a battle unit consists of six battle elements, and each battle element contains six battle squads. Each of the six battle elements is color coded separately, and the lines containing their respective squads give some notion of their area of responsibility. The laydown of this force was closely coordinated with TRADOC and TRAC representatives to ensure operational and tactical compliance, particularly since no formal doctrine, tactics, techniques, and procedures exist for this force.

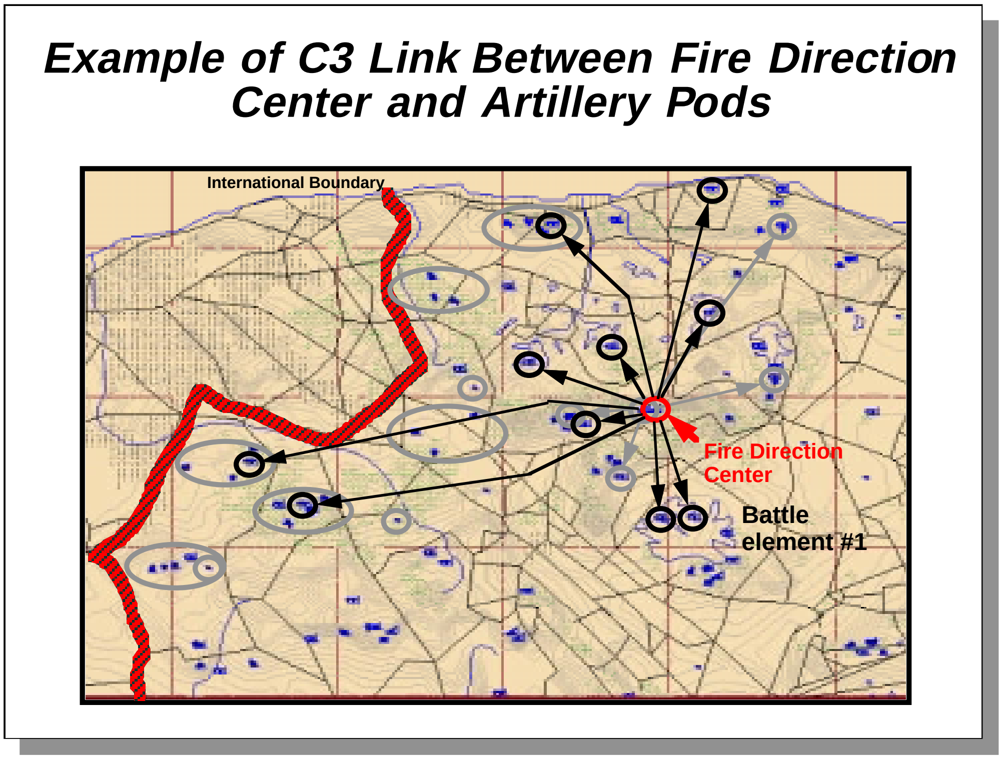


This graphic depicts the planned deployment of Blue battle squads and their allocations of munitions pods. The polygons indicate the engagement area for each battle unit. These areas were selected based on trafficability of terrain, road networks, proximity to intermediate objectives, and foliage level. When possible, Blue battle squads are not positioned inside engagement areas, to minimize potential fratricide. The positioning of munitions pods is less restrictive.

The Blue force depicted represents the dismounted fighting elements of one complete battle unit that will participate in the indirect fire battle. In some of our runs, an additional battle unit was equipped with direct fire weapons (Javelin) and positioned in the towns for local defense.

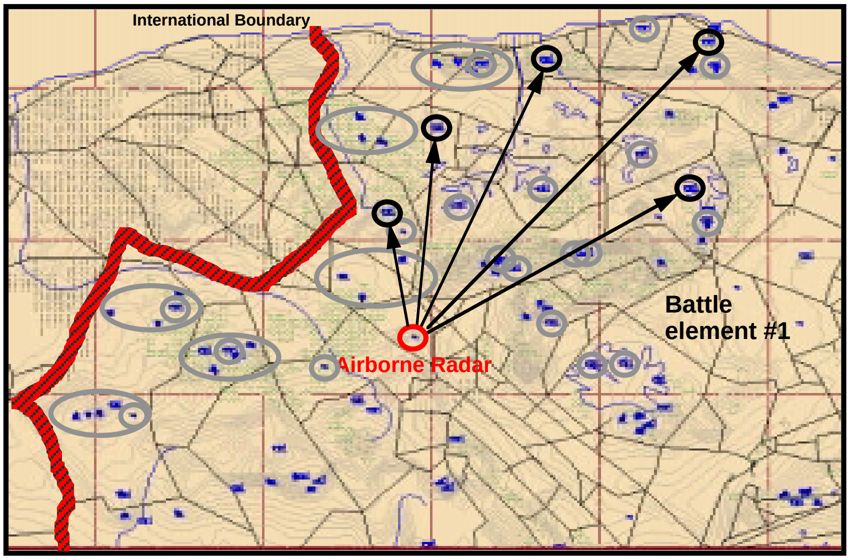


One of the more extensive changes made to the model was in command and control modeling (coded into the MADAM model). Message passing nodes, line-of-sight blocking, and delays are modeled between the sensors, battle unit and battle element fire direction centers and fire support elements, and the weapon systems. Loss of any node, such as a fire direction center, results in a delay for reconfiguration of the system. Connections between the higher-level battle force TOC and the other elements are assumed (with delays only) and not yet explicitly modeled. No jamming was played between links in this study.



The image above illustrates how we model fire support in our simulation. Here, we show the deployment of the anti-armor firing battery supporting the first battle element in Janus. The fire direction center for the firing battery is also shown. Ten of the sixty artillery pods are connected to this FDC, and they cover a large area that includes the first battle element's area of responsibility.

Air Defense Is Cued by Airborne Radar-Based System



A separate fire control system is used for air defense. This second set of links in the C2 system is shown above. This figure illustrates the deployment of an air defense firing battery (five AD pods) supporting the first battle element. As a reference point, the AWACS-like airborne radar platform is circled.

Outline

- **Methodology**
- **Light battle force**
- **Scenario**

→**Initial findings**

- **Future work**

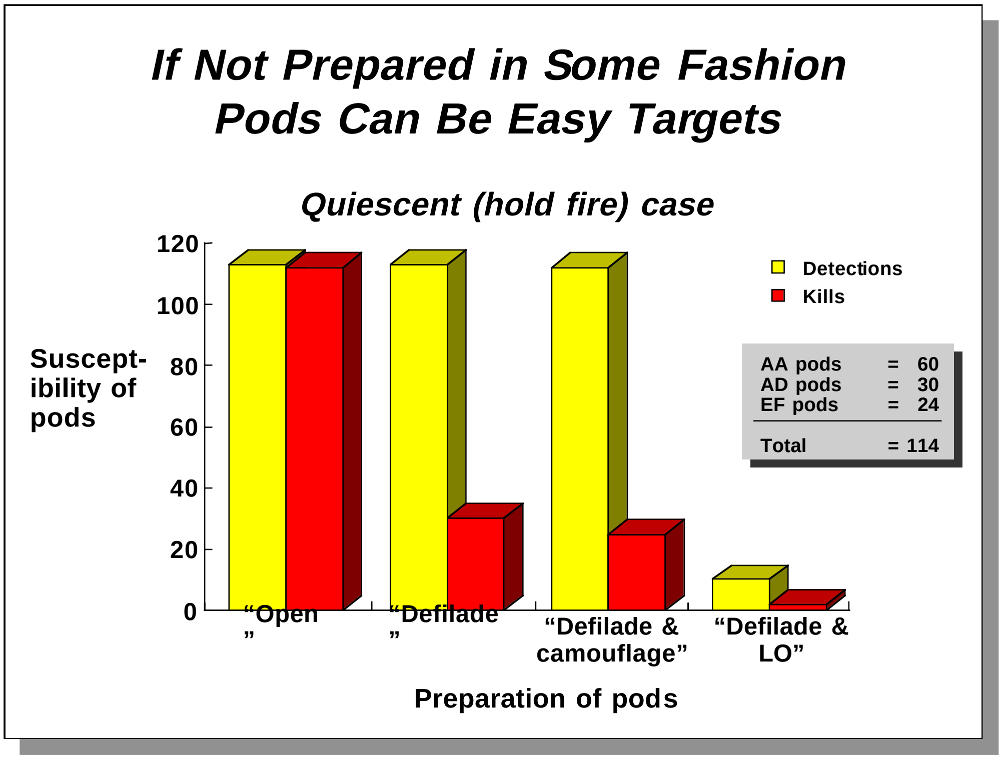
This section describes our initial findings on the light battle force effectiveness.

Key to AAN Light Battle Unit Involves Ability to Create "Virtual" Ambush

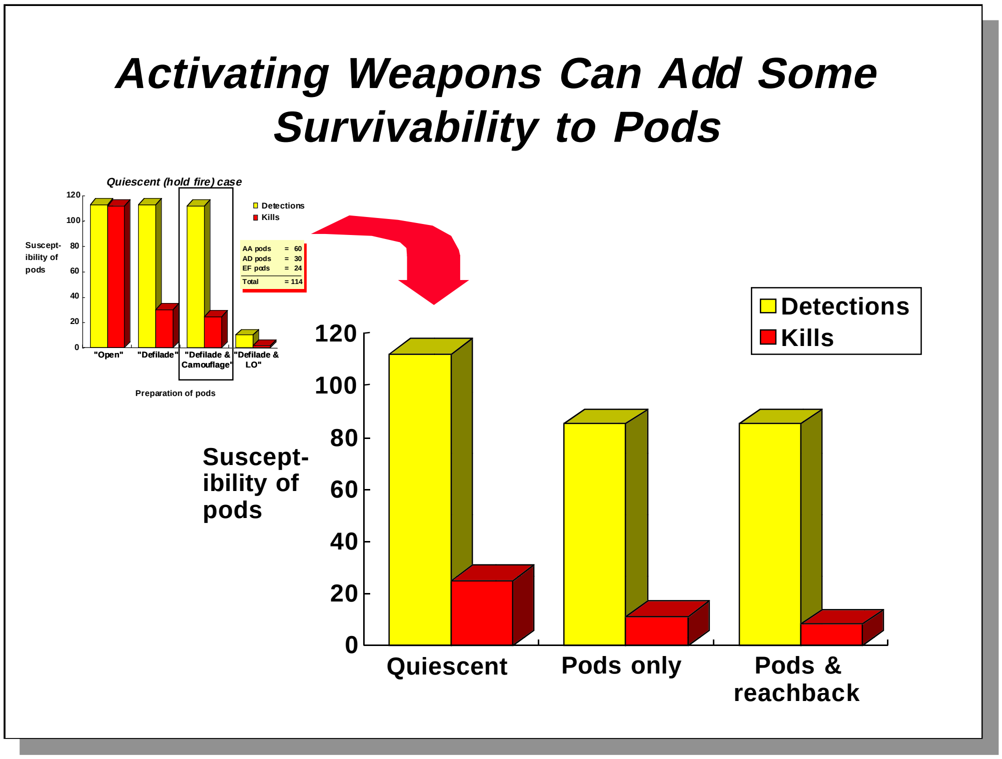
- **Quiescent cases (battle unit on hold fire)--ability to be bypassed**
  - **Open deployment of pods**
  - **Pods in defilade**
  - **Pods in defilade and "camouflaged"**
  - **Pods in defilade and "low observable"**
- **Active cases (fire on detect)**
  - **Battle unit pods only**
  - **Battle unit pods and reachback weapons**

One of the key concepts behind the AAN light battle force is that it can hide and wait for the right opportunity to create a "virtual ambush"—massing quick-strike precision fires at range on enemy forces when they are most vulnerable. To see if the pods can be effectively hidden while waiting for the right opportunity (and often being bypassed by enemy systems), we looked at four levels of camouflage—deployment in the open, digging them in to place them in defilade, then adding camouflage, and then assuming a level of signature control that might correspond to a "low observable" condition. Each of these was a parametric level rather than a physical system performance level. Defilade assumed that two-thirds of the pod was concealed. Camouflage reduced thermal and visible signatures by 50 percent compared to when pods are in the open, and low observable reduced them down to 25 percent of their original level.

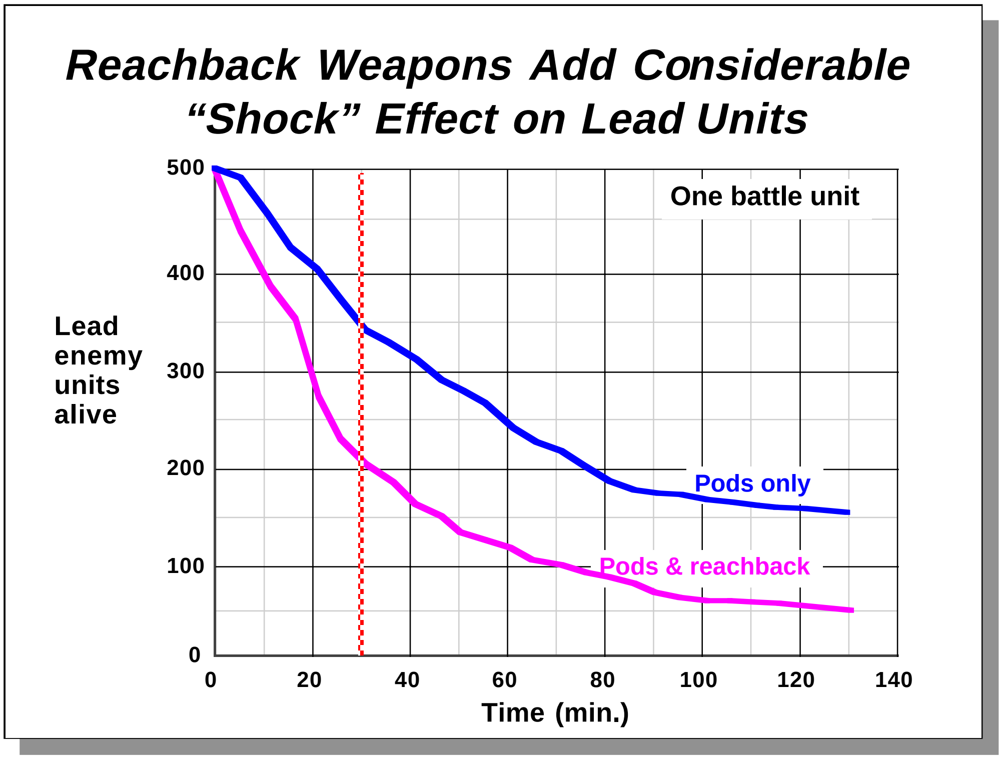
We also examined the effect on system survivability of immediate firing when targets were detected rather than waiting for an ambush.



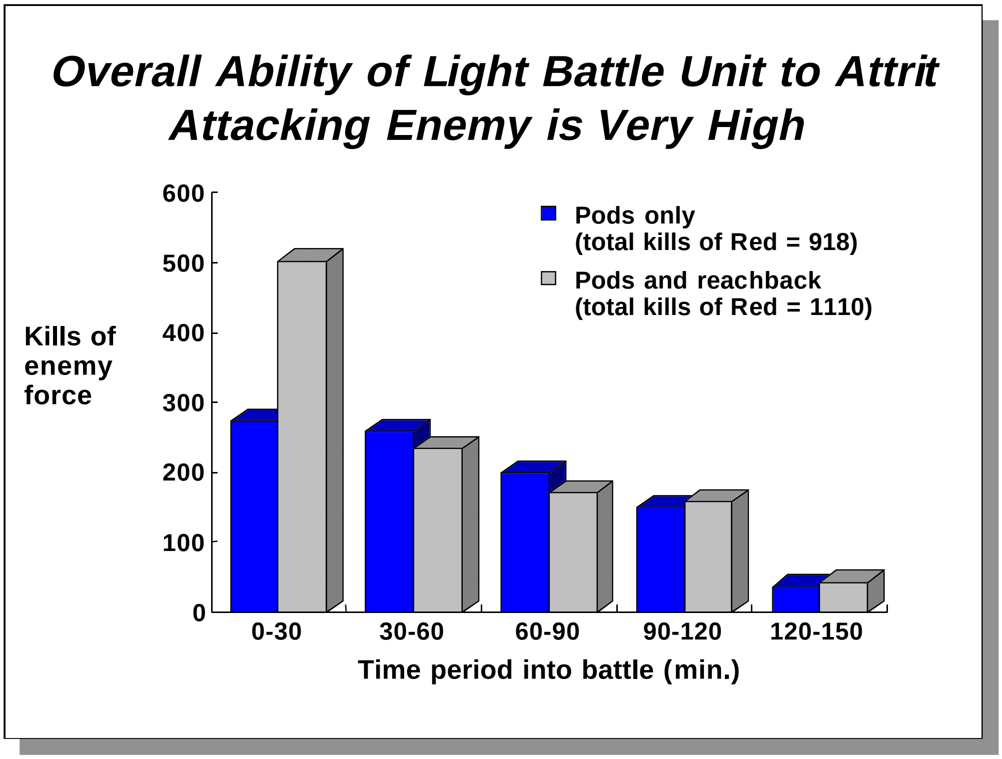
Signature management of the pods was found to be a critical aspect of pod survivability. When they were placed in the open without camouflage, even though deployed in tactically advantageous positions, virtually all pods were found and killed, mostly by the overflying helicopters. Digging the pods in or hiding them in terrain folds (defilade) did not reduce the number detected, but it did strongly reduce the number killed. This unexpected outcome is due to the large number of Red systems (1,500) that will spot each pod at much shorter ranges and, as a result, will have reduced opportunities for effective shots as they move past the systems in defilade compared to when they are in the open. As modeled, defilade and camouflage were still not sufficient to hide from all of the advanced sensors of the attacking force; however, they did further reduce the enemy's weapon effectiveness, since the numbers of shot opportunities go down, as do the probabilities of hit and kill. Defilade and LO, finally, make the systems both hard to see and hard to kill from even relatively short ranges.



We next re-examined the case where the weapon pods were in defilade and camouflage. As shown before, in the quiescent or ambush mode, most were detected and about 25 percent were killed. However, as the battle unit's weapons were activated, some added survivability could be gained, essentially "buying survivability through fires." When pods alone were allowed to fire, the number of pods lost was halved; when both pods and reachback weapons were used, even fewer pods were lost. These increases in survivability were due to earlier kills of systems that would have otherwise seen and destroyed the pods.



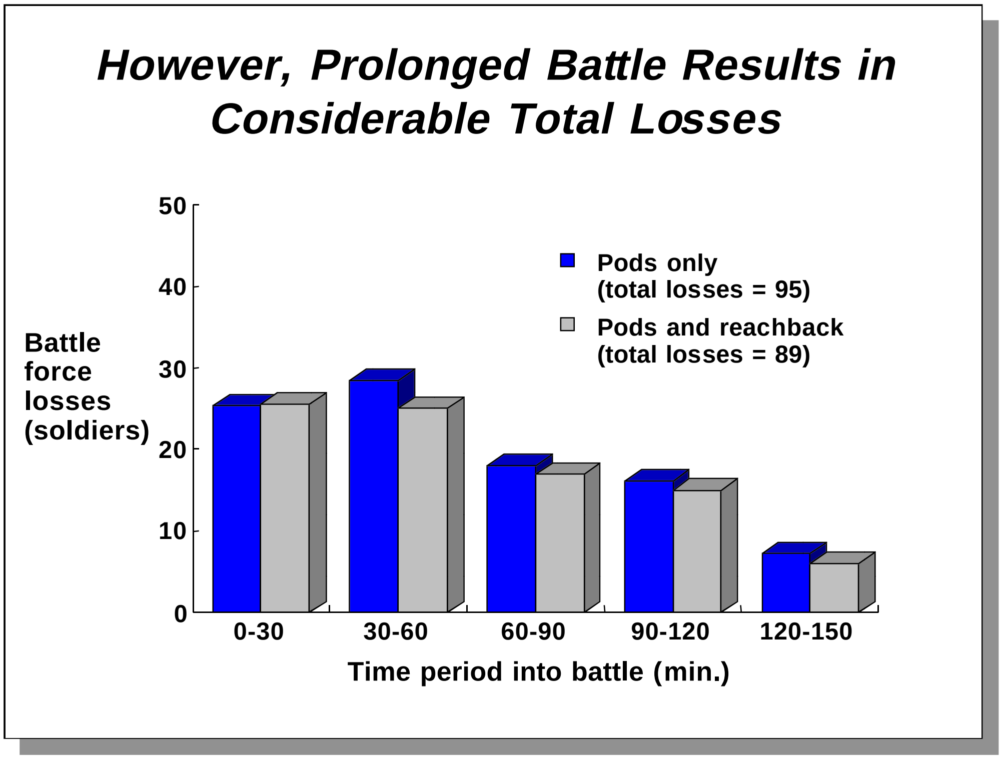
In ideal conditions, the application of one battle unit with its organic firepower, including the anti-armor artillery, advanced EFOG-M, and air defense pods, is able to attrit a large percentage of the lead enemy units. The addition of the reachback weapons, in this case U.S. Army long-range fires (could also include USAF or Navy air support), improved on overall force performance in total number of kills. However, the most notable reachback contribution was in kills with respect to time. Specifically, in the first 30 minutes the kills of the lead vehicles went from 150 to almost 300, nearly doubling force lethality. If enough compression of kills occurs (kills within a small period of time), one can argue that a "shock" effect can be created; this shock effect can temporarily disrupt or even stop the attack. If followed up or exploited by a subsequent attack, perhaps a limited direct fire engagement by a maneuvering unit (such as an air-mechanized battle unit or a Force XXI unit), even greater levels of damage can be attained. However, since the light battle unit cannot maneuver, it cannot itself exploit these key opportunities.



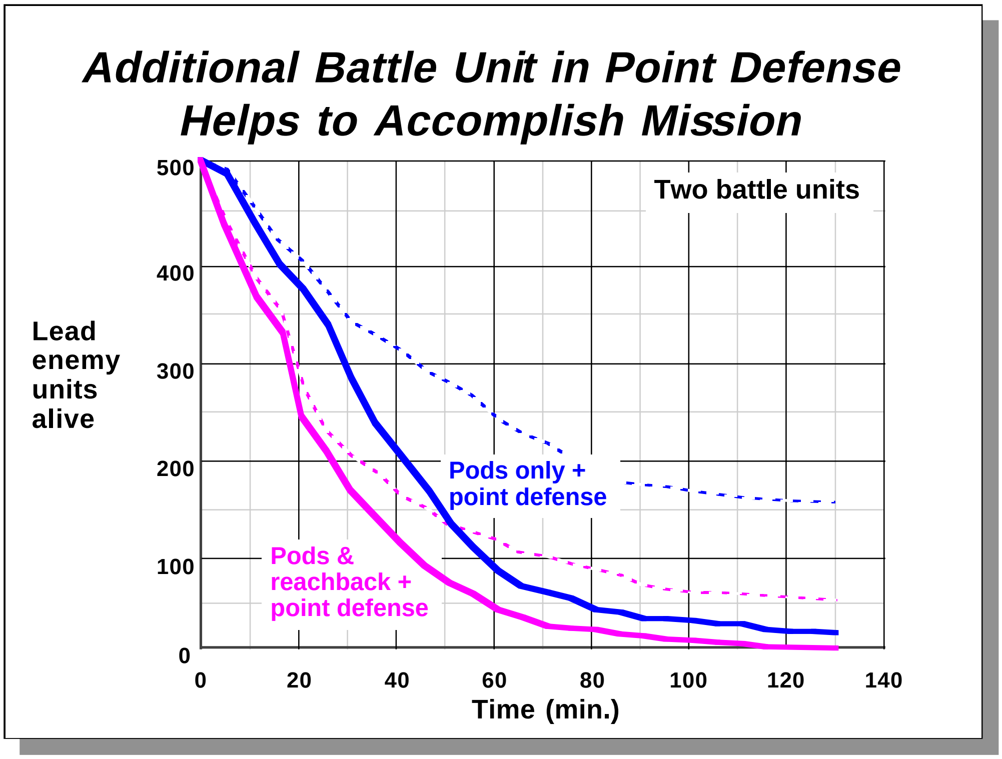
Examining the larger set of data from the entire force, we divided the duration of the battle into 30-minute segments. When no reachback weapons are present and the units rely on anti-armor artillery, advanced EFOG-M, and air defense pods to ambush the enemy, the attrition is very orderly. About 50 percent of the 1,500-plus Red units have been killed by 90 minutes into the battle, and the attacking force would likely go to ground.

With ATACMS in the force as the reachback weapon augmenting the pod weapons, the outcome is decided much earlier. Approximately one-third of the enemy systems are killed, many of them across the border, in the first 30 minutes, which may be enough of a shock to stall the attack. About 50 percent are killed by 60 minutes and about 65 percent by 90 minutes.

In both cases, it is evident that given time (since both reachback and the organic pods consist of precision-guided weapons) the ability of this force to attrit an attacking force is quite formidable. However, many of the urban areas are only 10–15 km from the border and may become occupied and provide sanctuary to the attacking force.

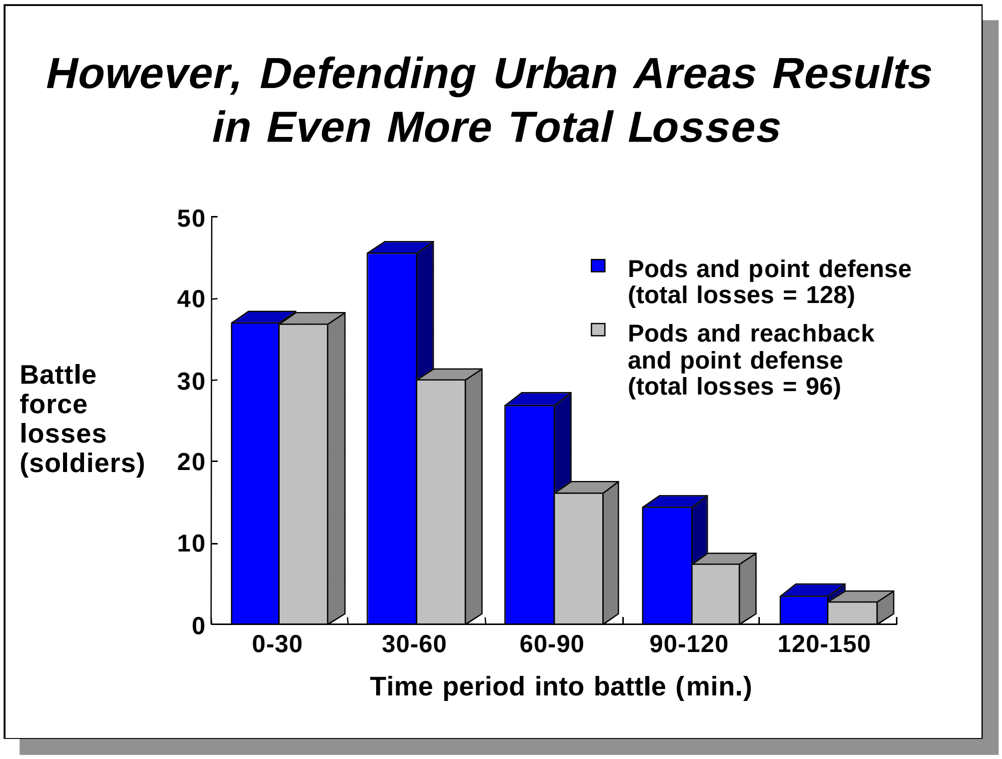


Considering the other perspective, however, it becomes clear that the battle unit's success can come at some significant cost, particularly if the battle lasts longer. As we note from our simulation, if the battle is allowed to continue to completion, e.g., the enemy advances until dead without regard to losses (the full 150 minutes), over one-third of the battle unit can be attrited. Most of the battle unit's losses were the result of receiving direct fire from the attacking Red air and ground units. Since most of the soldiers were deliberately positioned to find enemy vehicles and target weapons, they had some level of line-of-sight to the attacking force. Even though they were in defilade, the soldiers were still vulnerable to Red attacking systems. It is interesting to note that the use of reachback weapons did not appreciably alter the survivability outcome in this case.



As effective as the unit was, there was no guarantee that one battle unit with reachback weapons would succeed entirely with its mission to halt the attacking force, for two key reasons. First, it is unclear how much attrition will be required to repel an attacking force in the future (e.g., at what point does the attacking force stop?). Second, after advancing as little as 10 to 15 km, the enemy force has the option of seeking refuge in the many urban areas instead of continuing the attack. As good as reachback weapons were at producing kills, they could not prevent enemy movement over terrain. For these reasons, we deemed that a single battle unit primarily employing indirect fires was not sufficient to ensure mission success, even with the other ideal scenario conditions assumed.

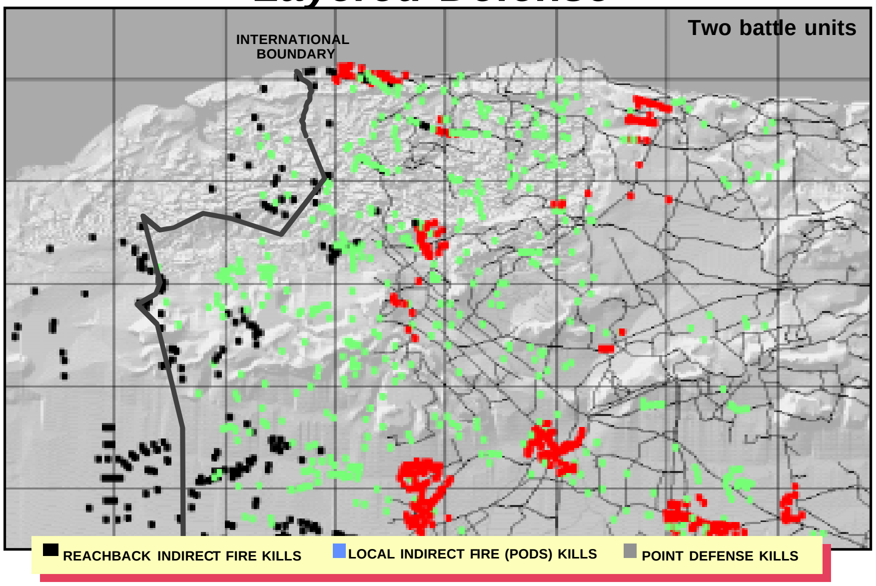
Thus, we employed an additional battle unit, heavily armed with direct fire weapons, around the urban areas. The effects of this “point defense” capability were quite compelling, as shown by the above figure. In the case where direct fire was added, both previously shown curves almost reach the full attrition level. That is, with or without reachback, nearly all the lead elements of the attacking force were destroyed. Also, because of the unit in point defense, the urban areas were not penetrated.



However, as successful as the two battle units were in accomplishing their mission, protecting the urban areas resulted in higher overall losses for Blue. If the battle is allowed to continue to completion (the full 150 minutes), well over one-third of a battle unit is lost. Although the loss-exchange ratio for Blue is less favorable, the mission is now successful with the additional battle unit in point defense. The primary reason for this is the battle unit losses associated with protecting the urban areas. That is, unlike employing weapons from afar (reachback), which alone fails to accomplish the objective and incurs less contact with the enemy, employing weapons in a point defense with the additional battle unit results in more contact but also more losses.

This suggests that if producing attrition with minimal losses is the only objective, reachback and organic indirect fire pods might be a possible solution. However, if the objective includes defending or controlling terrain, then a combination of direct and indirect fire weapons appears to be required.

Light Units Achieve Mission Through Layered Defense



Examining where the attrition occurred for the three classes of weapon systems present in the AAN light battle units—reachback, organic pods, and close-range direct fire systems—we see that each contributes differently to the battle. The black dots above show reachback kills. These are primarily early in the battle, when the enemy systems are massed and at range. Some of the targeting is even done against rear echelons across the international boundary. Many more kills in total are achieved by the three types of pods. All these kills are shown in blue, and they span the entire defended zone. Close-range direct fire kills shown in red, finally, concentrate around the urban areas, and these kills represent the last but perhaps the most critical line of defense.

Preliminary Insights from the Light Battle Unit Analysis

- **All weapons played role in defense**
  - **Indirect fires were essential but alone did not achieve decisive attrition in either time or space**
  - **Reachback systems offered most benefit from LER perspective, but had least contribution to mission**
  - **Direct fire provided final defense but with losses**
- **Stationary posture (no maneuver) was limiting factor**
  - **Minimal presence of soldiers still resulted in moderate number of losses**
  - **Created shock effect but without exploitation--devolved to basic attrition**

Initial insights coming out of this year’s work centered on two themes: weapons effectiveness and battle unit posture.

First, all weapons associated with the light battle units (reachback, organic indirect fire pods, and direct fire weapons) played a role in the defensive mission. However, there were some notable limitations seen from the analysis. Indirect fire weapons (because of their long cycle times), were not able to achieve decisive attrition over either time or space on the battlefield. For example, reachback systems employed *en masse* could kill a substantial portion of an enemy force with little or no losses to Blue; however, this kind of attrition is more opportunistic and less systematic than that needed to actually halt or repel an attacking force. Direct fire weapons, on the other hand, provided short enough cycle times to systematically respond to the changing presented threat, but sometimes exposed soldiers to enemy fire. However, this aspect was seen as essential for controlling the time and location of attrition.

Second, the light battle units were limited by their lack of maneuver capability. They were not able to reposition out of harm’s way from the large attacking force. Nor were they capable of exploiting the effects of the simultaneous and highly effective indirect fire attacks which, in theory, could have led to a disintegration of the enemy force. Although it was deemed unlikely that an air-mechanized battle force could arrive in time, it is envisioned to consist of agile vehicles for executing maneuver operations.

Outline

- Methodology
- Light battle force
- Scenario
- Initial findings

→Future work

The last section describes where we plan to go from here.

Future Research

- **Explore light battle force in other conditions**
- **Shift focus to include air-mechanized battle force**
- **Emphasize integration of battle force concepts**
  - **Define spectrum of technology options and operational concepts**
  - **Identify key scenario considerations**
    - **Feasibility across environments (e.g., terrain)**
    - **Sensitivity to threat (e.g., size, sophistication)**
    - **Mission excursions (e.g., OOTW)**
- **Coordinate research with upcoming wargames and exercises**

As for future research, we plan to continue our examination of the light battle force. Most of the research to date has concentrated on performance of the battle force in near-ideal circumstances. Future work will now ask the question: "What can go wrong, and what will its impact be?" For example, we plan to address issues that explore the effects of enemy countermeasures and the impact of a large enemy dismounted force. We are also planning to shift our focus to help the AAN community assess the effectiveness of the air-mechanized battle force. To date, there have been several analyses examining the performance of an air-mechanized battle force. We hope to leverage these and perform detailed force-on-force combat analyses to further quantify the effects of such a force.

Research Issues

- **To what extent can survivability be achieved through mobility, agility, signature management & control, active protection, lightweight armor, comprehensive situational understanding, terrain masking, deception and indirect fires?**
- **What are critical components and performance attributes of the air-mechanization concept and mobility?**
- **What are appropriate combinations of sensors and weapons for adequate lethality?**

This chart lists research issues we hope to address in the upcoming year. First, to what extent can survivability be achieved through alternatives to armor (e.g., mobility, agility, signature management and control, active protection, lightweight armor, comprehensive situational understanding, terrain masking, deception, and indirect fires)? Some of these will be explicitly modeled; others will be treated parametrically. Second, what are the critical components of the air-mechanization concept and fast ground mobility? Finally, what are appropriate combinations of sensors and weapons?

While we do not expect to fully resolve the aforementioned issues, we will provide analysis to the AAN community, which should in turn provide insights into these and other issues.

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