DOCUMENTED BRIEFING

RAND

Rapid Force Projection

Exploring New Technology Concepts for Light Airborne Forces

Randall Steeb, John Matsumura, Terrell Covington, Thomas Herbert, Scot Eisenhard

Arroyo Center
National Defense Research Institute

The research described in this report was conducted within two RAND federally funded research and development centers: The Arroyo Center sponsored by the United States Army, Contract DASW01-96-C-0004 and the National Defense Research Institute, sponsored by the Office of the Secretary of Defense, the Joint Staff, and the defense agencies, Contract DASW01-95-C-0059.

ISBN: 0-8330-2428-0

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Published 1996 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1333 H St., N.W., Washington, D.C. 20005-4792
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Prepared for the
United States Army
Office of the Secretary of Defense

Arroyo Center
National Defense Research Institute

Approved for public release; distribution unlimited

PREFACE

This annotated briefing summarizes early RAND work that supports the Rapid Force Projection Initiative (RFPI) Advanced Concept Technology Demonstration (ACTD). The RFPI explores new technologies and concepts of operations for improving light force early-entry capability; the ACTD is designed to provide a means for user trial and evaluation of these technologies and concepts. RAND has been involved in RFPI from its outset and continues to provide analytic support for the initiative in a number of ways, most recently providing early force-on-force combat effectiveness analyses through high-resolution constructive simulation. Already influential in the early decisionmaking process, RAND's work continues to evolve as the research provides new insights and raises new questions.

RAND's RFPT (Rapid Force Projection Technologies) project is jointly sponsored by the Office of the Secretary of the Army for Research, Development, and Acquisition and the Office of the Under Secretary of Defense for Acquisition and Technology. The project research was jointly managed by the Acquisition and Technology Policy Center of RAND's National Defense Research Institute (NDRI) and the Force Development and Technology Program of RAND's Arroyo Center (AC). NDRI and AC are federally funded research and development centers sponsored respectively by the Office of the Secretary of Defense, the Joint Staff, and the defense agencies, and by the United States Army. This research should be of interest to Department of Defense (DoD) decisionmakers, technologists, and operations research analysts.

For a more detailed analysis of RFPI indirect fire weapons, refer to RAND DB-169-A/OSD, *Rapid Force Projection Technologies: A Quick-Look Analysis of Light Indirect Fire Systems*, R. Steeb, J. Matsumura, et al., 1996.

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SUMMARY

The days of U.S. military forces defending a predetermined terrain with a large, prepositioned force appear to be drawing to a close. In the future, as in the recent past, the U.S. Army will need to deploy to areas of potential or actual conflict. Furthermore, because response time is often critical in overseas operations, the United States must have land forces that can deploy quickly and decisively, both by air and sea. This study concentrates on the airliftable portion of these forces in the early-entry role. In this role, light airborne forces may encounter heavy enemy forces in terrain suitable for tank maneuvers. Such situations pose a grave challenge for U.S. light forces as they are currently configured. As part of the Rapid Force Projection Initiative (RFPI), we examined new "technology concepts" that potentially allow light forces to fight and survive against such heavy forces.

DEFINITION OF TECHNOLOGY CONCEPT

A "technology concept," as defined in this work, is a concept of operation made possible by emerging technologies. Ultimately, many different concepts exist for improving light force capability. One fundamental concept of operation examined in this work is the hunter/standoff killer (HSOK). This concept involves separating the target engagement cycle normally associated with direct fire systems, such as a light tank, into two distinct components. Whereas a light tank, for example, performs its own target acquisition and weapons employment—which in turn makes it immediately susceptible to return fire because of its direct line-of-sight exposure and firing signature—the HSOK concept envisions a distinct "hunter" component for target acquisition and a distinct "standoff killer" for laying the weapons. Essentially, the hunter finds the targets and passes information to the killers. *By breaking the engagement cycle into two components, the benefits of indirect, precision-fire battle can be introduced. The standoff killer can be positioned in relatively safe, nonexposed locations on the battlefield, and the hunters can perform "silent" target acquisition without giving off firing signatures.*

Emerging technologies play a critical role in enabling the HSOK concept. Notionally, the key to success for the hunter is to be able to acquire targets without being acquired itself. To accomplish this, hunters can take advantage of evolving technologies including better long-range sensors,

e.g., second-generation forward-looking infrared systems (FLIRs) that allow a hunter to see at ranges before it can be seen; acoustic sensors that can be hidden from the enemy in non-LOS (line-of-sight) locations; and LO (low observable) technologies that can reduce a hunter's signature.

In conjunction with the new technologies, an effective standoff killer must be able to destroy the target passed from the hunter without the benefit of having LOS and often from much greater distances than direct fire killers. Small sensors for submunitions, fiber optics, automated target recognition methods, and sensor-fusion and processor technologies allow standoff killers to be effective at long range without LOS. Also, the means by which the hunters communicate to the standoff killers, the command and control (C2) method, is critical to the success of the HSOK concept.

SCENARIOS USED FOR THE ANALYSIS

To study the impact of new technology concepts on light forces, we assembled two very stressing scenarios (one in Southwest Asia, the other in East Europe) where notional U.S. light airborne forces were placed against heavy forces. In many ways, the two scenarios were similar. In both cases, the light forces represented the first insertion of a larger operation; they were required to defend a critical objective that mandated that they hold a geographic position on the battlefield; and they faced an enemy force much larger than themselves (a U.S. light airborne brigade against a heavy enemy division[1]).

In one key way, however, the two scenarios were different. The terrain in Southwest Asia is relatively flat, providing very long lines of sight. The terrain in East Europe is relatively hilly, providing fairly short lines of sight. *Going into the analysis, we postulated that terrain would be a major factor governing the success of new technology concepts, particularly those associated with the HSOK concept.*

SIMULATION TOOLS

A locally distributed simulation environment was used to assess the combat effectiveness of different technology concepts. This simulation environment is constantly evolving; at the time of this research it included the following components: the RAND version of the U.S. Army's Janus force-on-force effectiveness simulation, the Cartographic Analysis and Geographic Information System (CAGIS) for processing the digital terrain

[1]Enemy consisting of two armor regiments and one mechanized infantry regiment.

elevation and the feature area data, RAND's Jamming Aircraft and Radar Simulation (RJARS) for simulating air defense interactions, the model to assess damage to armor with munitions (MADAM) for assessing the effectiveness of smart and brilliant munitions, and the RAND Target Acquisition Model (RTAM) for estimating the detectability of ground vehicles in different spectral backgrounds.

Janus provides the scenario context (up to 1200 units per side) and is used to determine the force-on-force combat interactions. The other simulations listed above provide the capability for more-detailed computations than are currently available in the RAND version of Janus.[2] These different simulations are linked together with the Seamless Model Integration (SEMINT) system, a message protocol and simulation networking system developed by RAND (Marti, et al., 1994). A combination of these models was used to assess the different light force technology concepts.

RESEARCH FINDINGS

Our research entailed responding to three key high-level questions focusing on light force capability, particularly against a much larger heavy-armor force.

- How does a current light airborne force perform against existing heavy forces?
- Can a light airborne force be enhanced or reconfigured to repel existing heavy forces?
- What are the vulnerabilities of a light airborne force to a future heavy force?

Our simulation environment was used extensively to help answer each of these questions in the two different scenarios (Southwest Asia and East Europe) with dramatically different terrain. Our research focused on assessing the military utility of different technology concepts for a light airborne force through constructive simulation environment; we did not examine the feasibility or costs associated with these technology concepts. The above research questions are answered in the following subsections.

[2]Relative to the level of fidelity needed for our analysis.

How Does a Current Light Airborne Force Perform Against a Heavy Force?

Our analysis showed that a U.S. light airborne force, similar in composition and size to the current 82d Division Ready Brigade (DRB) in a defensive posture, can achieve a respectable loss-exchange ratio (LER) against a heavy enemy force consisting largely of already-proliferated Soviet equipment[3] employing Soviet-style tactics; however, *because of the close proximity of the main battle, the DRB could not sustain its defense and was ultimately overrun.*

Within our scenario, the DRB was positioned in a 270-degree defensive position, employing direct fire weapons to engage the encroaching enemy force. Although the DRB was equipped with existing indirect fire assets such as towed artillery cannons, the effectiveness of the existing munitions, including high explosive (HE) and dual-purpose improved conventional munitions (DPICM) rounds against armor was minimal. Thus, the DRB force had to rely extensively on its organic direct fire weapons including Apache attack helicopters, Sheridan light tanks, Dragon shoulder-fired missiles, and tube-launched, optically tracked, wire-guided missiles (TOW II) mounted on high-mobility multipurpose wheeled vehicles (HMMWVs) to destroy the threat force. See Figure S.1 for one possible breakdown of a DRB force organization.

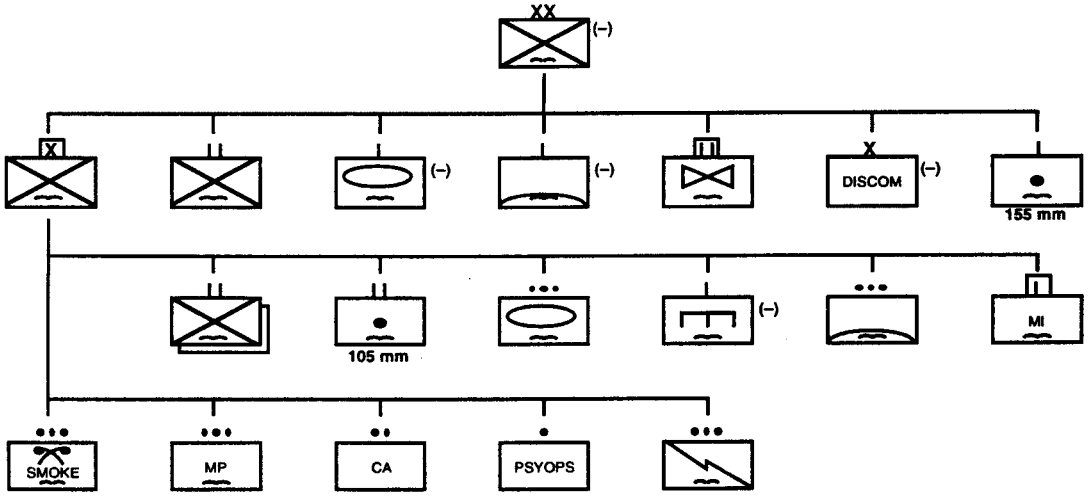


Figure S.1—One Possible Organization of a Division Ready Brigade

[3]Enemy forces were equipped with T-72 tanks, BMP-2 and BTR-60 personnel and equipment carriers, BM-21 multiple rocket launchers, 2S3 self-propelled howitzers, and a mix of Havoc and Hind helicopters.

In the Southwest Asia scenario, with its long lines of sight, our simulation showed that the DRB was able to start attacking the enemy force before being engaged itself. This is primarily due to the long-range sensor superiority of the DRB's direct fire systems. However, because the enemy approached en masse, with a considerable force size advantage, it was only a matter of time before the enemy closed and overwhelmed the DRB. Near the end of the simulated battle, the LER ranged between 4 (during the direct fire battle, in which the DRB was killing four enemy systems for every one of its own systems lost) and 3 at the breach of the defense.

In the East Europe scenario, with its much shorter lines of sight, the DRB was at a greater disadvantage than in the Southwest Asia scenario. Although the DRB possessed superior sensors—and, thus, range—on its direct fire weapons, the close terrain afforded fewer opportunities to attack and engage the approaching threat force at range. In this scenario, the LER ranged from about 3 (during the battle) to 2.5 at the time of the enemy breach of the DRB defense.

In both scenarios, a much higher LER was deemed necessary to achieve success because of the disparity in the initial DRB-to-enemy-force ratio.[4]

Can a Light Airborne Force Be Enhanced to Repel Existing Heavy Forces?

To improve the DRB performance described above, we considered three different "core" enhancements: (1) improve the direct fire battle, (2) add the HSOK concept (introducing a greater emphasis on the non-LOS battle), and (3) add faster C2 to the HSOK (thus, allowing the hunters and standoff killers to better emulate a direct fire system). Each of the three enhancements involved adding different combinations of RFPI candidate systems. Because we imposed a constant airlift constraint in this study, DRB systems had to be swapped out for any new systems added. Even though no additional lift requirements were imposed, *our analysis showed that the DRB with core RFPI enhancements was able to repel an existing enemy heavy force.*

Improving the Direct Fire Battle. At the time of this research the U.S. Army was already undertaking efforts to improve the lethality of its light forces by developing a new light tank, the Armored Gun System (AGS),

[4]This conclusion is based in part on a subjective assessment of how the respective DRB and enemy commanders would react to force attrition and numbers of combat elements. The DRB is outnumbered about 4 to 1 at the beginning of the battle, only if one assumes a very generous counting scheme (e.g., both a Dragon and a T-72 count as one entity).

and by developing a new, longer-range shoulder-fired antitank missile, the Javelin. When we substituted these weapons for the Sheridan and the Dragon, respectively, in the DRB, our simulation showed some improvement in force effectiveness between the two scenarios. In the Southwest Asia scenario, the LER improved from 4 to about 7; however, in the East Europe scenario, the LER went from 3 to 5. Most of this improvement was driven by the Javelin, largely a result of the limited number of AGS included in the DRB.

Adding a Hunter/Standoff Killer and Fast Command and Control. As a next step for improvement to the DRB, in addition to the AGS and Javelin enhancements, we swapped-in hunter scout vehicles[5] and enhanced fiber-optic-guided missile (EFOG-M) systems for HMMWV-TOWs. The introduction of this "core" HSOK combination provided different effects in the two scenarios. For Southwest Asia, dramatic improvement was seen, with an LER of 11.5. The open terrain allowed for very long-range detections by the hunters and relatively long-range attrition was achievable with the use of the EFOG-M. Additionally, the enemy elements that survived the longer-range HSOK attack were "metered in" at rates that allowed the direct fire weapons to attack without being saturated and overwhelmed. In East Europe, however, the LER increase to 6.5 was less remarkable. Close terrain did not allow for as many long-range detections by the hunter vehicles. Furthermore, the close terrain made the hunters vulnerable to "surprise" and "blind side" encounters with the approaching threat force.

A Faster Command and Control Link Between the Hunter and the EFOG-M. By halving the time for C2 between the hunter and EFOG-M, the HSOK concept can better emulate a direct fire weapon. That is, the faster the indirect fire weapon is put over target, the smaller the uncertainty resulting from target movement. As was expected, where the hunter vehicle and EFOG-M combination was effective (Southwest Asia), a fast C2 link further improved the LER (up to 14). Likewise, where the hunter and the EFOG-M offered less improvement to the DRB (East Europe), a fast C2 link only marginally improved the LER (up to 7.5).

Additional RFPI systems. In both cases above, "core" enhancements appeared sufficient to repel a heavy force. Nonetheless, we also examined the contribution of other existing and notional systems to the DRB. These systems included Remote Sentry (a hand-emplaced and remotely operated FLIR), unmanned aerial vehicles, the line-of-sight antitank (LOSAT)

[5]The hunter vehicle is a modified HMMWV with some signature reduction and a mast-mounted sensor suite (providing a means for the base vehicle to stay out of LOS).

kinetic energy missile, wide area munitions (WAMs), the precision guided mortar munition (PGMM), and the high-mobility artillery rocket system (HIMARS). With the same airlift constraints as before, these systems were added individually and then collectively to the DRB. Individually, these systems provided incremental improvements to the DRB. Most notable was the addition of the WAM to the force (in part because its relatively light weight enabled it to be added to the DRB without sacrificing other systems). Collectively, these systems improved the LER in both scenarios to the extent that an enemy commander would be compelled to call off an attack early in battle. See Figure S.2 for a summary of DRB performance, with and without the various enhancements.

What Are the Vulnerabilities to a Future Heavy Force?

The DRB discussed above clearly loses its advantage against a *future* heavy force equipped with modern Soviet systems.[6] This future enemy force (as we have defined it) with longer-range sensors and weapons can

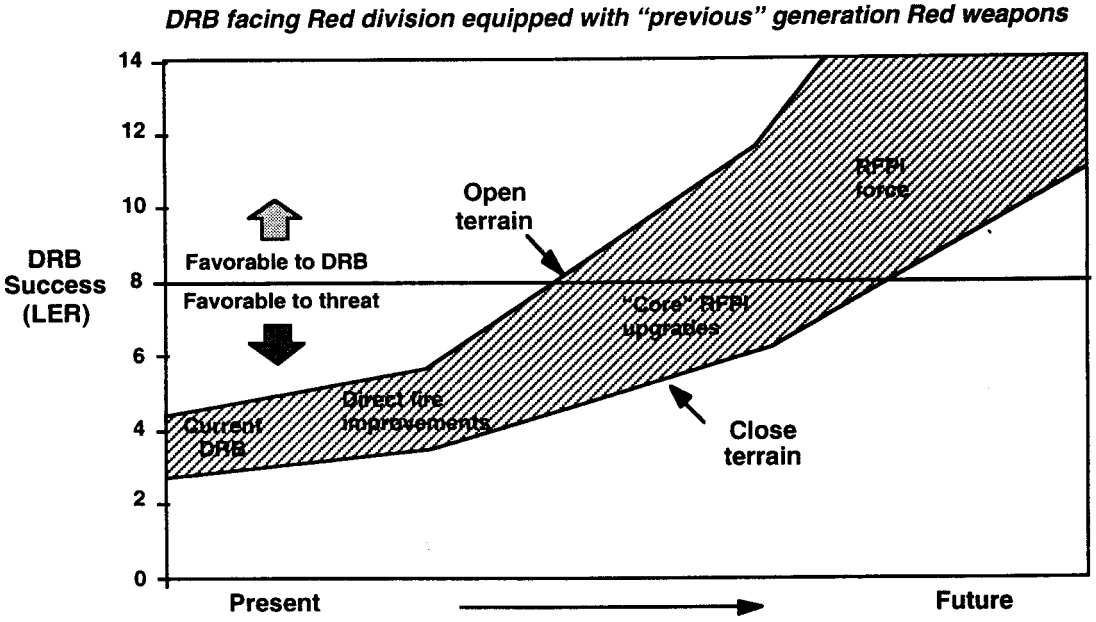


Figure S.2—Improvement of DRB Against Existing Enemy Division with Different Force Enhancement Options

[6]Most vehicles equipped with FLIRs; platforms include T-80+ heavy tanks, BMP-X armored personnel carriers, AT-8 antitank missile (long-range 5-kilometer missile), MCS-E1 smart artillery munitions, and 2S6 air defense units.

rival the DRB direct fire systems. Our analysis showed that the LER, even in a defensive posture, was between 2 and 1.5 for the respective scenarios. The "core" DRB enhancements discussed above[7] nearly doubled LERs in the two scenarios, but this improvement was not enough to repel an attack by a very capable, larger heavy force. Factors that greatly influenced the outcome included (1) enemy use of smart artillery munitions to prepare the battlefield—improving its maneuver success during the attack; and (2) more-capable enemy sensors matched with long-range weapons—enabling it to find the DRB elements much earlier and eliminate them (including hunter scout vehicles).

We also examined the contribution of the additional RFPI systems discussed above against future heavy forces. The use of the combination of these systems in the Southwest Asia scenario more than doubled the LER, bringing it to 12.5. However, in East Europe, where these additional systems were able to make a difference against a current generation threat force, they provided only marginal improvement. In East Europe's close terrain, the forward-positioned reconnaissance, surveillance, and target acquisition (RSTA) elements, including the remote sentries, the UAVs, and the hunter scout vehicles, all tended to be susceptible to early attrition against this future heavy force. Without these elements providing "eyes" on the battlefield, the HSOK concept was less effective, forcing a greater reliance on the higher-attrition direct fire battle. To explore this further, we added a notional distributed sensor net (more than 300 sensors covering all possible axes of enemy advance). With this extensive RSTA, the LER in East Europe terrain improved dramatically.

INTERIM CONCLUSIONS

Our simulation results suggest that a DRB can be improved to fight and survive against a current and future heavy force. The HSOK concept, which is made possible by a number of emerging technologies, proved to be a major contributor to the success of a DRB against a larger, more maneuverable heavy force. The primary reason is that this concept allows for an extension of the battlespace into the non-line-of-sight region. Essentially, the DRB was able to start the fight earlier before becoming vulnerable to the attacking force, and, further, as the remaining heavy forces closed, they were metered-in at a rate that allowed the DRB's direct fire systems to operate without becoming overwhelmed. Examination of the simulation results indicates that the viability of the HSOK is extremely

[7]Enhancements include AGS, Javelin, hunter scout vehicles, EFOG-M launchers and missiles, and fast C2.

dependent on the survivability and success of its "hunters." Further, with limited LOS, these hunters may be challenged by a very capable enemy force.

ACKNOWLEDGMENTS

A number of RAND colleagues and U.S. Army and RFPI analysts contributed extensively to the formulation of this work. At RAND, Gail Halverson, Phyllis Kantar, John Pinder, and Angela Stich contributed simulation definition and programming support (separately documented). Elliot Axelband, John Gibson, and Eiichi Kamiya provided thoughtful reviews of this work.

At U.S. Army Armaments Research, Development, and Engineering Center, Jeff Dyer, Kevin Wong, Steve Pearcy, and Robert Reisman provided information on many systems examined. At U.S. Army Missile Command, Greg Tackett and William McCorkle supplied information on several other systems and provided useful insights on the simulation process. At the Dismounted Battlespace Battle Lab, CAPT Rick Gronemeyer provided some early information on tactics, techniques, and procedures; LTC Daniel Burgoine and COL Arnold Canada provided insightful comments throughout the research process. At the Office of the Assistant Secretary of the Army for Research, Development, and Acquisition, Dr. A. Fenner Milton provided critical guidance and feedback.

The research at RAND was conducted within the NDRI's Aquisition and Technology Policy Center and the Arroyo Center's Force Development and Technology Program under the direction of Dr. Gene Gritton and Dr. Kenneth Horn, respectively.

The authors alone are responsible for the information contained in this work.

GLOSSARY

ABN	Airborne
AC	Arroyo Center
ACTD	Advanced Concept Technology Demonstration
ADA	Air defense artillery
AGS	Armored gun system
APC	Armored personnel carrier
ASP	Acoustic Sensor Program
ATACMS	Army Tactical Missile System
ATD	Advanced technology demonstrator
BAT	Brilliant antitank
BMP	Russian armed personnel carrier
CAGIS	Cartographic Analysis Geographic Information System
C2	Command and control
DIS	Distributed Interactive Simulation
DoD	Department of Defense
DPICM	Dual-purpose improved conventional munition
DRB	Division ready brigade
EFOG-M	Enhanced Fiber-Optic-Guided Missile
EFP	Explosively formed penetrator
EXDRONE	Expendable drone
FLIR	Forward-looking infrared
GPS	Global Positioning System
HE	High explosive
HIMARS	High-Mobility Artillery Rocket System
HMMWV	High-Mobility Multipurpose Wheeled Vehicle
HSOK	Hunter/standoff killer
IMF	Intelligent minefield
IR	Infrared
IREMBASS	Improved remotely monitored battlefield sensor system
Janus	High-fidelity, force-on-force simulation
JSTARS	Joint Surveillance Target Attack Radar System
LER	Loss-exchange ratio
LO	Low observable
LOS	Line of sight

LOSAT	Line-of-Sight Antitank
LW	Lightweight
MADAM	Model to Assess Damage to Armor with Munitions
MICOM	U.S. Army Missile Command, Redstone Arsenal
MLRS	Multiple-launch rocket system
MMW	Millimeter wave
MOE	Measure of effectiveness
MRL	Multiple rocket launcher
NDRI	National Defense Research Institute
PGMM	Precision-guided mortar munition
RF	Rapid force
RFPI	Rapid Force Projection Initiative
RFPT	Rapid Force Projection Technologies
RJARS	RAND's Jamming Aircraft and Radar Simulation
RSTA	Reconnaissance, surveillance, and target acquistion
RTAM	RAND Target Acquistion Model
SADARM	Sense and Destroy Armor
SEMINT	Seamless model integration
SER	System-exchange ratio (kills by a system in an engagement divided by losses to that system)
SINCGARS	Single Channel Ground and Air Radio System
SPH	Self-propelled howitzer
STAFF	Smart target-activated fire and forget
SWA	Southwest Asia
TACAIR	Tactical aircraft
TOC	Tactical operations center
TOW	Tube-Launched, Optically Tracked, Wire-Guided missile
TRADOC	Training and Doctrine Command
TRAC	TRADOC Analysis Center
TTP	Tactics, techniques, and procedures
UAV	Unmanned aerial vehicle
WAM	Wide-Area Munition

RAPID FORCE PROJECTION TECHNOLOGIES:

Exploring New Technology Concepts for Light Airborne Forces

1. INTRODUCTION

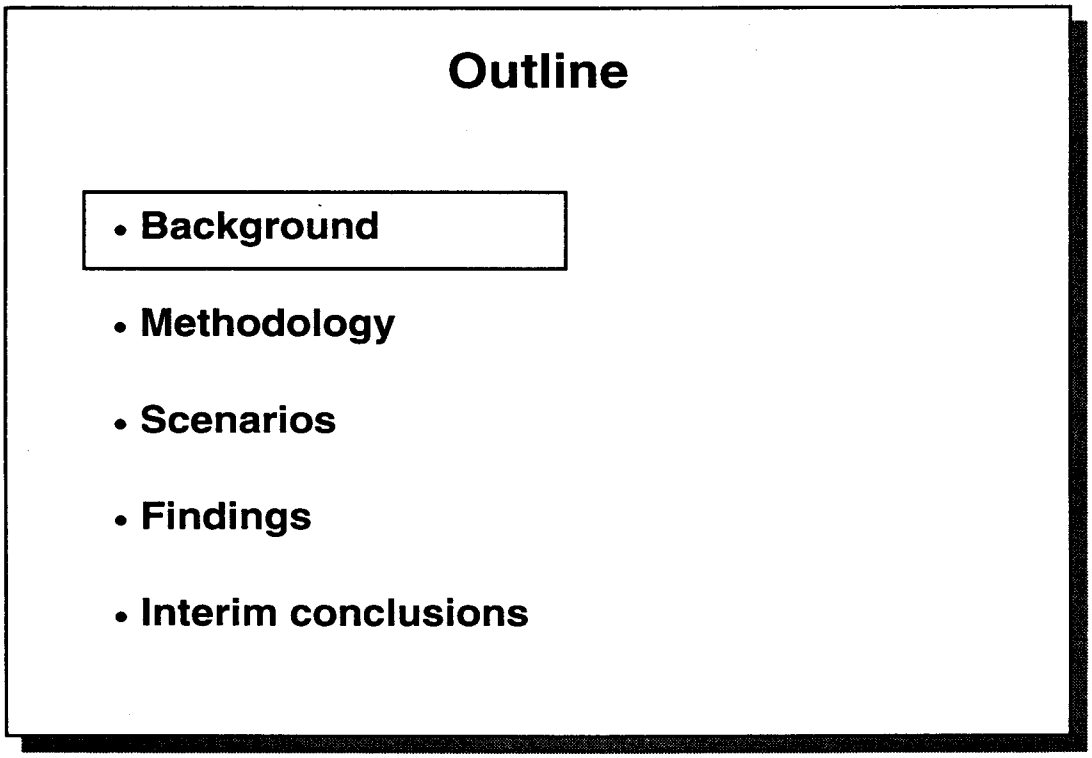
Rapid Force Projection Technologies (RFPT) is an ongoing project at RAND, with the primary charter to explore new technology concepts that can potentially improve U.S. light airborne forces. The research supports the Rapid Force Projection Initiative (RFPI) Advanced Concept Technology Demonstration (ACTD), which is intended to provide light airborne forces with the ability to evaluate advanced concepts and technologies for improving their capability, particularly in the early phase of conflict against a larger, heavy-armor force. The project is jointly sponsored by the Office of the Secretary of the Army for Research, Development, and Acquisition and the Office of the Under Secretary of Defense for Acquisition and Technology. This research is being conducted within the Force Development and Technology Program in the Arroyo Center (Army Research Division) and the Acquisition and Technology Policy Program in the National Defense Research Institute (National Security Research Division) at RAND.

Project Focus

- **Project objective--explore technology concepts that can potentially improve light force capability**
- **Research questions:**
  - **How does a current generation light airborne force perform against a current generation heavy force?**
  - **Can this light airborne forces be enhanced to repel a larger current generation heavy force?**
  - **What are the vulnerabilities of light airborne forces to a *future* heavy force?**

Our fundamental project objective is to assess the military utility of technology concepts for light airborne forces. Implementing this objective has involved identification and specification of concepts, exploration of how different systems might best be used, development of appropriate scenarios for evaluating the systems, assessing their performance, and acting as the Red Team (probing the systems' robustness and susceptibilities to countermeasures) across different conditions and threats.

This part of our research evolved around answering three primary questions: (1) How does a current generation light airborne force perform in a defensive operation against a larger current generation heavy force? (2) Can this light airborne force be enhanced to meet the objective of repelling a larger current generation heavy force attack? and (3) What are the vulnerabilities of light airborne forces to a future heavy force? Before we attempt to answer these questions (in the findings section), we will provide some background on the RFPI, a brief description of the simulation tools and methodology, and a description of the scenarios we used for the analysis.



2. BACKGROUND

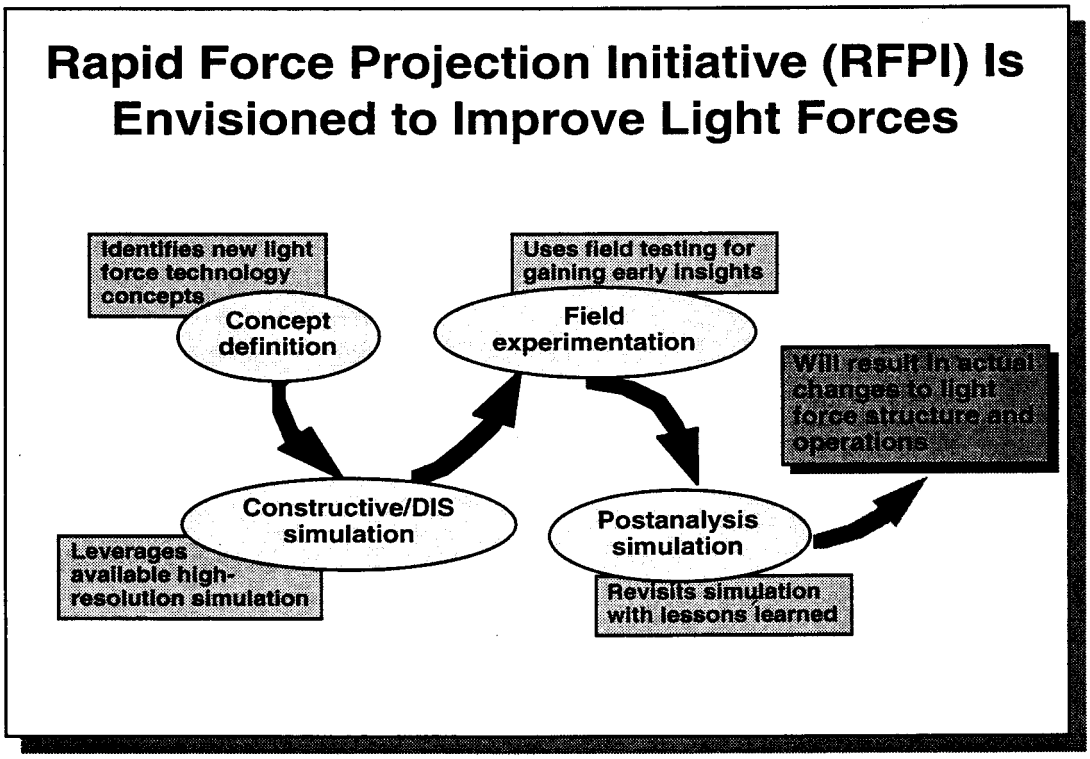
This documented briefing is divided into five sections. In the first section, we provide some background, discuss the main concepts behind the RFPI effort, and list the systems and technologies we are examining in this research effort. The second section describes our methodology for assessing force effectiveness, which is based on integrating multiple simulations and exploring light force options in the context of several different scenarios. The third section describes two different scenarios that we used for analysis. The fourth section summarizes our findings in response to the three main research questions. The final section presents key conclusions that have come out of this work so far.

Capability of Rapid-Projection Forces Is of Increasing Importance

- **Possibility of using light forces to repel a larger heavy force in early phase of conflict still exists**
  - **Large threat uncertainties make it difficult to hedge all contingencies with prepositioned forces**
  - **Limitations on airlift to bring "sufficient" heavy forces into theater can be expected**
- **U.S. Army light airborne force should be improved**
  - **"Shortfalls" still appear to exist in light force survivability and lethality**
  - **Increasing range and volatility of flashpoints can expand light force missions**

The effectiveness of U.S. rapid-projection ground forces is becoming of increasing national concern. This concern is, perhaps, most recently exemplified by the widely acknowledged vulnerability of the early-entry light forces during the Desert Shield buildup. Although the U.S. military is responding to the changing nature and uncertainties of conflict with the introduction of prepositioned forces afloat for heavy units, these options may be limited in their availability and responsiveness to crises around the globe. Even with optimistic projections, enough airlift to bring heavy forces into the theater rapidly is unlikely. Thus, the prospect of using light forces against larger and heavier forces in the early phase of conflict still exists.

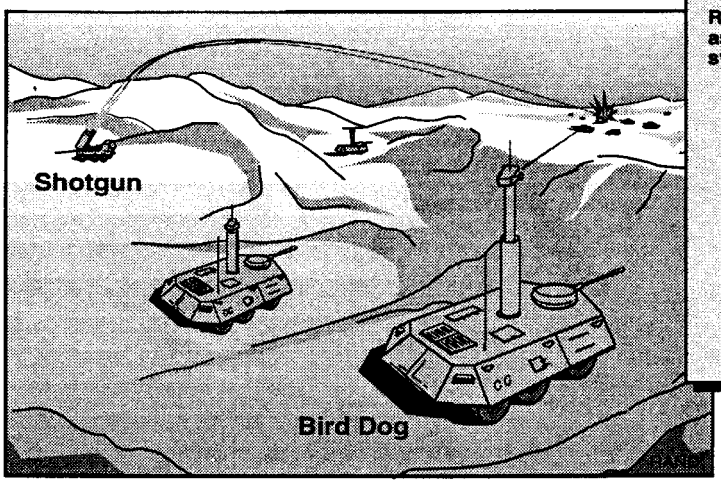
Much of the current discussion on this topic suggests that light forces will need to have much greater survivability and lethality to operate effectively against an increasingly wide range of situations and threats, particularly in conflict against heavy forces.



The Rapid Force Projection Initiative (RFPI) Advanced Concept Technology Demonstration (ACTD) relies on a model-test-model paradigm in which near-term technologies applicable to light forces are identified, modeled, tested, refined, and, in some cases, actually introduced into the force. The overall effort is managed by the U.S. Army Missile Command (MICOM).

RAND is a member of the simulation team led by MICOM and has responsibilities in each of the phases. RAND was instrumental in concept development of many of the new systems, in particular the hunter/standoff killer concept, and continues to refine the system components. RAND is responsible for Janus-based constructive simulation and analysis associated with the RFPI. RAND is also involved or plans to be involved in other parts of the ACTD, including observing field experiments of various advanced technology demonstrators (ATDs), interacting with various users for exploration of tactics, techniques, and procedures (TTPs), and performing a significant portion of the postanalysis constructive simulation.

Early RAND Work Helped Define the Current RFPI ACTD



RAND conceptualized and assessed many early light force system technologies

- Hunter/killer systems
- Distributed sensor nets
- Low-observable scout systems
- Sensor-to-shooter C2 concepts
- Reduced crew platforms
- Battlefield robotics

Depiction of early hunter/killer concept

RAND has a long history of exploration, analysis, and modeling of the types of systems envisioned for RFPI. In fact, early conceptual work on light force options such as "Bird Dog" and "Shotgun" (a hunter/standoff killer design) helped in formulating the initial definition of the RFPI program (see Steeb et al., 1995, for a summary of these results).[1] Other RAND projects, such as Armor/Anti-Armor, Future Conventional Forces, Advanced Concepts for Light Forces, Deep Fires Study, and Military Applications of Robotic Systems, are leveraged for contribution to RFPI.

[1]This document is for government use only and is not available to the public.

RFPT Emphasizes Exploring New Concepts Made Viable by Emerging Technologies

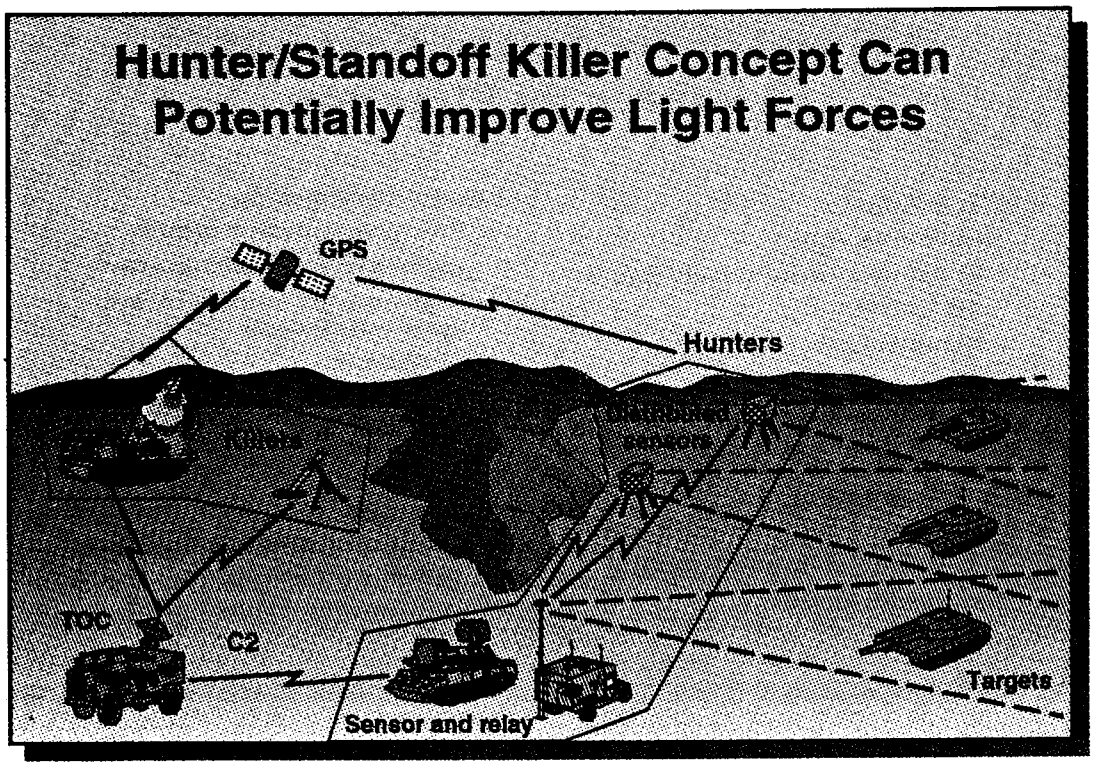
- **Explore different ways to fight**
  - **Improve direct fire capability**
  - **Increase indirect fire contribution with hunter/ standoff killer (HSOK)**
- **Examine contribution of emerging technologies**
  - **Distributed sensor networks**
  - **Agile command and control architectures**
  - **Smart and brilliant indirect fire munitions**
  - **Enhanced weapons platforms**

A "technology concept" as it is defined in this work is a concept of operation made possible by emerging technologies. Ultimately, many different concepts exist for improving light force capability. This research has, so far, explored two major themes.

A natural outgrowth for improving a light force is to improve its direct fire weapons. In this area, new technologies are already playing a role. For example, sensor technologies can be used to increase the range of detection and acquisition; new information processing technologies and automatic target recognition methods can be used to reduce fire cycle times; and weapons technologies can be used to increase range, accuracy, lethality, and rates of fire, to name a few.

Another means for improving a light force is to improve its indirect fire capability, with the hunter/standoff killer (HSOK) concept. That is, instead of focusing on the force's ability to fight "toe-to-toe" in the direct fire battle, shift the focus to the indirect fire battle. The RFPI is largely made up of this HSOK concept, which involves separating the target engagement cycle into two distinct components. That is, a distinct "hunter" detects, acquires, tracks (if needed), and hands off target information to a distinct "killer." The hunter can be placed in relatively inconspicuous spots on the battlefield (performing relatively

"silent" detections without producing highly visible firing signatures), while the killer can be positioned relatively far back and out of LOS (line of sight) to the targets. An entire suite of technologies is emerging that can enable this concept (some of which, listed above, are already envisioned for improving the direct fire capability).



The above rendering shows exemplary components of the HSOK concept. Hunters (manned and unmanned, air or ground, and mobile or stationary) sense the presence, position, and status of enemy systems. They communicate back the intelligence and targeting data to C2 (command and control) nodes, which quickly match targets to weapons on the basis of range, availability, and effectiveness. Killers (ranging from mortars to cannons to missiles) fire different types of munitions at the targets. Battle damage assessment may sometimes be performed by the hunters and possibly by the weapons themselves. GPS (Global Positioning System) technology can be used extensively throughout the force for positioning and navigation.

A Breakdown of Candidate RFPI Systems by Function

RSTA assets
- Hunter vehicle
- Unmanned aerial vehicle (UAV)
- IREMBASS
- Remote sentry

Command and control systems
- RFPI C2

Direct fire weapons
- Javelin
- Armored gun system (AGS)
- AGS with LOSAT

Indirect fire weapons
- Precision-guided mortars
- Lightweight 155mm howitzer
- High-mobility artillery rocket system (HIMARS)
  - SADARM
  - Damocles

Obstacles
- Wide area munitions

Multifunctional
- Enhanced fiber-optic-guided missile (EFOG-M)
- Intelligent minefield (IMF)

RFPI comprises a wide range of manned and unmanned RSTA systems. The hunter vehicle is a HMMWV-based (high mobility multipurpose wheeled vehicle), target acquisition system; it uses an advanced sensor suite on an extendable mast and can be equipped with a reduced signature package. Unmanned aerial vehicles such as EXDRONE (expandable drone) can be enhanced to carry FLIRs (forward-looking infrareds), and video communication links. Both IREMBASS (improved remotely maintained battlefield sensor system) and Remote Sentry are stationary ground sensors.

The RFPI C2 system is a networked set of C2 nodes with automated routing and decisionmaking overseen by human operators; the system primarily relies on SINCGARS (single channel ground and air radio system) links for connectivity.

RFPI also includes a wide range of weapons. Direct fire systems include Javelin, a short-range shoulder-fired antitank guided missile; the AGS (armored gun system), which is a light (18+ tons) tank with a 105-millimeter main gun; and LOSAT (line-of-sight antitank), a variant of AGS in which the main gun turret is replaced by a pod of kinetic energy missiles. Indirect fire weapons include precision guided mortars with a semiactive laser for terminal homing and either an IR (infrared) or MMW (millimeter wave) for autonomous target acquisition; the LW (lightweight) 155-millimeter howitzer with SADARM (sense and destroy armor) submunitions; and HIMARS (high-mobility artillery rocket system), a 14-ton platform carrying a pod of six MLRS rockets with DPICM, SADARM, or Damocles munitions. The wide-area munition is used as an autonomous obstacle, capable of engaging combat vehicles out to the 100-meter range.

The last category of RFPI encompasses the multifunctional systems, which can act both as sensor and weapon. These systems include EFOG-M (enhanced fiber-optic-guided missile), a 15-kilometer-range missile with a GPS antenna/receiver onboard and an imaging sensor in the nose that sends back video along a fiber-optic link. The intelligent minefield is envisioned to leverage acoustic information from WAMs (wide-area munitions) and other acoustic sensors. This information is fused and used to better engage targets both by the minefield and through coordinated attacks with other systems.

Some Other Potential Light Force Upgrade Options

RSTA assets
- Video imaging projectile
- Unmanned ground vehicle
- JSTARS

Command and control systems
- RFPI C2 excursions

Direct fire weapons
- Comanche/Longbow
- STAFF
- Gardian/directed energy

Indirect fire weapons
- Precision MLRS
- ATACMS
- BAT
- Smart 105mm

Multifunctional
- Hydra (obstacle)

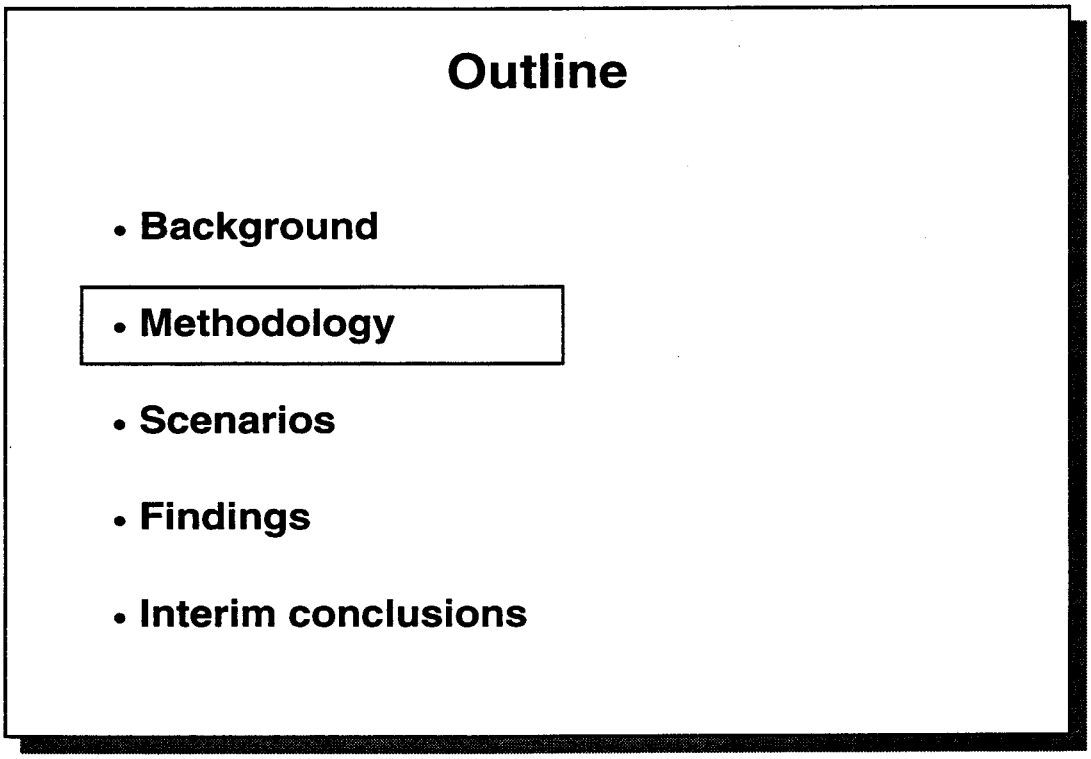
Self-protection
- 3rd generation smoke

The list of RFPI systems changes rapidly with research, development, testing, and analysis of new concepts. This chart lists several other systems which, by our determination, may also be of interest to RFPI.

The video imaging projectile is a 155-millimeter artillery round that ejects a sensor on a parafoil that can be used to presurvey a location before committing an artillery barrage. Unmanned ground vehicles might be used to deploy or reposition ground sensors, mines, or other weapons, with special applicability in high-risk areas. JSTARS (joint surveillance target attack radar system) may be available to the light force for long-range surveillance and targeting. RFPI C2 excursions may include additional networks, decision aids, and automation.

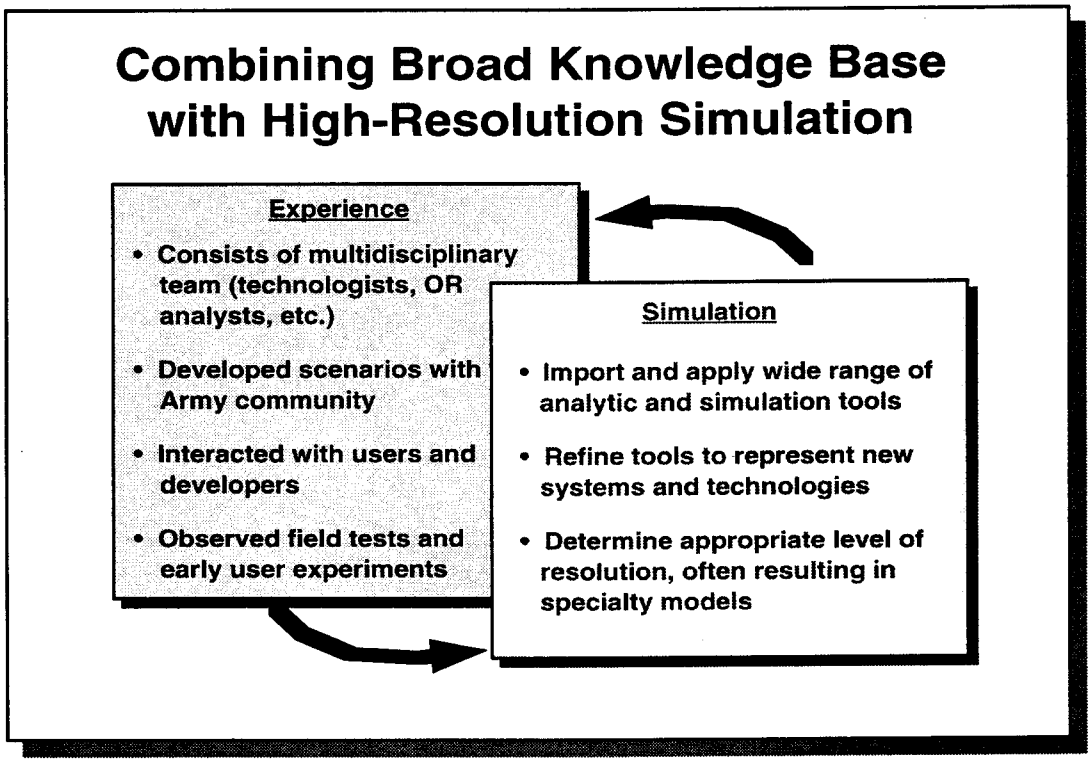
Comanche (or Apache)/Longbow is a long-range MMW radar-guided missile. STAFF (smart target-activated fire and forget) is a medium-range top attack tank-fired smart round. Indirect fire systems such as HIMARS may benefit from use of GPS or inertial guidance for the precision MLRS rocket, addition of long-range ATACMS, and incorporation of BAT (brilliant antitank) in the MLRS rocket or ATACMS. The Smart 105-millimeter submunition is a conceptual system, similar to the infrared terminally guided submunition, with a large footprint and shaped charge lethal effects.

Hydra is an obstacle consisting of a video system bore-sighted to an explosively formed penetrator (EFP) that is connected to and controlled by an operator console through the use of fiber-optic lines. With the video capability, this system can also provide overwatch and detonation of a conventional minefield (e.g., Claymore mines). Lastly, third-generation smoke is an obscuring agent with the reported capability of occluding visible, IR, and MMW signals.



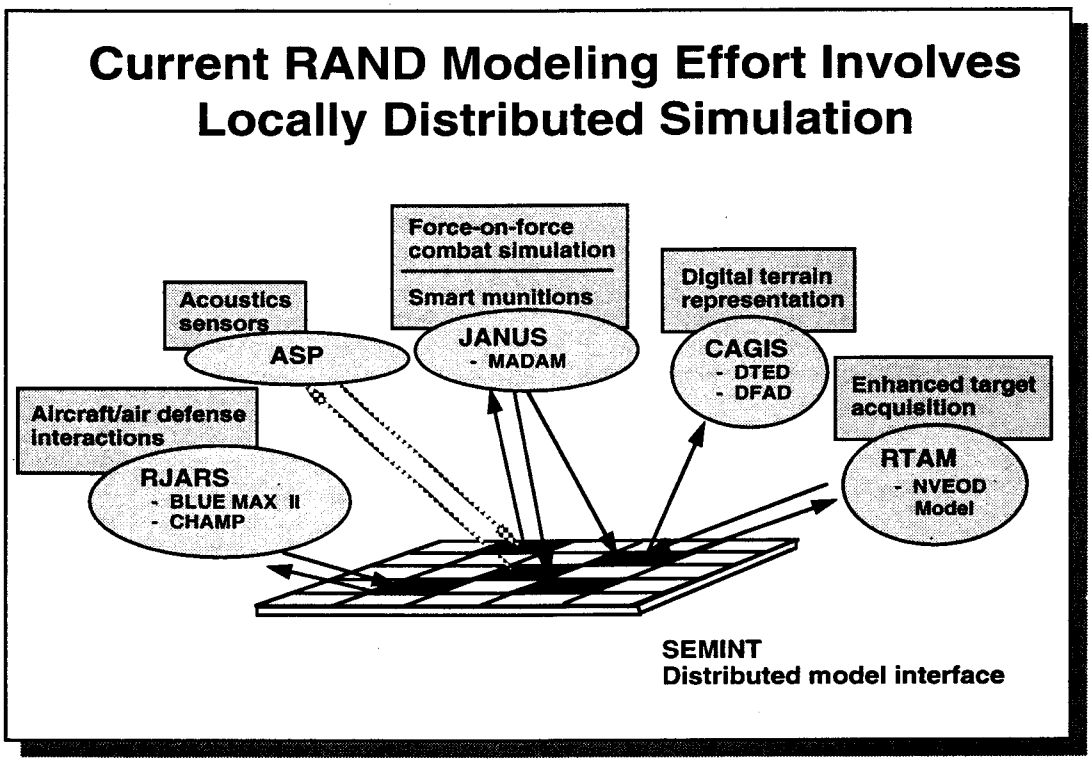
3. METHODOLOGY

This section very briefly describes the approach, the analytic (simulation) tools, and the assessment process we employed in conducting this research.



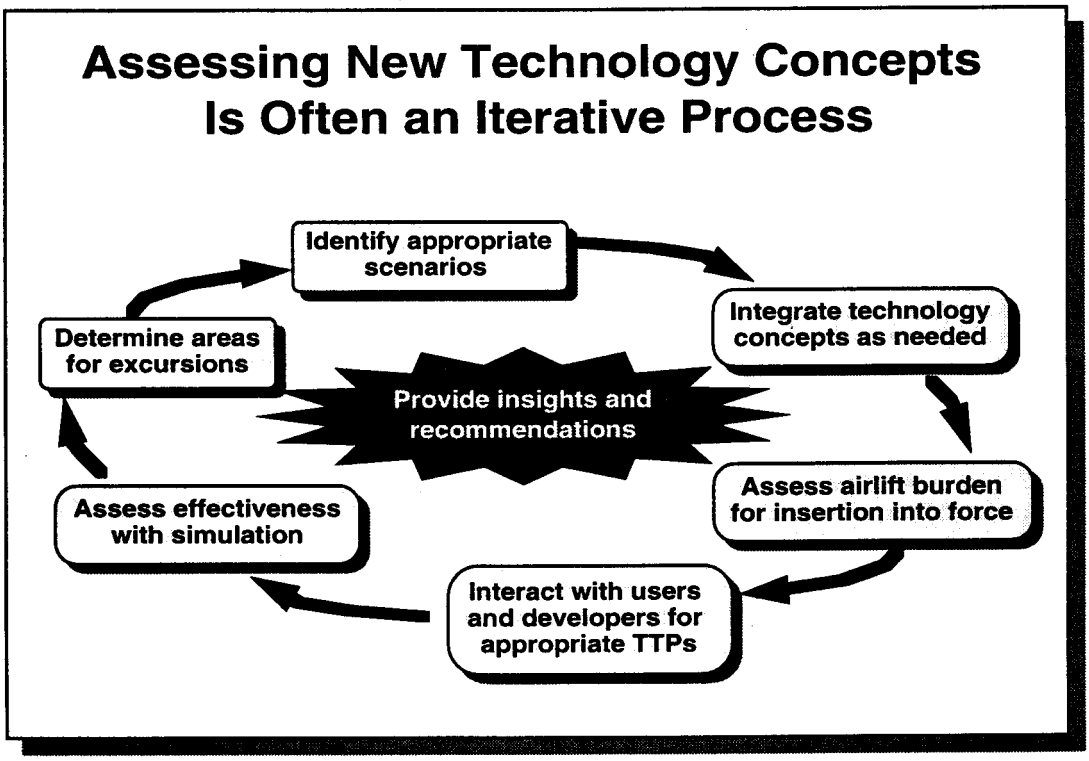
As indicated earlier, one of our primary research tasks was to provide constructive simulation leading up to the RFPI ACTD. This task entailed using our extensive and broad-based simulation environment, which has evolved over many years of development at RAND. Building on its current capability, new concepts and technologies have been added as needed to meet the objectives of this research.

Perhaps equally important, we relied heavily on a broad and extensive knowledge base that exists at RAND. Personnel who contributed to this research include a mix of technologists, operations research analysts, logisticians, and scenario specialists, among others. As part of this research, we regularly interacted with defense contractors, military users, and system developers and testers, and we continue to do so as the research evolves.

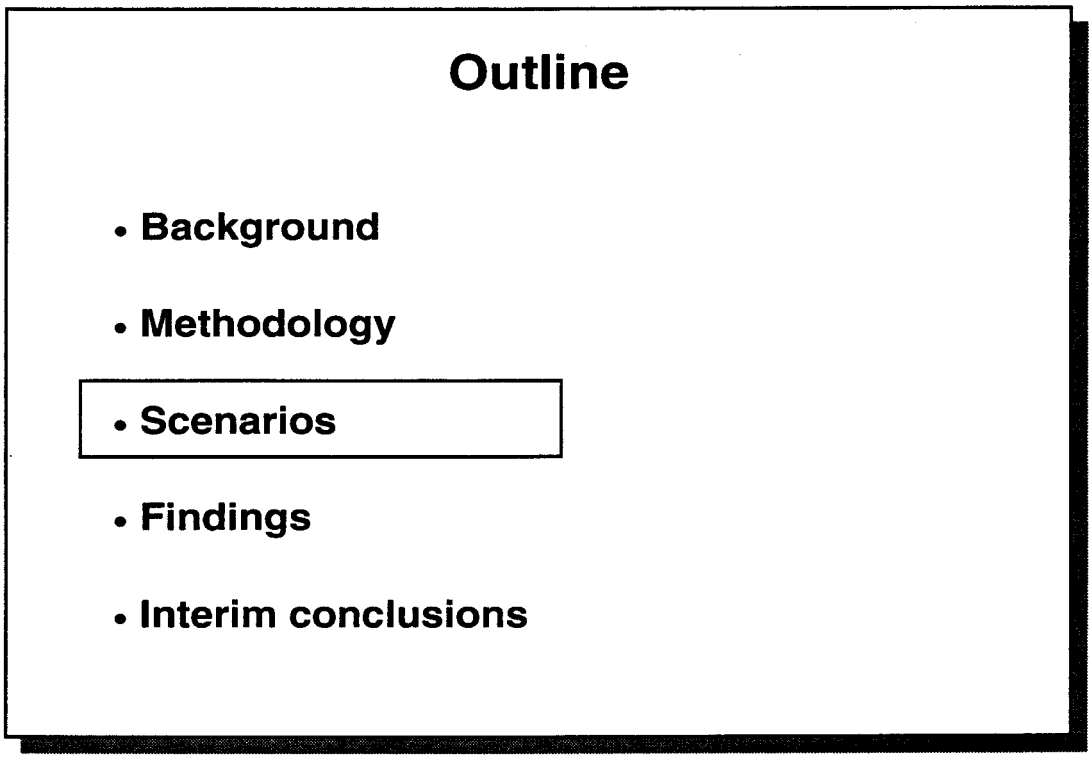


A significant portion of our research involved modification and/or development of high-resolution models capable of representing the performance of the advanced-technology RFPI systems. We assembled a locally distributed simulation environment to model the many different aspects of ground combat.

The RAND version of Janus served as the primary force-on-force combat effectiveness simulation and provided the overall battlefield context, modeling as many as 1,200 individual systems on a side. The combination of the RAND Target Acquisition Model (RTAM) and the Cartographic Analysis and Geographic Information System (CAGIS) allowed us to represent, as needed, detailed target detection/acquisition phenomenology including those associated with low-observable vehicles. RAND's Jamming Aircraft and Radar Simulation (RJARS) provided a means to simulate the detection, tracking, flyout, and fusing of air defense missiles. The Model to Assess Damage to Armor with Munitions (MADAM) allowed us to simulate the effects of smart munitions, including chaining logic, multiple hits, and unreliable submunitions, among others. The Acoustic Sensor Program (ASP), a recent addition to our suite of models, now allows for a detailed simulation of acoustic phenomenology for a number of different systems such as the acoustic overwatch sensor and wide area munitions. And the Seamless Model Integration (SEMINT) allowed all of these simulations to communicate during an exercise.

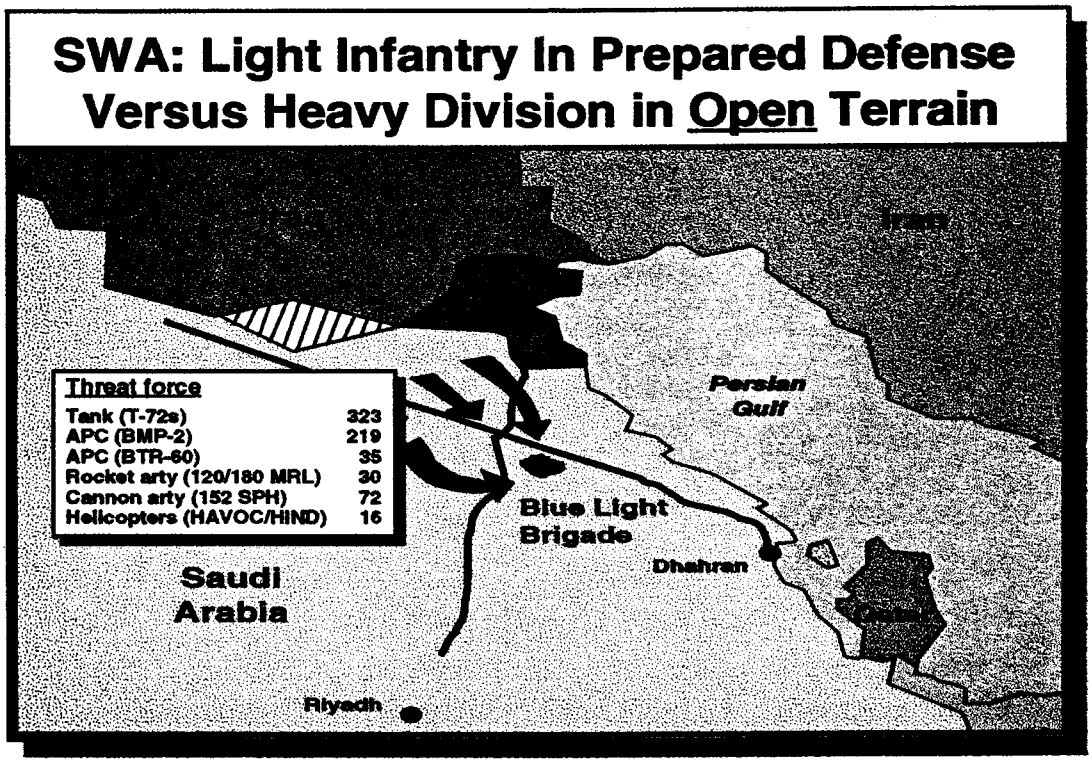


The assessment process consists of a cycle of functions. Normally, the process starts with the identification of stressing scenarios that exercise the range of roles and missions for a current and/or future light airborne force. New technology concepts such as advanced sensors or smart munitions are integrated into light force operations. Airlift burden with the new systems is assessed to ensure that the number of sorties required to bring the force and its equipment into theater remains constant. Users and developers are contacted to provide insights and data on tactics, techniques, and procedures (TTPs) for use of the new systems and the rest of the force. The suite of integrated simulations are then run (over many iterations) to assess effectiveness for a wide variety of MOEs (kills, losses, LER, SER, range, pace). This process typically results in identification of other excursions to make, and the cycle continues. This process also raises insights, which often lead to further findings and recommendations.



4. SCENARIOS

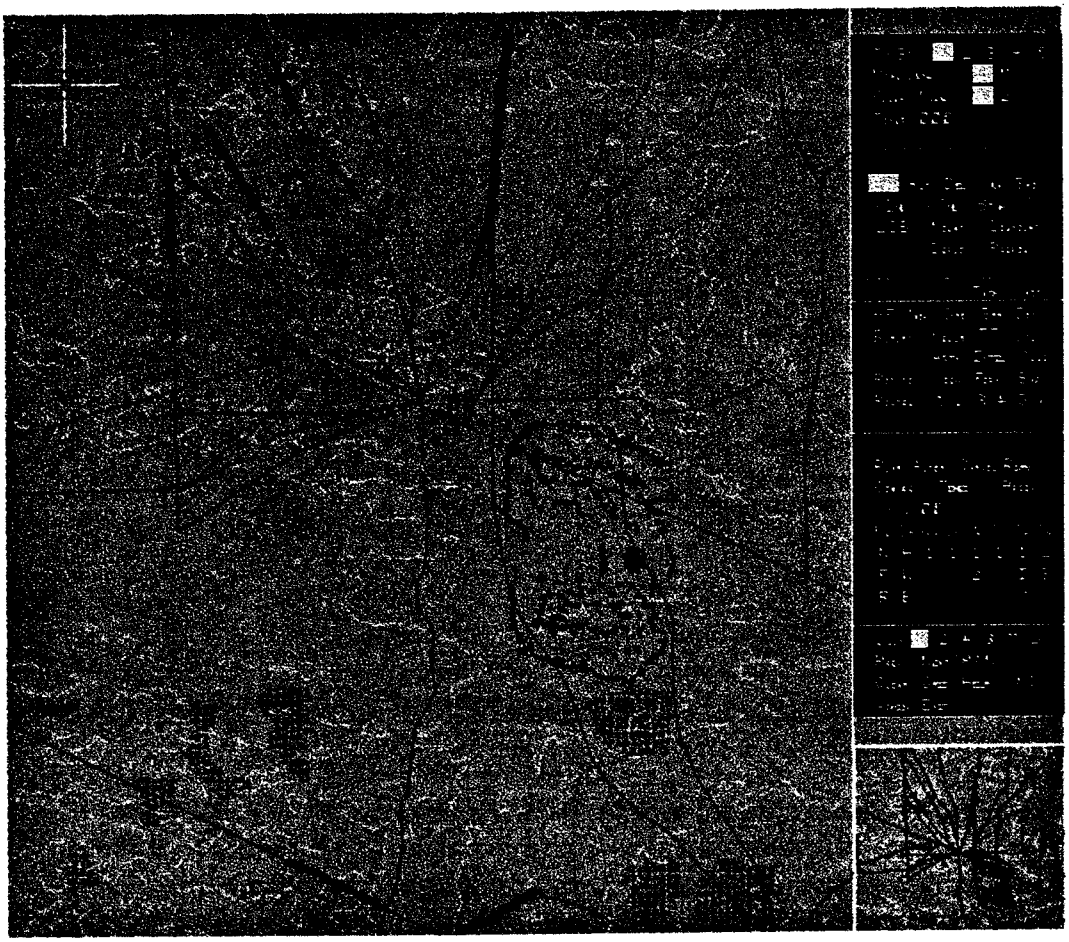
This section provides brief descriptions of the scenarios we used for assessing the different technology concepts for light airborne forces. Southwest Asia represents the setting for the first scenario. This environment consists of relatively open terrain with very long lines of sight. East Europe represents the setting for the second scenario. In contrast to Southwest Asia, this environment consists of relatively close terrain with very short lines of sight. Aside from the nature of the terrain, the scenarios are otherwise generally quite similar with equal initial force sizes on both sides (i.e., one Red division attack against one Blue brigade in hasty defense). Both scenarios have been modified somewhat from approved TRAC (TRADOC Analysis Center) scenarios.



The first scenario takes place in Saudi Arabia. The Blue light force must defend a critical junction along the major pipeline road. A Red division (consisting of two armor regiments and one mechanized infantry regiment) attack with the objective of destroying the Blue force and controlling the road network. The immediate Red objective is to defeat the Blue force because the road junction has critical strategic value for access to oil fields and for logistics and resupply to support a continued ground offensive.

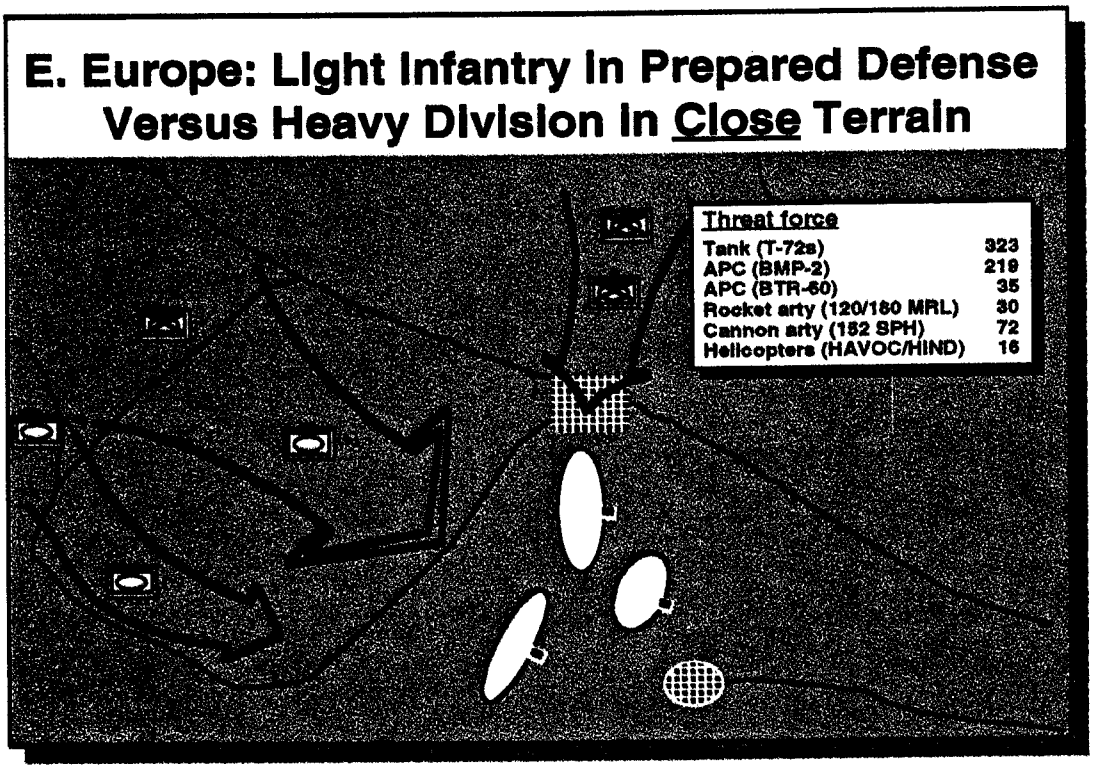
The terrain is very open, and typical lines of sight are on the order of three to five kilometers. Blue is positioned on high ground, but this is typically only 20 to 40 meters above the Red force. The ground is only moderately trafficable for heavy and medium armored vehicles.

Blue sets up a hasty defense with a battalion to the north, a battalion to the south, and a company strong point in the center. Red attempts to envelope the Blue force with two armor regiments to the north and a mechanized infantry regiment to the south.



A Janus screen image for the Southwest Asia scenario is shown above. This image shows the initial positions of the Blue and Red forces. The Blue force, shown in the center of the above chart, is organized in large-perimeter (270-degree) defense. Most of the Blue combat elements, including personnel, are designated as in "defilade" in Janus and therefore tend to be much less vulnerable to both indirect fire artillery and direct fire weapons than if they were in the open.

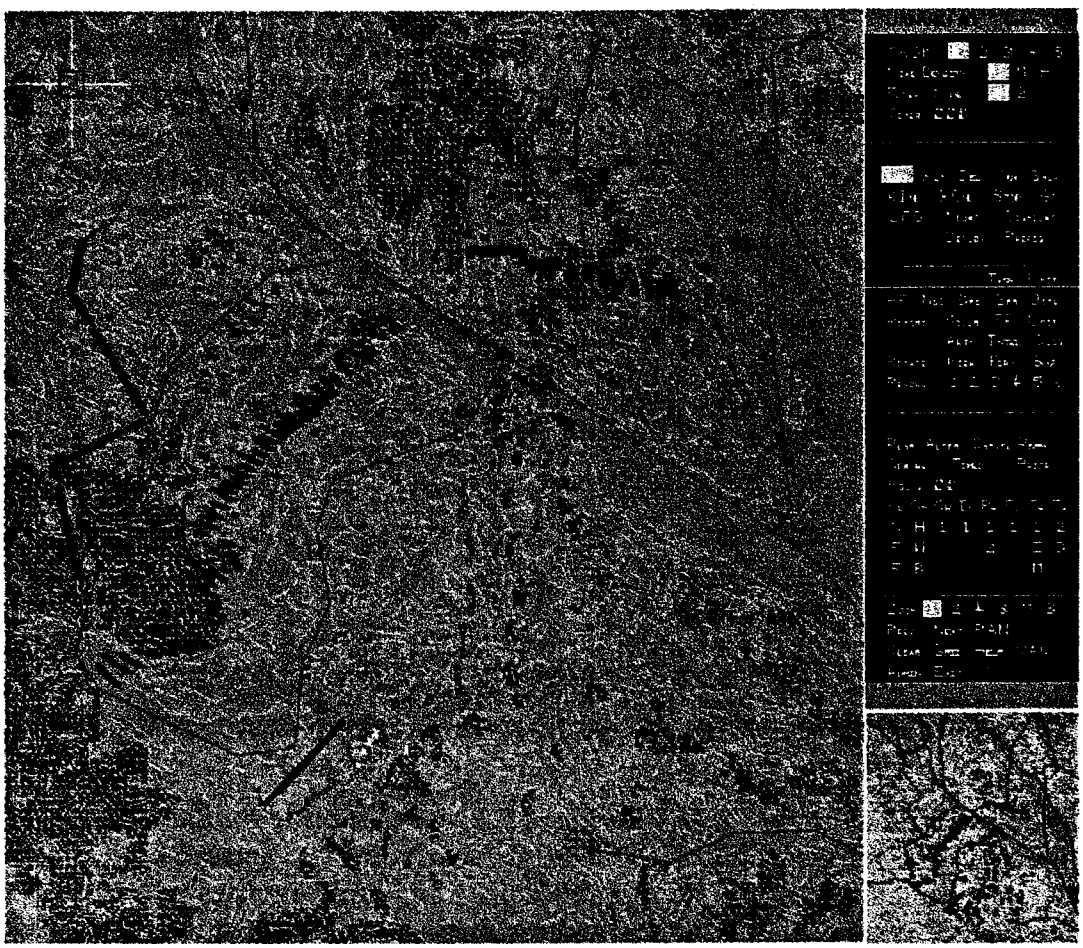
In both the north and south attacks, Red initially uses the existing road networks as much as possible. As the Red force closes with the Blue force, it separates into company-sized columns and then into attack formation. Because the terrain is only moderately trafficable, the travel speed of the Red vehicles is reduced automatically in Janus as the vehicles move off-road for the attack.



The second scenario is in East Europe. The basis for this conflict is a border dispute. Essentially, an East European country, motivated by the goal of ethnic reconsolidation, militarily reclaims previously lost (but still disputed) land. This action results in a retaliation, a recapture of the disputed land, and a probable counterinvasion. U.N. action involves quick emplacement of allied forces to dissuade this counterinvasion. Nonetheless, the counterinvasion proceeds without delay and unexpectedly escalates into general warfare involving the U.S. light airborne forces. The chart shown above represents only the U.S. portion of the much larger allied force conflict. (In the chart, lines represent local roads and cross-hatched areas represent urban centers.)

Although the events leading to the conflict are different in this scenario from those than in the previous Southwest Asia case, the force ratios and compositions are identical. Also, Blue once again is in a hasty defensive posture with Red attacking along multiple axes. The armor attack is from the west and the mechanized infantry attack from the north.

One quantitative difference between this scenario and the other is the terrain. This environment contains much shorter lines of sight and even more-limited trafficability. Typical LOS is about two to three kilometers along the regions that Red chooses to attack.



A corresponding Janus screen image for the East Europe scenario is shown above. This image shows the defensive position of the Blue force in the center of the screen, and the Red attack formation approaching from the north and west. As in the Southwest Asia scenario, the Blue force is organized in a large-perimeter defense, optimizing its position in the inherently limited LOS environment. In addition to terrain contours that can block LOS, foliage, which is much more prolific in this environment, provides additional reductions.

What Might a Current U.S. Light Airborne Force Look Like?

Representative Airborne (ABN) Division Ready Brigade

- 1 ABN brigade HQ company
- 3 ABN infantry battalions
- 1 artillery battalion (105mm towed)
- 1 ADA company
- 1 attack helicopter company
- 1 armor company
- 1 artillery battery (155mm towed)

15 HMMWV-Scouts
58 HMMWV-TOWs
54 Dragons
18 M102s
18 Stingers
6 Apaches
14 Sheridans
8 M198s

- Total weight: 4,297 tons
- Total personnel: 3,450 soldiers

In the two scenarios examined, the size, composition, and organization of the simulated Blue force is comparable to the 82nd Airborne Division Ready Brigade (DRB). The primary combat units and the weapons associated with the force we assumed are shown above.

In both scenarios, the Blue force is substantially smaller than the Red force. A direct count of individual combat elements shows that Blue is outnumbered about four to one. This count does not reflect the qualitative difference between the combat elements of this light airborne force and the enemy heavy force (e.g., a Dragon and a T-72 count as one element). Thus, even though the light airborne force is assumed to be in a defensive position, the disparity in initial force ratios, as might be the case in an early entry situation, is considerable.

Both Scenarios Presume an Initial "Forced Fight" as a Prelude to a Larger Battle

- **Deployment assumptions**
  - **Airborne DRB is forward-positioned (air dropped) to defend critical objective**
  - **DRB has time to set up defense prior to start of scenario**
- **Rules of engagement**
  - **Both Red and Blue forces fire on recognition**
- **TACAIR availability**
  - **Blue establishes air superiority and destroys 10-15% of attacking enemy force**

Some key assumptions are made for the two scenarios. It is assumed that the DRB must be confronted by the threat force. That is, the DRB is defending a critical objective and this force must be faced rather than circumvented. The DRB is also assumed to be air dropped near the objective with enough time before the start of conflict to set up a defensive position.

The basic rules of engagement assumed in our scenario require both Red and Blue forces to "fire upon recognizing" their respective adversaries (distinguish between armor and wheeled vehicles) prior to weapons launch. For these scenarios, it was envisioned that "fire on detect" would be too permissive a criterion for weapons launch and "fire on identification" would be too restrictive for either force.[2] In other lower-intensity conflicts, the "fire on identification" criterion may be more appropriate.

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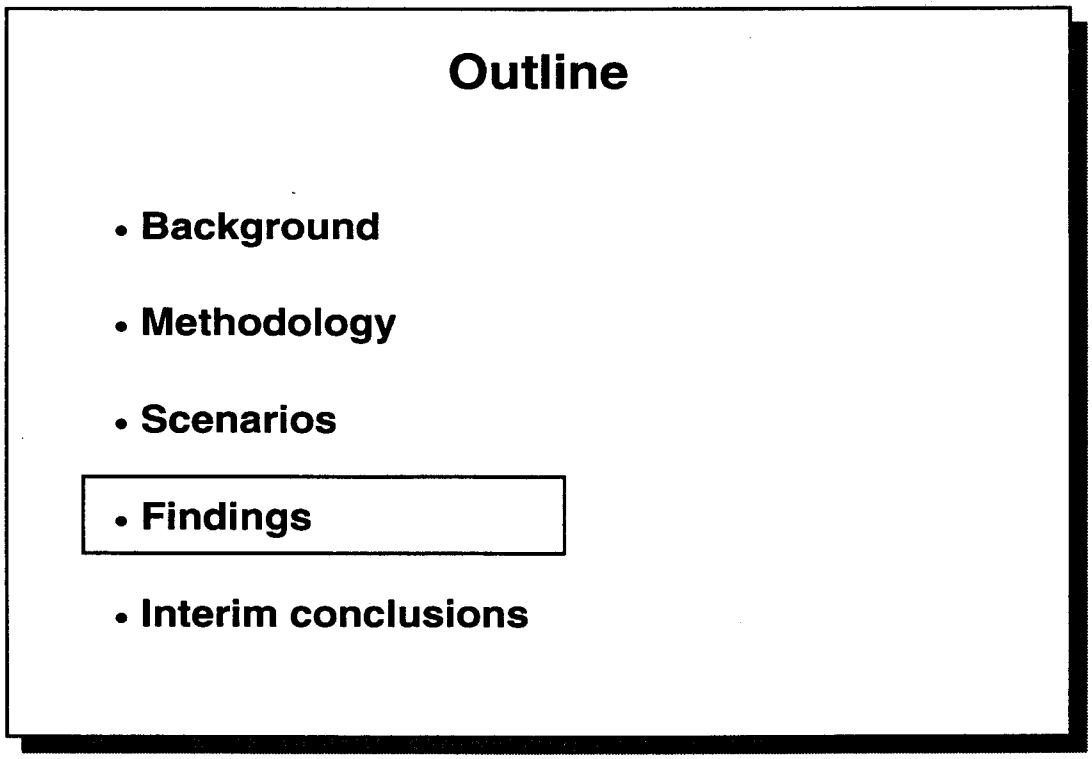
[2]Detect, recognize, and identify are formally distinguished in Janus by numbers of "cycles" or bars on target from a sensor, referred to as the Johnson criteria; Janus uses the U.S. Army night vision electro-optical detection algorithm to determine sensor-to-target performance.



5. FINDINGS

This section provides our "work-in-progress" answers to the three key research questions posed earlier.

Findings

How does a current light airborne force perform against an existing heavy force?

Can light airborne forces be enhanced to repel larger existing heavy forces?

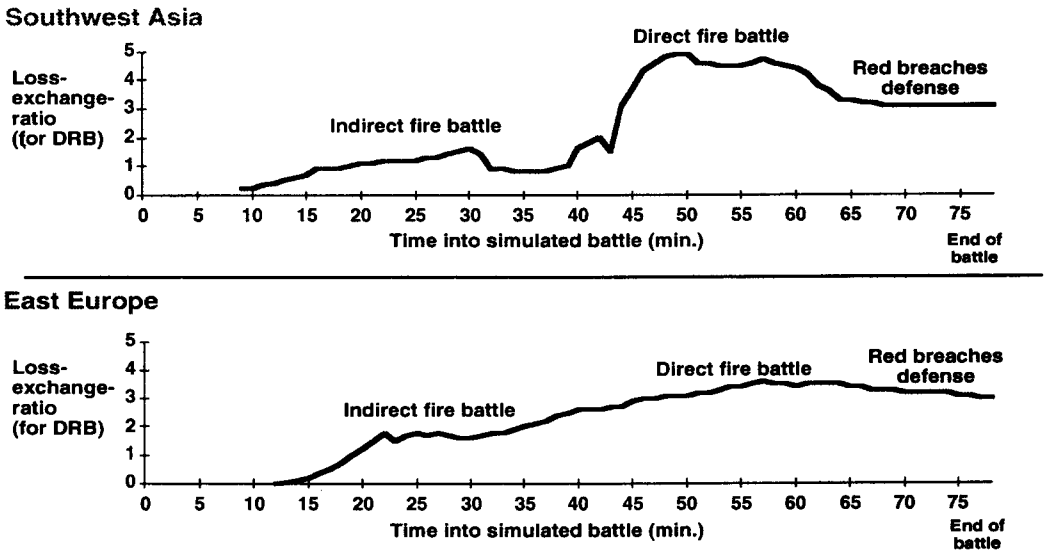
What are the vulnerabilities of light airborne forces to a *future* heavy force?

Although respectable loss-exchange-ratios were achieved, the current force could not *sustain* a defense.

We begin this section by answering the first question, "How does a current light airborne force perform against an existing heavy force?" Within the context of our aforementioned scenarios and assumptions, our research shows that a current DRB cannot sustain a defense against a much larger existing heavy force. Although respectable loss-exchange ratios (LERs) were achieved by the DRB, the simulated performance was not good enough to repel the attack of the much larger force.

The following charts will provide an elaboration of this finding, including some of the simulation results.

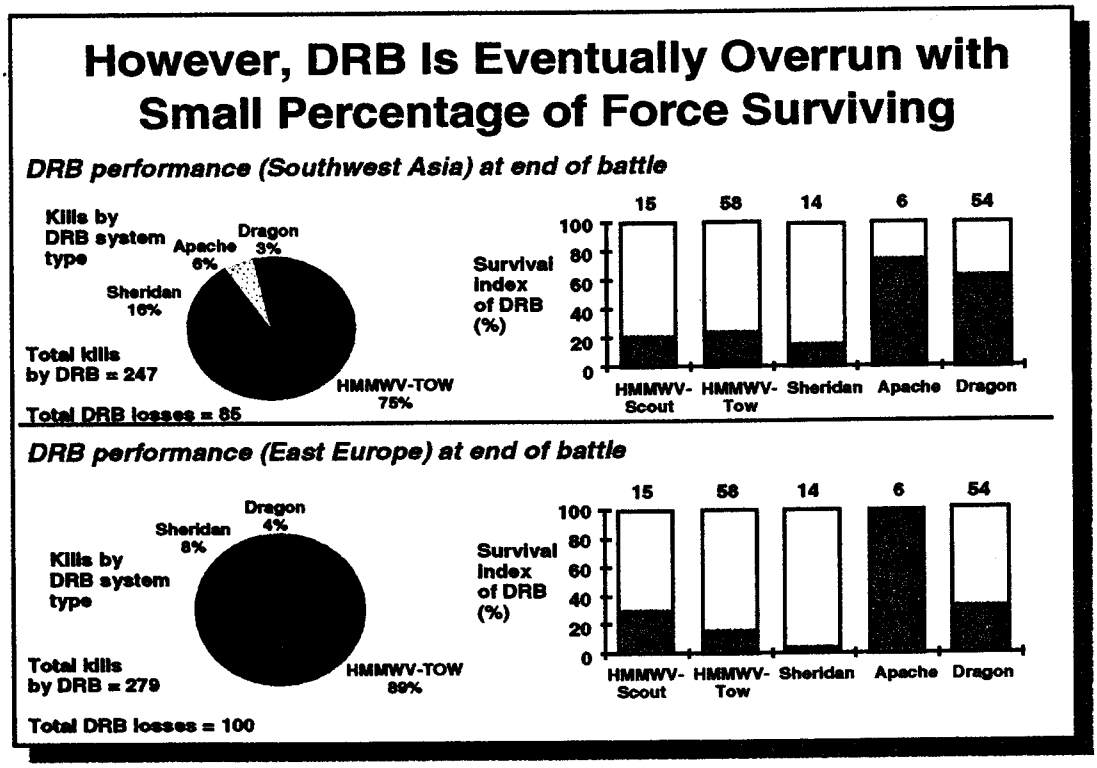
Simulation Shows Current DRB Has Lethality in Defense Against Heavy Force Attack



The LER produced over time by the simulation shows the unraveling of the respective Southwest Asia and East Europe battles. In the first few minutes, very little attrition occurs simply because the forces are positioned out of range of each other. As the Red force begins its advance toward the DRB, the DRB artillery is fired. Although the attacking Red combat vehicles (moving in columns) are relatively lucrative targets at this initial phase, the limited lethality of the DPICM (dual purpose improved conventional munition) rounds and the inability of high-explosive (HE) rounds to hit moving targets produced very few kills. Likewise, because the DRB is in defilade, the Red artillery preparatory fires also yielded relatively few kills. LERs were between 1 and 2 for the DRB across both scenarios, being slightly higher in East Europe because of the increased susceptibility of Red armor to artillery fire with slower-moving vehicles (tougher terrain in East Europe).

Attrition on both sides begins to occur at a more rapid rate during the direct fire, close battle. The front line of the direct fire battle for the DRB is the Apache/Hellfire attack. Even though the Apaches are assumed to stand off (with highly capable enemy air defense), because of their ability to improve their LOS with altitude, they typically could see farther and attack first. This was the case in Southwest Asia; however, the terrain in East Europe precluded a successful Apache standoff attack. As the direct fire battle progressed, other direct fire assets (HMMWV-TOWs, Sheridans, and Dragons) participated.

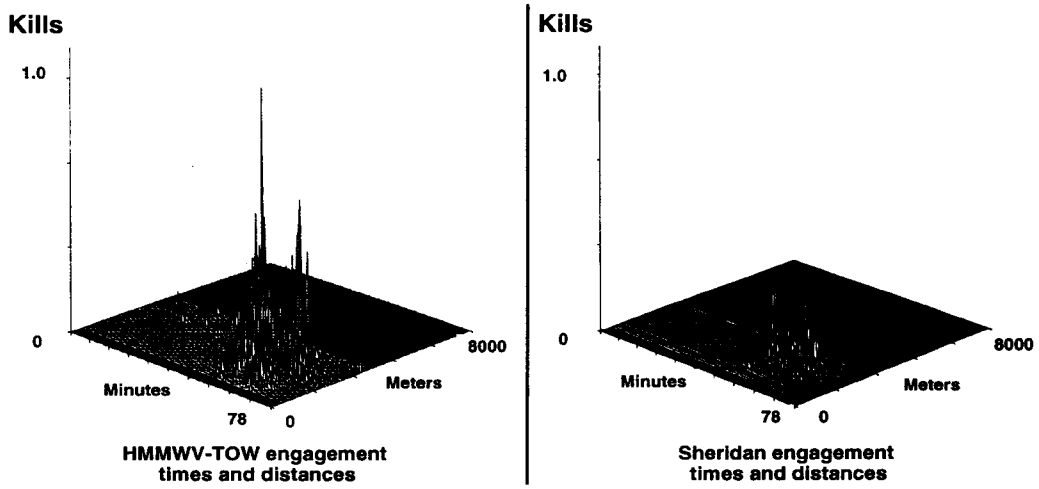
Although the DRB systems tend to have a range advantage over the enemy systems, the massive attack by Red quickly became the deciding factor. The LER in both cases dropped as the DRB defense was breached.



In both scenarios, the threat force eventually overruns the current-generation DRB. Although the DRB was able to obtain a respectable LER during most of the close battle, because of the larger size of the enemy force, the DRB is eventually overrun. The above chart shows simulation results at the end of battle (after the breach of the DRB defense). In the respective scenarios, between 247 and 279 Red systems were destroyed by the Blue force in the respective scenarios, mostly by the HMMWV-TOWs. However, from the bar charts shown above, it is evident that relatively few systems of the original Blue force remain. (The numbers above the chart show the total number of systems at the start of the conflict, the gray bars reflect the percentage of the force remaining.) With the exception of the Apaches, which fly only a single mission in the 78 minutes of simulated battle, the Blue force suffers very high attrition.

To summarize, in the Southwest Asia scenario, the Red force penetrated the DRB defense in the north by committing the one armor regiment to lead the attack with the second armor regiment following closely in reserve. At the time of breach, the second regiment was almost completely intact. In the East Europe scenario, the Red force was able to turn the southern flank, penetrate the Blue force, and destroy it.

Breakdown of Engagement Locations and Times Shows Why DRB Becomes Overrun



Southwest Asia scenario

The primary reason that the Blue force does not survive the Red attack can be directly attributed to the "close-in" location of the engagements. More specifically, the two primary killers, the HMMWV-TOWs and the Sheridans, engage at points on the battlefield where they are exposed (within the LOS of the missiles and main guns of enemy systems). Even though the DRB has some sensor and weapons range advantage over the assumed capabilities of the attacking force, it was only a matter of time before Blue became overwhelmed by Red's larger force. We show in the above charts that many of the engagements occurred relatively late in the simulated battle at relatively close range (well within a 4-kilometer range) even in relatively open terrain in the Southwest Asia scenario.

DRB Could Not Sustain the Heavy Force Attack for Several Reasons

- **Indirect fire battle**
  - **DRB artillery (HE and DPICM) has limited performance in both scenarios**
- **Close battle**
  - **DRB initially has weapon (sensor) advantage resulting in respectable LERs, about 4.5:1 in Southwest Asia and 3.5:1 in East Europe**
- **Breach of DRB defense (decision node for Red)**
  - **At time of potential breach, heavy force has roughly 70% of forces intact in both scenarios**
  - **Similarly, Blue has 70% to 65% of force intact—but no longer maintains system-exchange ratio advantage**

We summarize the DRB performance in the different "spaces" of the battle.

First, examining the indirect fire battle, the current artillery systems—the towed 105- and 155-millimeter howitzers (cannons) and the associated rounds of artillery—(DPICM and HE)—did not provide significant attrition against the armored, mobile Red force.

Next, examining the close battle, the direct fire weapons of the DRB outperformed those of the attacking force. With longer-range sensors and weapons reach, the DRB was generally able to start the close fight before the attacking force. This advantage, however, was short lived. As the Red force continued its advance, the DRB range and reach advantages were reduced, resulting in a notable reduction to the overall LER.

At the end of the close battle or time of breach of the DRB defense (58 minutes into the simulation), we gathered statistics to determine whether the Red force would likely continue the attack. As it turned out, at this time in the battle, both forces suffered relatively high attrition. The Red force had roughly 70 percent of its forces intact. Likewise, the DRB had 70 percent and 65 percent of its forces intact in the respective scenarios. However, because of the much closer parity of exchange at this time in battle, with Red having a much larger overall force remaining, it is altogether likely that breach of the DRB defense would occur, resulting in a loss.

Findings

How does a current light airborne force perform against an existing heavy force?	Although respectable loss-exchange-ratios were achieved, the current force could not *sustain* a defense.
Can light airborne forces be enhanced to repel larger existing heavy forces?	**RFPI upgrades provided means to repel heavy forces, with considerable increase in indirect fire part of battle.**
What are the vulnerabilities of light airborne forces to a *future* heavy force?	

We now provide the answer the second question, "Can the light airborne forces be enhanced to repel larger existing heavy forces?"

Generally, our analysis involved incrementally adding new technology concepts to the DRB. We started off with "improving the direct fire battle," then added "a hunter/standoff killer concept," and then modified the hunter/standoff killer concept with "fast command and control." Generally, we found that these upgrades, with the underlying technologies and selected RFPI systems, provided the DRB with the ability to successfully repel a much larger, current-generation heavy force. As before, the following charts provide an elaboration on this finding.

Upgrade Options for the Light Forces *(with Some "Core" RFPI Systems)*

- **Current DRB force (previously assessed)**
- **Themes and systems for enhancing DRB force**
  - **"Direct fire" (improved base force)--82nd DRB with AGS and Javelin**
  - **"Hunter/killer"--direct fire concept *plus* LO Hunter vehicle and EFOG-M**
  - **"Fast C2"--hunter/killer concept *plus* reduced timeline for EFOG-M delivery**

Starting with the DRB as defined before, we systematically added new capability to this force along different themes. First, we introduced an "improved direct fire capability" to the DRB. To represent this, we selected two key direct fire systems that the U.S. Army is already pursuing: (1) the armored gun system (AGS) to replace the Sheridan, and (2) the Javelin, the shoulder-fired antitank missile, which is envisioned to replace the Dragon.

Second, we built on this improvement by adding a representative "hunter/standoff killer" capability to the DRB. To represent this enhancement, we selected a reduced signature hunter vehicle (with mast mounted sensors) and the enhanced fiber-optic-guided missile (EFOG-M). These two systems work as a team, with the forward-positioned hunter vehicle acquiring targets and handing them off to the more safely positioned EFOG-M platform.

Lastly, we further altered the force by streamlining the hunter standoff killer with "fast command and control (C2)." Essentially, the RFPI envisions using an improved command and control system, based on the U.S. Army light tactical operations center (TOC). Although, at the time of this work, the architecture had yet to be defined, we were able to simulate the effect of one key parameter—the time it takes to hand off target information between hunter and standoff killer—by halving the C2 delay time between hunter and standoff killer.

Airlift Capacity Sets the Limit on "How Much Is Available?"

Airlift analysis:

- **108 sorties (54 C-5 and 54 C-141 eq.) required for initial deployment**
- **37 C-141 required per day for resupply**

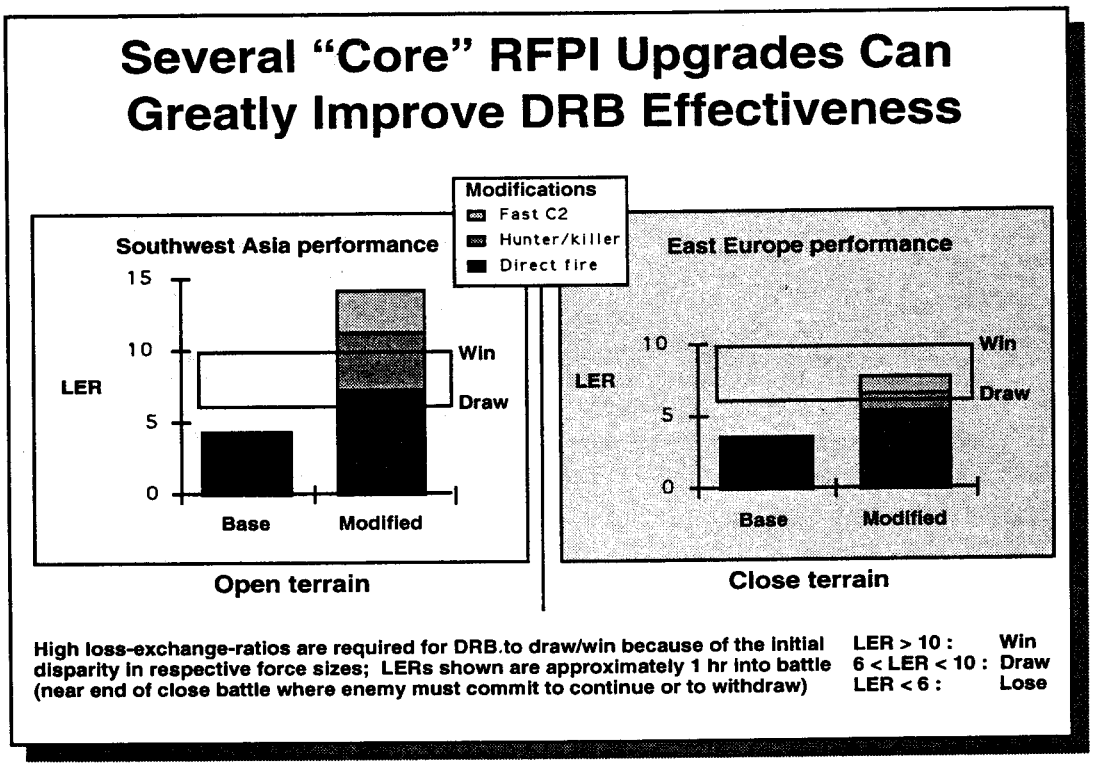
CONUS sortie generation rate is one constraining factor

	Base Force	"Direct fire"	+ "Hunter/ killer"	+ "Fast C2"
Sheridan	14	0	0	0
AGS	0	14	14	14
Dragon	54	0	0	0
Javelin	0	54	54	54
HMMWV-Scout	15	15	15	15
HMMWV-TOW	58	58	18	18
Hunter	0	0	24	24
EFOG-M	0	0	18	18
Apache	5	5	5	5
Stinger	18	18	18	18

Fairly "even" exchanges can be obtained with force elements

As brought out earlier, our analysis was governed by the constant airlift rule. That is, the resources available to deliver the light airborne forces are assumed to be fixed, with approximately 108 sorties being required to move the current DRB into theater. We examined what must be traded out to include the different DRB upgrade options (direct fire, hunter/standoff killer, and fast C2). For the direct fire systems, it is essentially a one-for-one swap. For every AGS added to the force, one Sheridan is removed. For each Javelin added to the force, one Dragon is removed.

For incorporating the systems associated with the hunter/standoff killer, it is not as clean a swap. Only some of the HMMWV-TOWs are swapped out for a precalculated ratio of hunter vehicles and EFOG-M platforms. We assumed that the fast C2 concept did not require any additional hardware and, therefore, no airlift change would be required in this last upgrade.



Examining the LERs at 58 minutes into the simulated battle,[3] it was apparent that different upgrade options provided considerable improvement to the DRB. The chart above shows the respective (cumulative) improvement in LER obtained by the three different upgrade options compared to the base DRB at the same time in battle. While for the base DRB, the LER was not good enough to result in a successful defense against the Red force, the DRB with the enhancements was able to decisively stop the attack in the Southwest Asia scenario, and only marginally able to fight to a draw in the East Europe scenario.[4]

Also notable was that the addition of only the direct fire systems (AGS and Javelin) improved the force, but not enough to turn the tide. It was not until the hunter/standoff killer concept (hunter vehicle with EFOG-M) was introduced that a "win" LER was achieved in Southwest Asia and a "draw" in East Europe.

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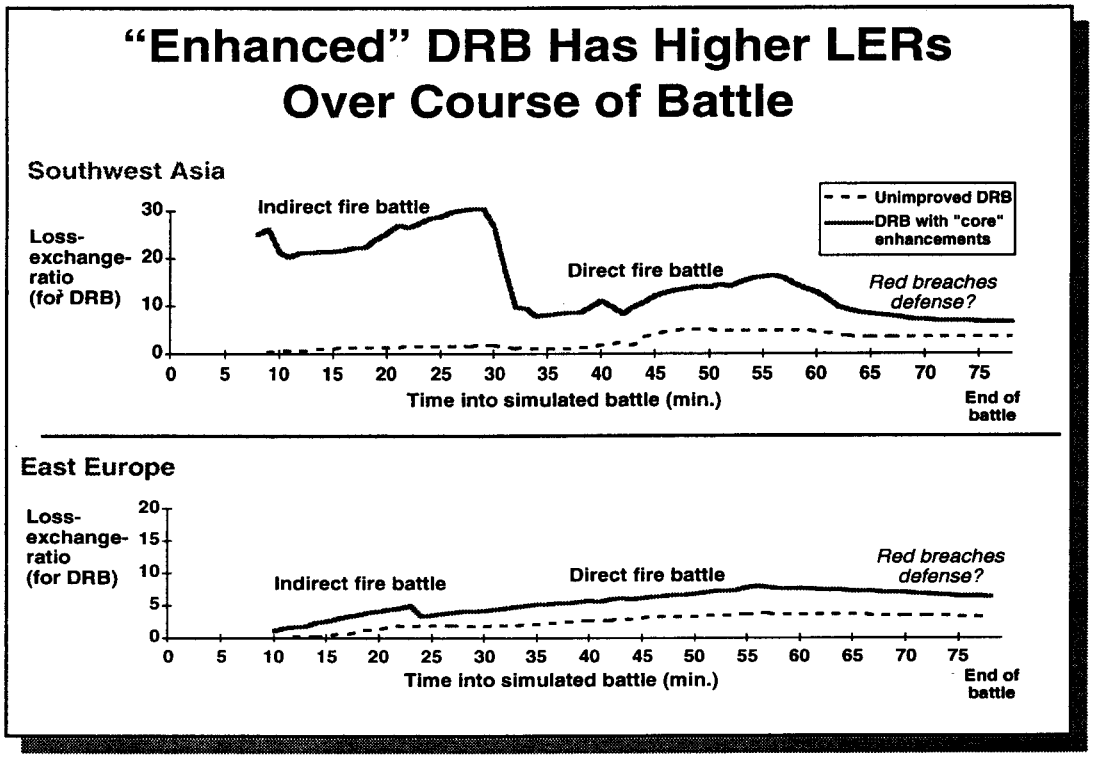
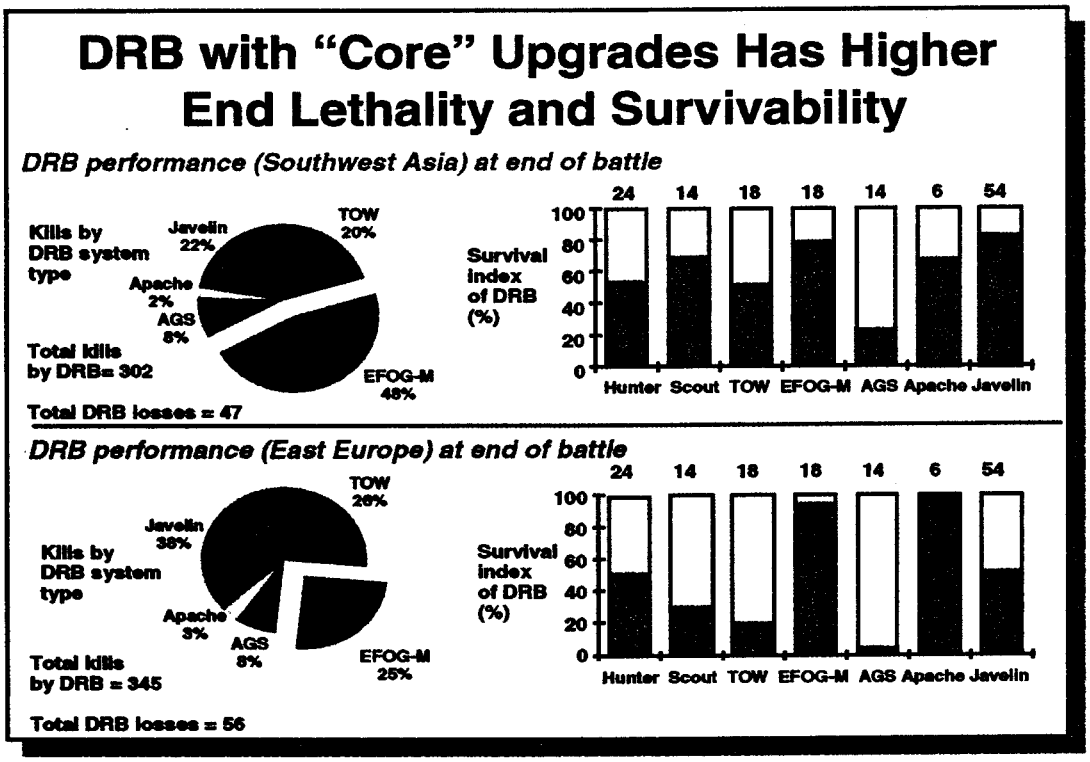
[3]Approximately one hour (more specifically, 58 minutes) represents an important time in the battle nearing the end of the close fight; this represents the likely decision time for the Red to continue or to call off the attack.

[4]A win was define by an LER of 10 or higher, and a draw defined by an LER of 6 to 10. These numbers were subjectively determined by an examination of the force ratios at this time in the battle and a correlation to what might be needed for a decisive victory and a partial victory, respectively.



The 58-minute snapshot look at the LER on the previous page provided only a partial picture of the outcome of the simulated battle. In the Southwest Asia scenario, in particular, it became apparent that the LER at the end of the indirect fire battle was actually as high as 30. The contribution of the hunter/standoff killer systems in this scenario is very evident—the battle, as far as the DRB was concerned, could start much sooner and could be waged at much longer ranges, well before the main force became susceptible to the direct fire assets of the attacking force.

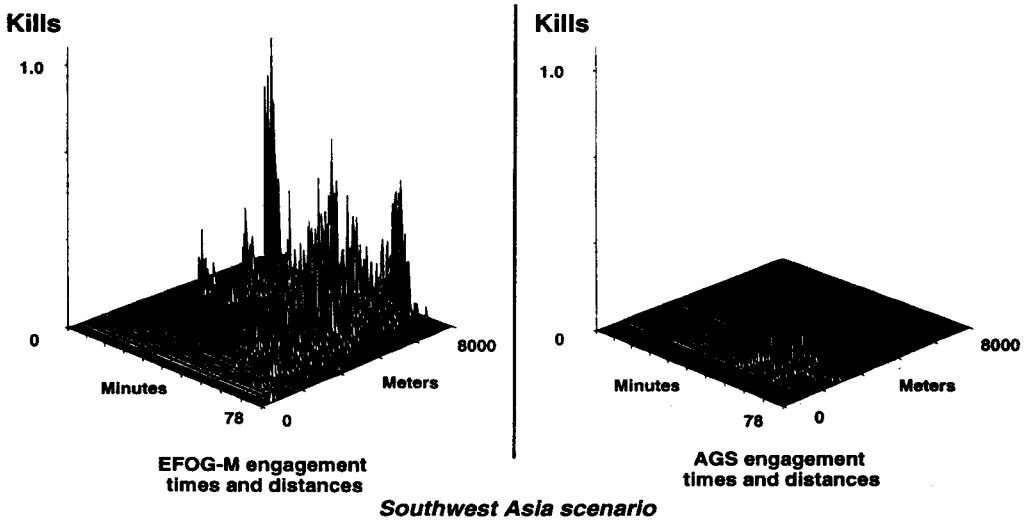
Although not as dramatic, the impact of the hunter/standoff killer systems in the East Europe scenario is still quite evident. The LER improved by a factor of 2 leading into the direct fire battle.



Although we envision that the battle would likely have been called off by Red prior to the breach of the enhanced DRB defensive position, we show the outcome of the simulated battle if it had been carried out to the full 78 minutes. Here, it becomes apparent that many more Red systems are killed (302 versus 247 in Southwest Asia and 345 versus 279 in East Europe); however, an even more profound difference can be seen with the survivability numbers of the DRB (only about half the losses seen before). Unlike the base DRB, which was mostly attrited at the end of battle, this force is still partly intact, particularly so in the Southwest Asia scenario.

Whereas before, the primary killer was the HMMWV-TOWs, the EFOG-M and Javelins provide the bulk of the lethality to the enhanced DRB force. Since HMMWV-TOWs were traded out for an EFOG-M presence, it is inherent that the HMMWV-TOW contribution would go down with some increase in EFOG-M; however, in Southwest Asia, the EFOG-M contribution is proportionally much higher. It is also notable that the Javelin, a one-for-one exchange for the Dragon system, provided a much greater share of the overall force lethality in this case.

Engagement Distances Between Direct and Indirect Fire Systems Can Be Substantial



EFOG-M engagement times and distances

AGS engagement times and distances

Southwest Asia scenario

The enhanced DRB does considerably better than the base DRB, in large part because of the hunter/standoff killer concept. This concept clearly allowed the fight to begin much earlier and from much farther away (as can be seen in the above 3-D image, showing the EFOG-M engagement times and distances). Unlike in the previous case, where the engagements were occurring within four kilometers of the force elements, here the engagements started from beyond eight kilometers. This difference not only increased the window in which Red systems could be attacked, resulting in higher DRB force lethality, but it also allowed for a "metering in" of the Red force into the direct fire battle. That is, when the Red force closed, the enemy systems were fewer and could be more easily managed by the DRB's direct fire systems. Thus, with this "shaping of the battlefield," improved DRB lethality was accompanied by higher overall DRB survivability.

What Are the Factors Governing the DRB Improvement?

- **Enhanced force does better**
  - **New direct fire systems have greater lethality**
  - **Hunter/killer engagements occur at greater distances, "metering- in" direct fire engagements**
  - **Faster C2 permits increased volume of fires with reduced targeting error**
- **Performance varies between scenarios**
  - **Hunter line-of-sight (topography and foliage) is reduced in close terrain (East Europe)**
  - **Chance encounters increase substantially in close terrain (East Europe)**

To summarize, the enhanced DRB performed as one intuitively might expect. The new direct fire systems had higher lethality, allowing for a higher LER. The addition of the hunter/standoff killer concept was a key enhancement that provided enough initial firepower to change the dynamics on the battlefield—greatly reducing the possibility of the DRB being overrun. Fast C2 allowed for synergistic effects; not only were more rounds delivered, they were placed with reduced error (less target movement until round impact).

Although improvement was observed in both scenarios because of the DRB upgrades, the level of improvement was quite dissimilar between the two scenarios. As stated earlier, the benefit was considerably less apparent in the close terrain of East Europe. Examination of the scenario data showed that the hunter vehicles' ability to "see" was the primary distinguishing factor. That is, in the limited-LOS terrain, not only were the hunter vehicle sensor ranges much shorter, reducing the number of calls for fire from the EFOG-M platforms, but also these hunter vehicles tended to be simultaneously more susceptible to unexpected or "chance" encounters with the advancing enemy force.

Findings

How does a current light airborne force perform against an existing heavy force?	Although respectable loss-exchange-ratios were achieved, the current force could not *sustain* a defense.
Can light airborne forces be enhanced to repel larger existing heavy forces?	RFPI upgrades provided means to repel heavy forces, with considerable increase in indirect fire part of battle.
What are the vulnerabilities of light airborne forces to a *future* heavy force?	**Direct fire battle becomes significantly more challenging; more extensive set of systems needed to prosecute HSOK concept with emphasis on RSTA.**

So far, all of our research the examined the effectiveness of the DRB against a current-generation enemy force. The third question asks, "What are the vulnerabilities of the light forces to a future heavy force?" A future heavy force is generally defined here as a force with upgraded weapon systems including high-tech Russian systems that are either currently available on the arms market or are nearing the end of their development.

With these improvements, it becomes evident that the advantage previously held by the base DRB in the direct fire battle goes away. Also, because the limited number of hunter vehicles becomes more susceptible to the more capable Red sensors, it is more difficult to successfully prosecute the hunter/standoff killer concept.

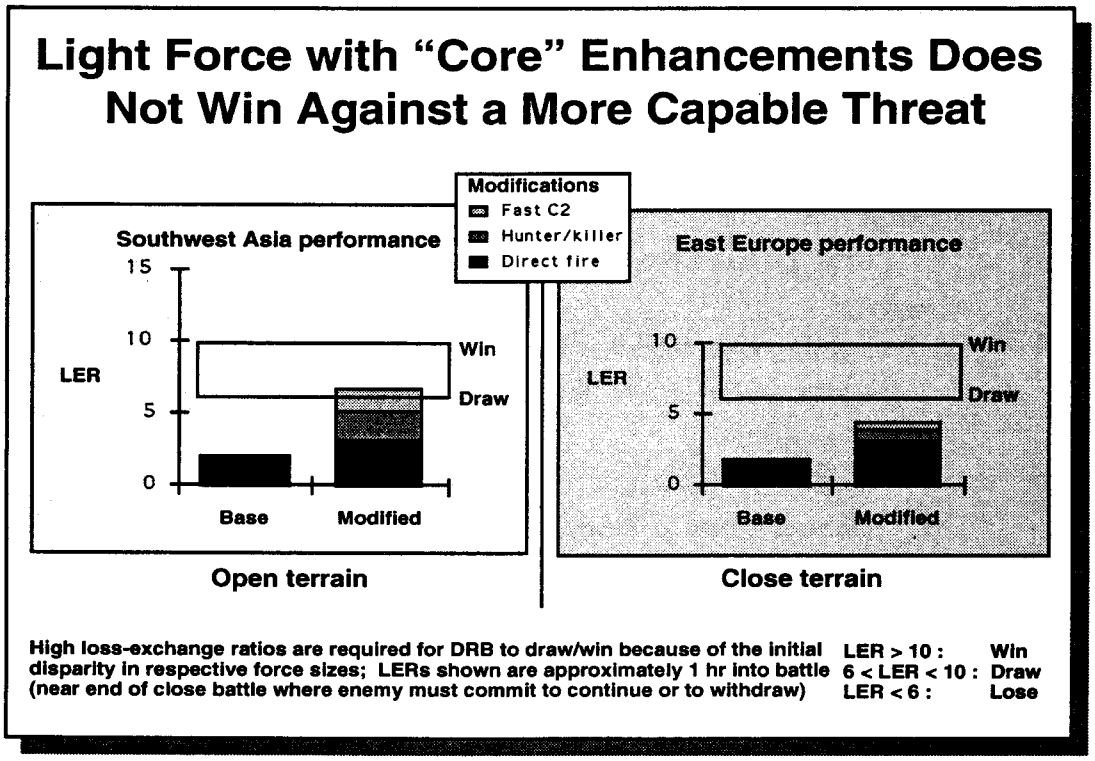
Essentially, we found that a more extensive suite of RFPI (and non-RFPI systems) may be needed to achieve success against a future heavy force. Current results suggest that multiple indirect fire systems, when coupled to forward sensors (as part of the hunter/standoff killer concept), appear to offer high leverage. The match of sensor coverage to munition footprint varies with terrain and target activity (moving or stationary). In close terrain against an attacking threat, proliferation of a large number of notional short-range sensors provided needed coverage, whereas the introduction of a few very capable ones did not.

The next several pages will elaborate on these findings.

There Is a Possibility the Threat Will Become More Capable

- **Sensors**
  - **Proliferate FLIRs throughout the force**
- **Armor**
  - **Tanks: from T-72 to T-80+**
  - **BMPs: from BMP-2 to BMP-X**
- **Weapons**
  - **Anti-tank: from AT-5 to AT-8**
  - **Rocket artillery: from HE to MCS-E1**
- **Air Defenses**
  - **RF systems: from SA-8 to SA-15 and added SA-19 (as part of 2S6 system)**

The upgrades that we postulated for enemy forces covered several dimensions. Improved sensors (FLIRs) were provided to all threat elements, instead of being available to only the command vehicles. Armor was improved to reflect the state-of-the-art Russian tank (T-80+ versus T-72) and armored personnel carrier (BMP-X versus BMP-2). More effective munitions supplanted their current counterparts: the longer-range AT-8 (5-kilometer missile) replaced the AT-5 (4-kilometer missile), and a smart munition referred to as the MCS-E1 (very similar to the U.S. Army's SADARM) replaced the HE artillery. Also, very high-end air defense was provided. Generally, these high-tech systems were swapped into the enemy force in a one-for-one exchange with the the old systems.



With the aforementioned changes, a future threat force is able to significantly improve its performance against both the base DRB and the enhanced DRB. Essentially, Red is able to change the LER to the point where only a draw could be achieved in Southwest Asia by the DRB and a resulting loss occurs in East Europe. Although the enhanced DRB, with the "core" RFPI enhancements, still does considerably better than the base DRB, the upgrades were not sufficient to accomplish the stated force objective—to repel the attacking Red force—especially so in East Europe.

In simulating the future Red force, we presumed that the attack would be carried out in a way similar to that of the the existing Red force (Red attempts to overwhelm the smaller DRB from a multiple-axes attack). In the future, it is possible that the threat will adopt new ways to fight that mirror recent U.S. thinking—that is, dispersed forces, maneuver by fire, use of deception, and other methods not assessed in this work.

Why Light Forces with "Core" Enhancements Do Not Win

- **Improved threat sensors can better detect and respond to forward-based scouts and hunter vehicles**
  - **Loss of situation awareness**
  - **Reduction in calls for fire**
- **Improved threat weapons can more successfully engage direct fire systems**
  - **Blue light force target-acquisition edge is reduced**
  - **Threat can engage with improved exchange rate**
- **Threat artillery with smart rounds is more lethal against stationary targets**

Several reasons explain why the DRB does not do as well against the future threat. First, the improved threat sensors allowed for an earlier detection of the forward-based scouts and hunter vehicles. Early DRB losses of these systems translated to less situation awareness and a significant reduction in calls for indirect fires.

In addition to the loss of the "eyes" on the battlefield, which reduced the amount of Blue indirect fire, the Red systems were more capable in the direct fire battle. Red's improved sensors, in conjunction with its longer-range missile, greatly reduced the DRB close combat advantage. The Red force was able to fight on a level closer to parity, and the LER was effectively reduced from around 4-to-1 before to 2-to-1 here.

Also, the addition of the smart artillery munition proved to be effective against the DRB. Even though such "first generation" munitions as the MCS-E1 do not have a very large footprint, the DRB systems were still susceptible to these weapons because of their relatively stationary posture.[5]

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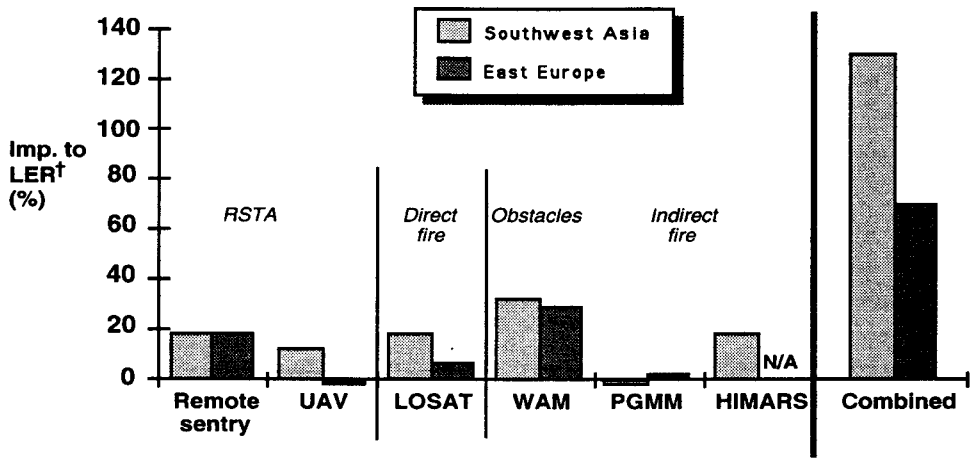
[5]It is postulated that a certain level of mobility, similar to artillery operating in shoot-and-scoot, may reduce the effects of top-attack weapons. However, this phenomenon was not examined in this work.

Addition of Other RFPI Systems Has Potential to Further Improve Force

- **More RSTA can improve "hunter/killer" concept**
  - **Remote sentry**
  - **Unmanned aerial vehicle**
- **Kinetic energy missile (LOSAT) can increase lethality for "direct fire" concept**
- **Wide area munition can provide synergy with other systems**
- **Indirect fire artillery and mortars represent other options as part of "hunter/standoff killer" concept**
  - **Precision guided mortar munitions**
  - **Rocket artillery with smart munitions**

Building on the enhanced DRB, we added additional RFPI systems to the force. For possible RSTA improvements, we considered two "unmanned" systems, the remote sentry (FLIR with acoustic cuer) and a UAV based a on close-range concept (such as the CL-227 Sentinel). Additional direct fire upgrades we examined included a kinetic energy missile (with relatively fast firing rates) to the AGS. We also examined the impact of wide area munitions (WAM). And we assessed the impact of augmenting the force with other indirect fire systems including shorter-range (relative to other indirect fire systems) precision guided mortar munitions (PGMMs) and longer-range rocket artillery (HIMARS with MLRS rockets containing sense and destroy armor munitions). All of these adjustments were made assuming constant airlift, where swaps of current DRB counterpart systems were made as necessary to the DRB; for example, addition of the HIMARS required some of the towed howitzers to be removed from the force.

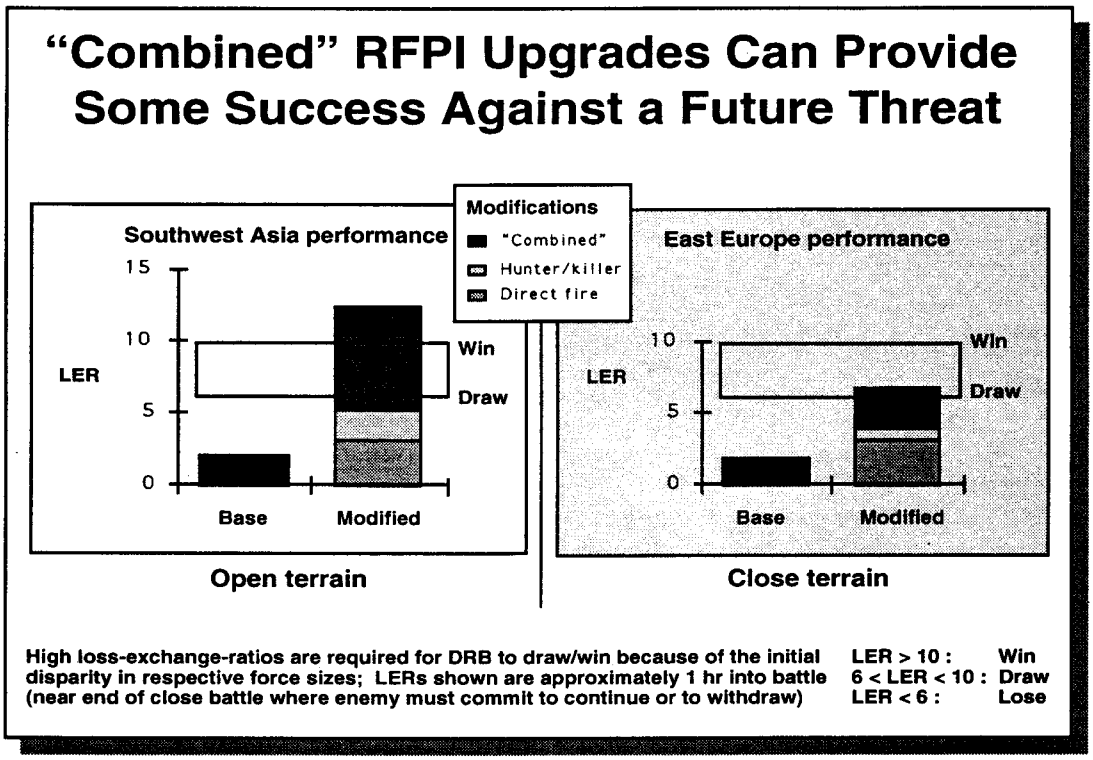
Additional RFPI Systems Provided Incremental Improvements



†Improvement to the loss-exchange-ratio for the enhanced force without "fast C2"

The above chart shows the impact of each RFPI system to the enhanced DRB LER. We found that most systems can provide at least some further improvement to the LER, but these tend to be relatively incremental improvements at best. The UAV did not survive in East Europe against radar-guided air defenses. The short-range precision guided mortar munitions competed with the direct fire systems and consequently did not provide meaningful improvement to the LER. HIMARS as an individual system traded-in to DRB was seen to be effective in Southwest Asia, but it was not assessed in East Europe because not enough sightings occurred of company-sized targets by the hunter sensors to call for this type of massed fire.

It is important to make the distinction that some systems come to the DRB with little or no airlift cost. For example, the remote sentry, the LOSAT missile, and wide area munition provided improvements without mandating a major swap-out. Other larger and heavier systems had to be "traded in," replacing other DRB systems. Thus, some systems should intuitively offer improvement, whereas others could increase or decrease the overall LER. Interestingly, when all of the listed systems are included in the simulation, a complementary improvement to the overall LER occurs. One example of this: WAM slows down the Red force and presents more opportunities for the other Blue indirect fire weapons to engage the force from afar.



The combination of the aforementioned RFPI systems was added to the enhanced DRB as described before (with improved direct fire and HSOK). In the Southwest Asia scenario against a future threat, the combination of systems provided enough improvement to the LER to offer a win, with an LER of 12.5 at the end of the close battle. Although there was considerable improvement to the LER in the East Europe scenario, it was barely enough to achieve a draw. For this scenario, we explored other means for achieving a win.

Exploring New Technologies to Overcome Scenario-Specific Force Weaknesses?

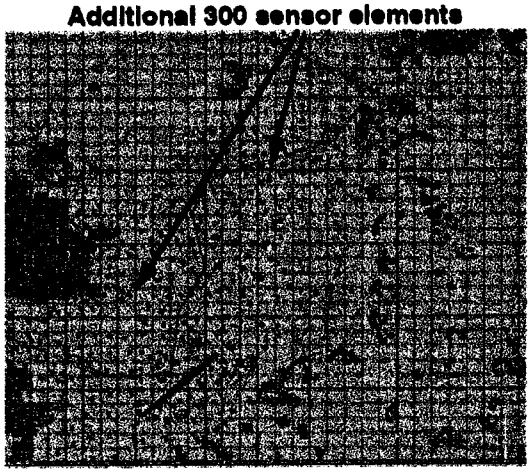
Current smart munitions have insufficient footprint against moving targets

Remote sentries and UAVs did not make up for lost hunter vehicles

- **Remote sentries are limited in numbers and vulnerable**
- **UAVs do not survive against high-end air defenses**

Add advanced artillery?
and
Notional distributed sensor net?

Additional 300 sensor elements



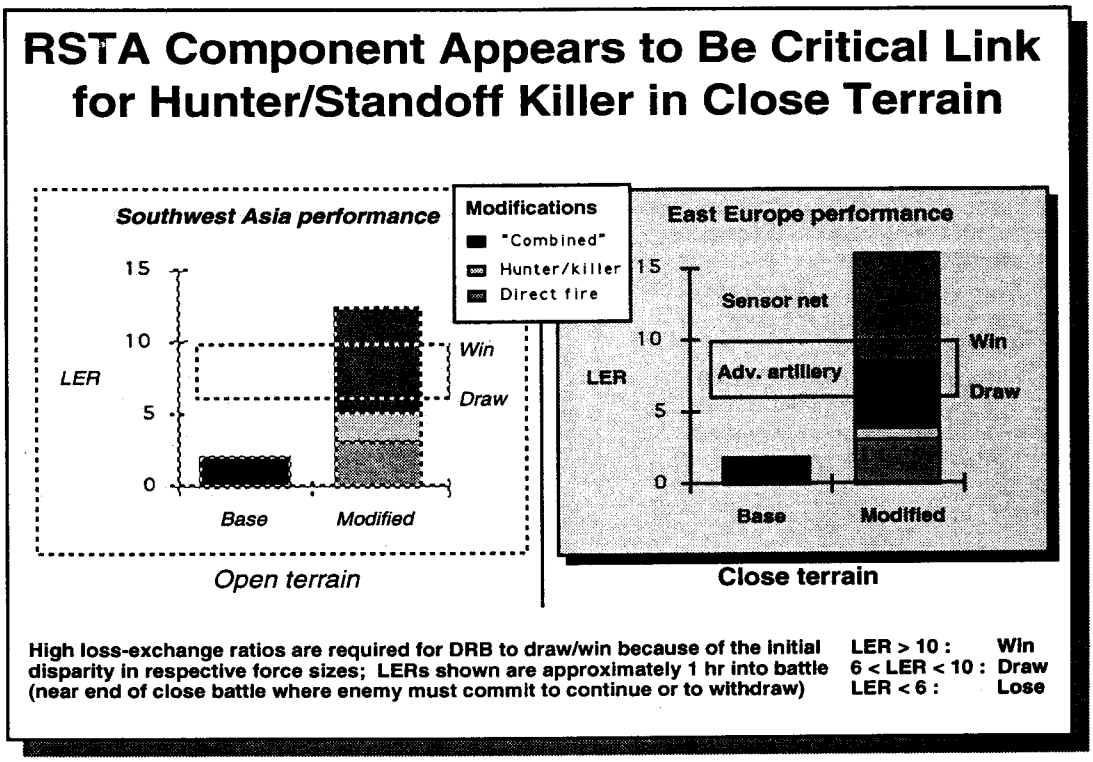
Janus screen image (E. Europe)

Two reasons were identified for the inability of the DRB, even with the combination of RFPI systems, to achieve a win in the East Europe scenario (with the HSOK system providing substantially less benefit than expected).

For one, the addition of the smart munitions was not exploitable because of the inability of relatively small-footprint munitions (a 75-meter radius in this case) to effectively "encounter" mobile targets in a dispersed attack formation. Although directly related to the quality of the RSTA that was available in this scenario, a larger-footprint munition that could better "seek" targets might have provided a means for ensuring an encounter with the combat elements of the attacking force.

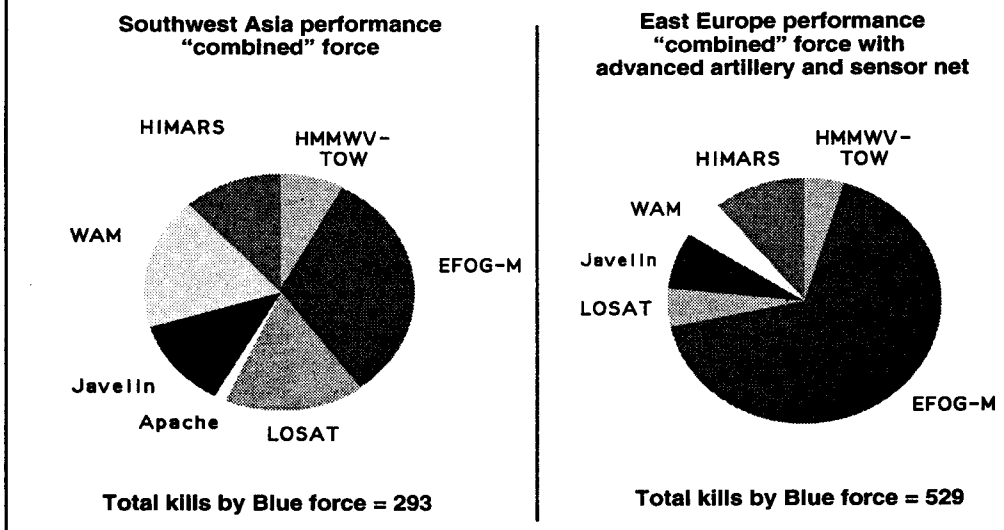
The second reason that the "combined" DRB did not win was directly attributed to sensor availability. The post-simulation analysis showed that the majority of forward-positioned sensors (manned hunter vehicles, remote sentries, and UAVs) did not survive throughout the engagement in East Europe. Thus, while the situation was target rich, the DRB was not able to fully capitalize on the indirect fire systems.

To examine these possible shortfalls, we postulated the following improvements to the DRB: (1) add a larger-footprint submunition (3x radius) to increase the probability of "encounter" and (2) add a large (300 element) distributed sensor net.

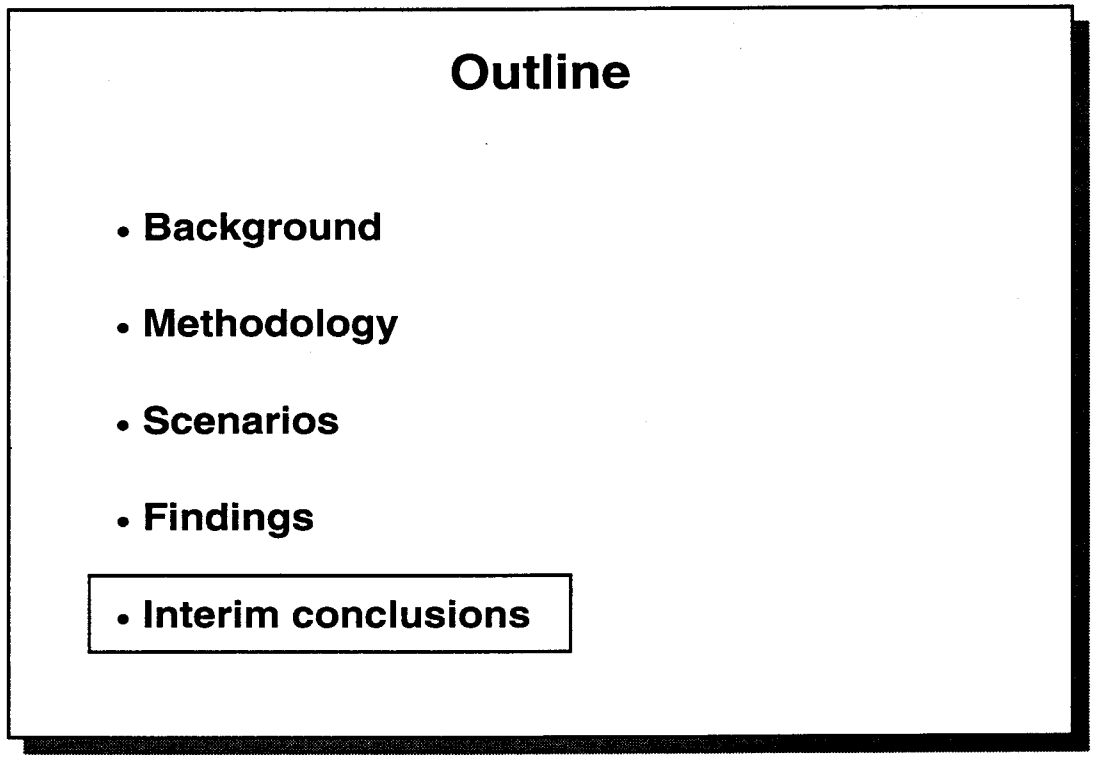


As expected, the two notional changes to the DRB in the East Europe scenario (addition of a larger footprint munition and an extensive distributed sensor net) were able to improve the LER to the point where a decisive win was attained. The above chart shows the cumulative effects of first adding the advanced artillery and then further adding the sensor net. As it turns out, the more advanced artillery with larger-footprint smart munition was not sufficient to provide a win. Rather, the lack of a good RSTA proved to be the deciding factor. With the addition of the notional distributed sensor net, the DRB performance at the end of the close fight yielded an LER of 16.

Moderate Number of Non-LOS Systems Produced Majority of Kills

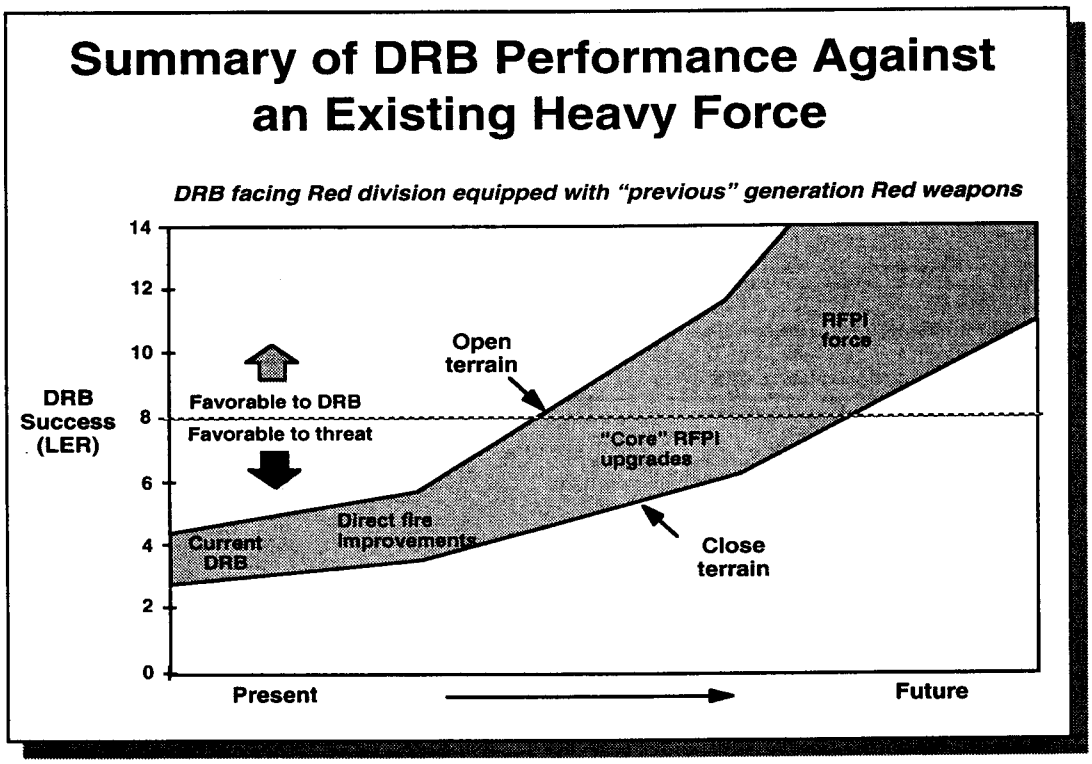


Breaking down the total kills of the "combined" force DRB by weapon type in the two scenarios revealed that an even larger proportion of kills could be attributed to indirect fire systems, especially notable in East Europe. Before, in the East Europe scenario, against the current-generation threat, much of the lethality was due to Javelin, against the future threat, the large percentage of kills were made up by EFOG-M with major participation also by HIMARS (both operating as standoff killers in the HSOK concept). This is the case even though a major part of airlift is still dedicated to the direct fire systems including LOSAT, HMMWV-TOW, Javelin, and Apache.



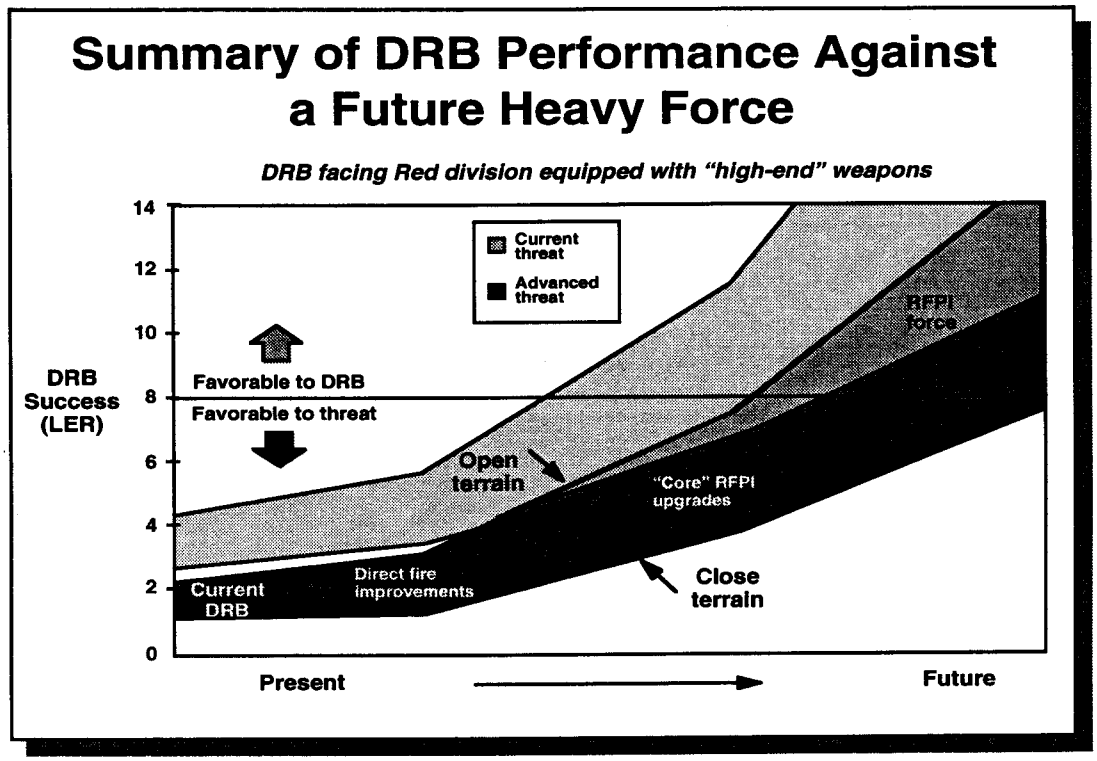
6. INTERIM CONCLUSIONS

In this final section, we provide a summary of our simulation-based results and conclusions.



In the above chart, we summarize the performance of different DRB enhancements against a current-generation heavy force. Generally, we see that, with an increasing number of RFPI-based upgrades, the performance of the DRB improves considerably, from a certain loss to a likely win. Direct fire improvements offer only marginal returns on LER performance. Depending on the terrain type, few-to-many RFPI enhancements produce dramatic change to the outcome of battle.

Depending on the terrain type, open versus close, the DRB performance varies substantially. The improvements in open terrain were much more dramatic than in close terrain. Much of this is attributable to the tactical "cost" of operating in close terrain, supporting the notion that more-difficult terrain and coverage in general can, in effect, reduce the inherent technological sensor advantage of the DRB. Similarly, we might expect the improvement to be even less in a more challenging environment, such as a jungle-like setting.



If the DRB faced a much more capable threat force, we found the LER was reduced by about a factor of two across the board. Instead of the 3-to-4 LER that is achievable by the unimproved DRB against a current-generation threat, the LER is closer to parity against a future threat, between 1 and 2. Improving the direct fire capability does little toward improving the LER situation. Not until the addition of the HSOK elements of the RFPI are there enough improvements to insure the force a win.

However, even with all of the RFPI components considered in this analysis, the DRB was still hard pressed to achieve a win in close terrain. Only when a notional RSTA asset was added to the close terrain scenario were dramatic improvements in force performance realized.

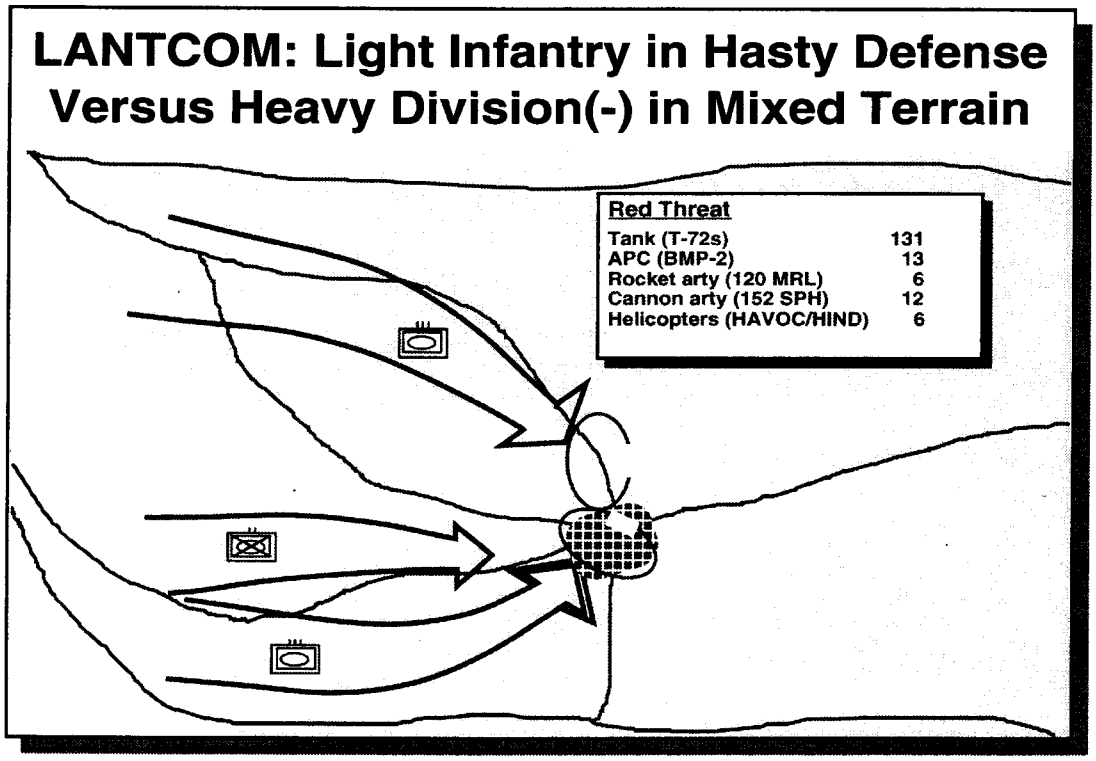
Conclusions

- **Light airborne forces can be improved in defense against heavy forces with new technology concepts**
  - **Battlespace can be extended to indirect fire area**
  - **Close-in battle can be shaped**
- **"RFPI" enhancements can be added/tailored to counter different levels of enemy sophistication**
- **Effectiveness of light airborne forces is highly dependent on terrain**
  - **In open terrain, simulation shows large payoffs with the addition of relatively few enhancements**
  - **In close terrain, *hunter* performance can be limiting factor, with shorter LOS and "surprise" encounters**

In conclusion, our simulation-based analysis suggests that light airborne forces, in particular a DRB, can be improved in defensive operations against a much larger heavy force. New technology concepts such as the hunter/standoff killer can provide an extension to the battlespace that can allow the fight to begin sooner and at farther ranges. This type of shaping of the battlefield also helps to minimize the consequences of the close-in fight as the main attacking forces are "metered in" at a more serviceable rate.

We also found that different levels and types of RFPI systems (and in one case, a non-RFPI system) can be tailored to provide a win, depending on the circumstances of battle (e.g., current-generation force versus future force and close terrain versus open terrain). In open terrain, simulation showed that large payoffs could be obtained with relatively few enhancements, whereas in close terrain, a more extensive RSTA capability might likely be required.

Appendix A--Planned Work



The new scenario we will be examining is a DRB forced entry into LANTCOM theater. While not facing as large a threat force (two regiments) as in the other two scenarios, the DRB is also smaller in size (attrition down to two battalions from an earlier forced entry phase). While this scenario was developed specifically for RFPI analysis, it is based on the TRAC High Resolution scenario 33.7.

Future Project Work Emphasizes Countermeasures

- **Initial work was based on available data and early estimates of performance**
  - **Data is being refined (MICOM, AMSAA, ARDEC)**
  - **System concepts are evolving through ATD development lessons learned**
- **Viability of technology concepts, in light of possible threat counters, is of increasing interest**
  - **RAND is tasked to head this effort**
  - **Task is being accomplished with model development effort and comprehensive analysis**

Much of our current work has involved examining the viability of emerging technologies to foster significantly different ways to fight. Although we will continue this effort, much of our future work will be directed to exploring the vulnerabilities of the RFPI concepts. Formally, RAND has the responsibility to head the "Red team" effort, which will involve generating possible ways the RFPI force can be defeated. This effort, which will encompass examinations of threat technologies, tactics, terrain usage, weather effects, and other factors, will also include a look into possible counter-countermeasures.

Current Insights Are Raising New Questions

- **With highly effective standoff capability, are multiple direct fire systems needed?**
- **What combination of manned and unmanned RSTA systems make sense?**
- **Can single C2 system be used to link a wide variety of hunters to killers?**
- **Which indirect fire systems effectively "match" available suite of RSTA systems?**
- **How do new technologies drive battlefield rules of engagement (or vice versa)?**

Our analysis to date has created almost as many questions as answers. Specifically, one overarching question comes to mind:"Given that new technologies can enable new ways to fight (such as the hunter/killer concept), to what extent should these new ways to fight be introduced?" Our analysis indicates that indirect fire systems have inherent value for shaping the close fight/direct fire battle, suggesting that direct fire systems, while they appear necessary, may not have as much leverage for light forces.

"If the hunter/killer concept is instituted, what is the right balance between direct and indirect fire systems (an old way that has been proven to work versus a new way that may not always work)?" Our planned countermeasure work should provide some insights.

A number of other high-level questions have emerged on RSTA system or combinations of systems needs, C2 system architecture alternatives, indirect fire munition needs (to be assessed in conjunction with the RSTA systems), and constraints on how system technologies might be used in the future (e.g., rules of engagement). As we move forward, we expect to gain further insights into these issues.

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DB-168-A/OSD

ISBN 0-8330-2428-0