ARMY SCIENCE BOARD

FY2001 SUMMER STUDY

FINAL REPORT

DEPARTMENT OF THE ARMY
ASSISTANT SECRETARY OF THE ARMY
(ACQUISITION, LOGISTICS AND TECHNOLOGY)
WASHINGTON, D.C. 20310-0103

"THE OBJECTIVE FORCE SOLDIER / SOLDIER TEAM"

VOLUME III
BACKGROUND AND CONTEXT

November 2001

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The Army Science Board was tasked to: (1) Characterize the level and nature of lethality, survivability, logistical and information systems for command, control, communications and computer improvements that must be achieved to yield a more effective Objective Force Soldier across the operational spectrum. Evaluate connectivity/interface between Future Combat System variants and the Objective Force Soldier. (2) Map the technology from present to future that would obtain the improvements as described above. (3) Include in the technology roadmap an assessment of current and projected Research Development and Acquisition efforts. Highlight those areas where modest investments now may yield significant capabilities in soldier effectiveness, weight reduction, power efficiency and affordability of soldier systems. (4) Recommend alternative science and technology strategies that can provide the level of improvements outlined above. Stratify the level of cost, technical and schedule risk associated with each alternative. Address emerging technologies from academia, industry and other government agencies. The ASB responded by identifying specific goals, highlighting the uncertainty in connectivity, identifying top effectiveness gains and preparing S&T investment/activity roadmaps. Each ASB subpanel provided specific recommendations corresponding to subpanel topics: Future Threats, Conceptual Framework, Analysis, FightabilityTechnologies, Weight Considerations, Power System Technologies, Manpower and Personnel, S&T Investment Strategy, Affordability and Cost Control, Senior Officer Observations.

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CONFLICT OF INTEREST

Conflicts of interest did not become apparent as a result of the Panel's recommendations.

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Bold denotes Panel Reports included in this Volume. For a listing of all participants see Appendix B

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The Objective Force Soldier, Fightability, Objective Force Fightability, Soldier System Weight, Power, Battlefield Power, Soldier System Power, Science and Technology, Soldier Systems Science and Technology, Soldier Systems Investment Strategy, Affordability, Soldier Systems Affordability, Cost Control, Soldier Systems Cost Control, Threats, Future Threats, Soldier Systems Conceptual Framework, Manpower & Personnel, Objective Force Manpower & Personnel, Senior Officer Observations

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In memory of LTG Timothy J. Maude,
Deputy Chief of Staff for Personnel,
who lost his life in the terrorist attack
on the Pentagon, 11 September 2001.

The Objective Force Soldier / Soldier Team

Volume III - Background and Context

Table of Contents

* The ASB will also publish the Manpower and Personnel Special Study separately and more completely in the Special Study Report entitled "Manpower and Personnel for Soldier Systems in the Objective Force."

The Future Threats Panel looked at the world environment during the 2008 to 2015 timeframe and attempted to characterize the threats that the Objective Force Soldier is likely to encounter.

We focused primarily on threats to the dismounted soldier.

SUMMER STUDY 2001

Future Threats Panel Membership

ASB Members

- **Robbi Perna, Norwich**
- **Tony Hyder, Notre Dame**

Government

- **Kathleen Kinsella, DA**
- **Earl Rubright, CENTCOM**
- **Mary Scott, DA**
- **CDT Kenton Justice, USMA ‘02**

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A small but dedicated group.

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Briefing Overview

- Future World Environment
- Impact of the World Environment on the Future Security Situation
- Resulting Future Threat Environment
- Threat to be Countered by the Objective Force Soldier

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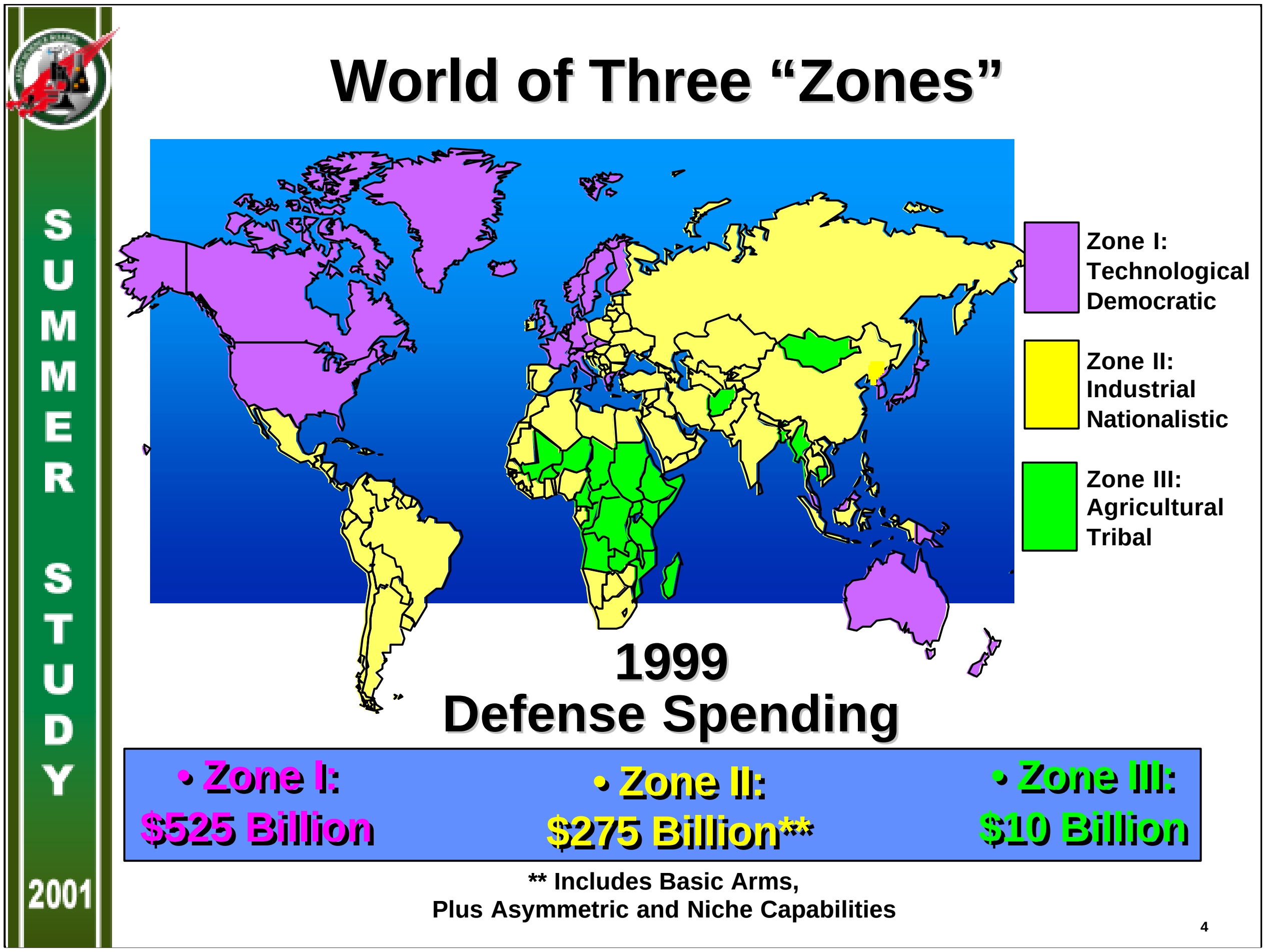
The overview of this brief tracks the panel mission



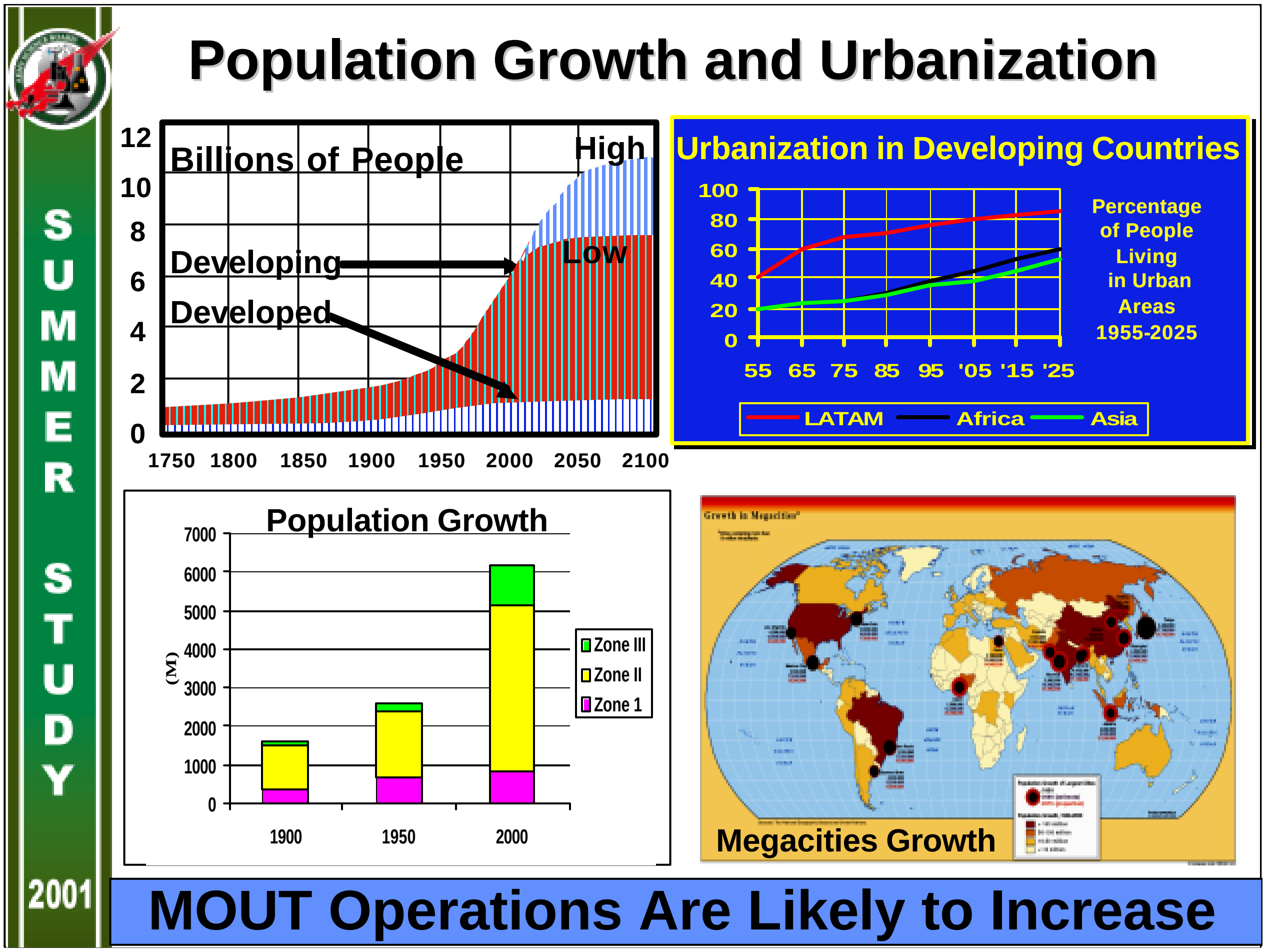
In characterizing the world environment, we divided the world into three zones, based on a country's economic and political status.

Zone I states consist of highly industrialized, democracies whose economies are now based upon technological progress, rather than further industrialization, while Zone III countries are largely tribal in political outlook and still dependent on agriculture.

Zone II comprises industrial, nationalistic countries. These countries are experiencing stress with resulting unrest that could lead to future conflicts with great potential for triggering U.S. military involvement. Their defense expenditures approach $300B annually, mostly for procurements since they carry relatively low personnel and R&D costs. Many of these countries also export arms.

This figure does not include expenditures by non-state entities which may be based in Zone II.

Here are some of the stressors we believe will create conditions that will increase instability during the Objective Force soldier timeframe

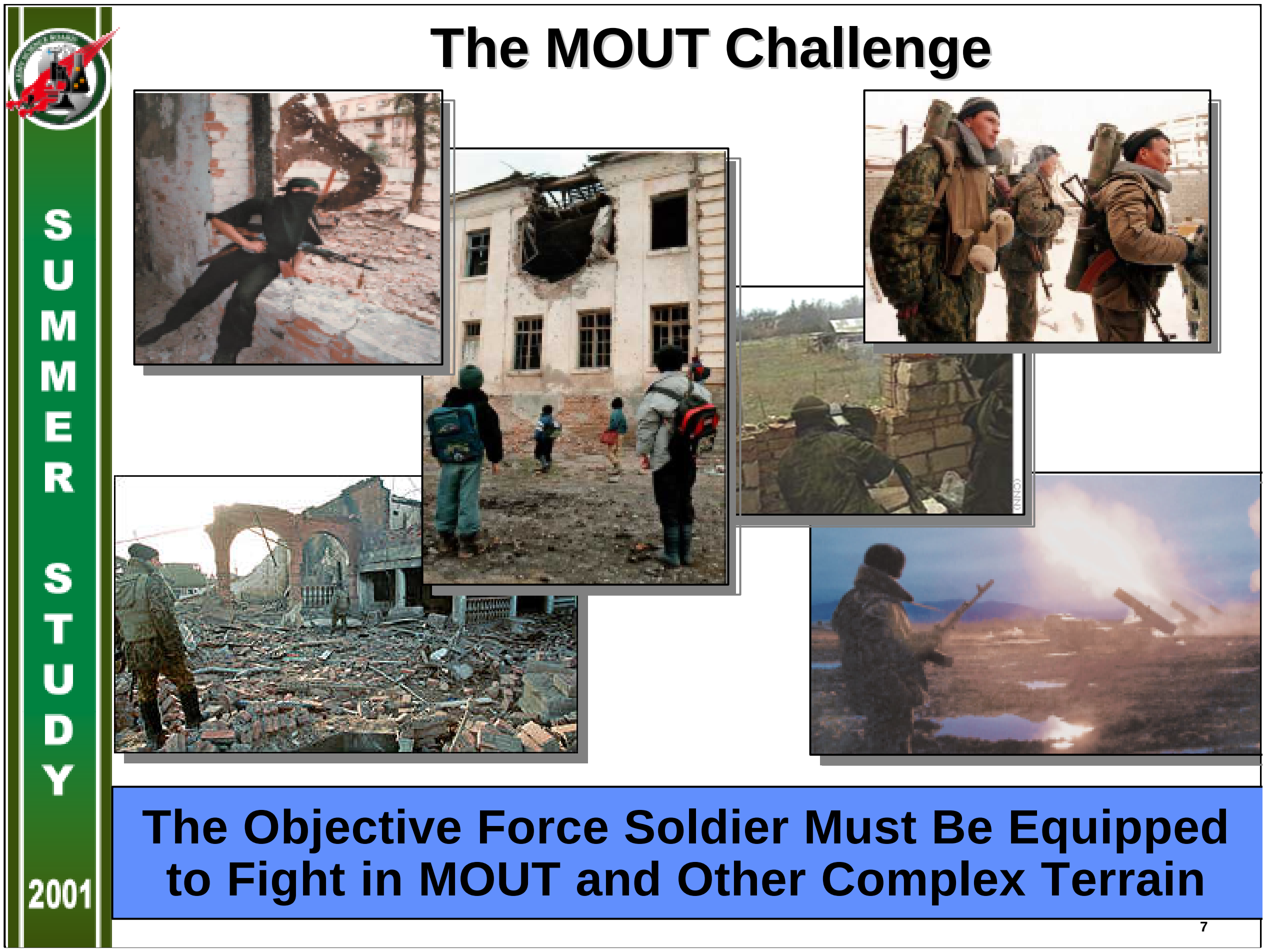


As one example, perhaps the dominant stressor is demographics.

The world population is expected to increase by at least 1B people by 2015

Most of the growth will occur in Zone II countries, who are the least equipped to accommodate growth, and where most of the growth will occur in already overcrowded urban areas.

This will give rise to a number of Zone II megacities and the inherent infrastructure problems that such growth creates will further undermine the stability of those regions.



This is all to say that the likelihood of MOUT will increase in the era of the Objective Force Soldier.

and we know well the challenges that urban operations pose, as seen in these images from Chechnya.

Unlike Chechnya, however, we may not have the option of demolishing cities.

There may be no alternative to placing the dismounted soldier in that environment.

MOUT is a critical area in which many of the S&T investments, identified later in the study, can bring significant improvements to our capabilities

Over the next 15 years, the United States is unlikely to face a military force that is willing to go toe-to-toe against our armed forces.

However, the threat environment will remain formidable. Strategic threats continue with some additions, and U.S. soldiers will face fairly sophisticated enemies -- enemies who understand U.S. vulnerabilities and who will try to capitalize on them.

These adversaries will have a myriad of modern weapons and technologies at their disposal.

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Threats to the Objective Force Soldier

Listed in Relative Probability of Occurrence*

* Worldwide, Conventional Conflict

Casualty Producing	Performance Degrading
• Fragment	• Vision Enhancement
• Bullet	• Radar
• Blast	• Ground Sensors
• Flame/Incendiaries	• U A V
• Lasers	• Camouflage, Cover, Concealment, Denial & Deception (C3D2)
• Chemical	• EW & IW
• Biological	• RF Weapons
• Nuclear	

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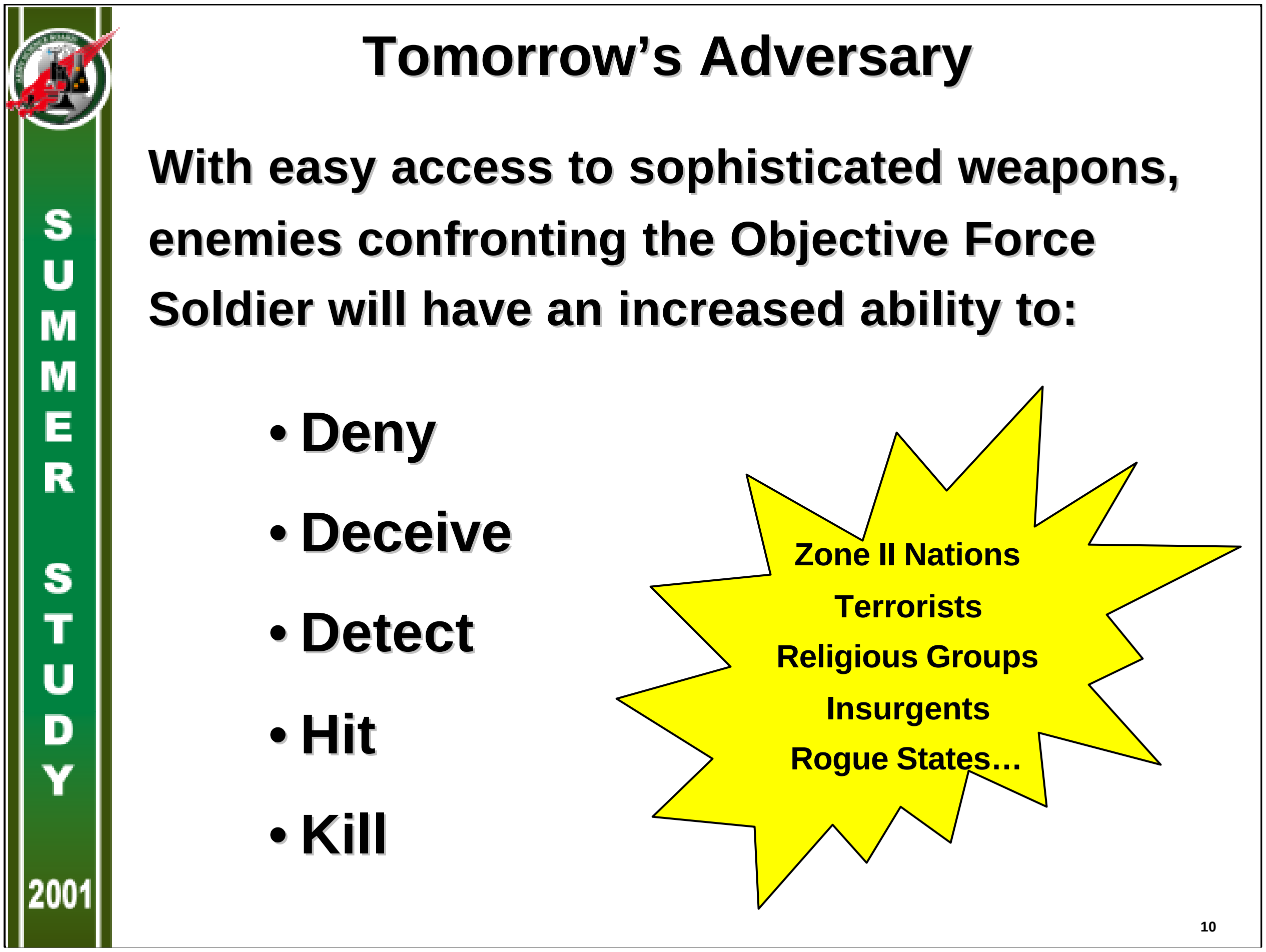
The rise in the threats created by the proliferation of these modern weapons fall into two categories:

- those that directly produce casualties and
- those that degrade systems needed by the soldier.

The full panel report will detail each of these threats to the dismounted soldier.



But for now, we want to key in on them collectively and briefly highlight some examples of the enemy's increased capability in these five areas:

Deny

Deceive

Detect

Hit

Kill

recognizing that the threat can come from a number of directions

One of the most challenging threats that the dismounted soldier will face is the enemy's increased capability to deny access.

Deep Strike Artillery may deny access to ports and staging areas.

A new Air Defense Artillery airburst munition –the AHEAD round-- is designed to be especially effective against helicopters. Antipersonnel rounds have also been developed.

Snipers have always been effective in denying territory, and modern obscurants can reduce the effectiveness of our PGMs.

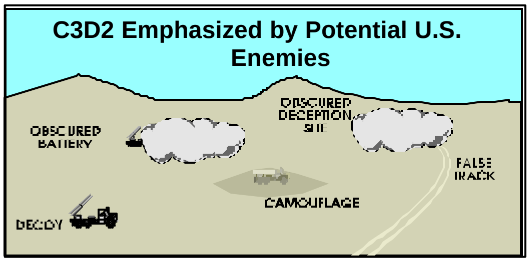
Today, estimates place as many as 84 million land mines in various regions of the world, some with sophisticated fusing, fragment shaping, and advanced, high-energy explosives.

Mine Layer – Skorpion -- covers an area 1500 m x 200 m in 10 minutes.

Later in the Study, you will hear of some S&T opportunities to counter these threats.

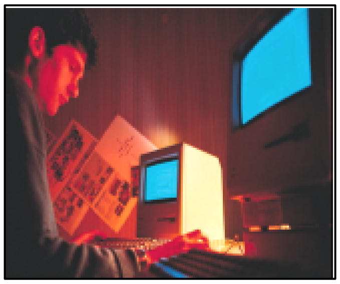
SUMMER STUDY 2001

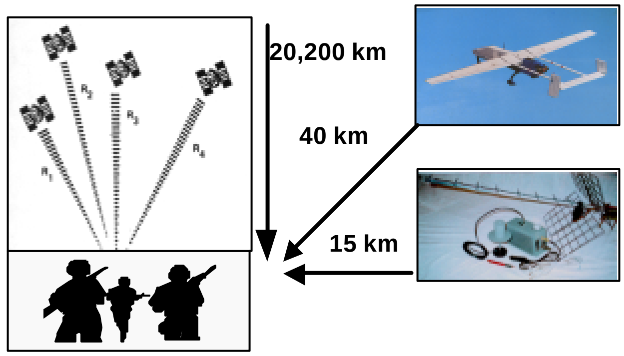
Increased Ability to Deceive



- **Camouflage, Cover, Concealment, Denial & Deception (C3D2) Threat**
  - **Today: Unsophisticated C3D2**
  - **By 2015: Multi-Sensor C3D2**

- **EW, IW, & RF Threat**





  - **Communication System & GPS Vulnerable to Enemy EW & RF**
  - **EW & IW Threat Expected to Rise Sharply by 2015**
  - **RF Expected to Become Credible Threat by 2020**

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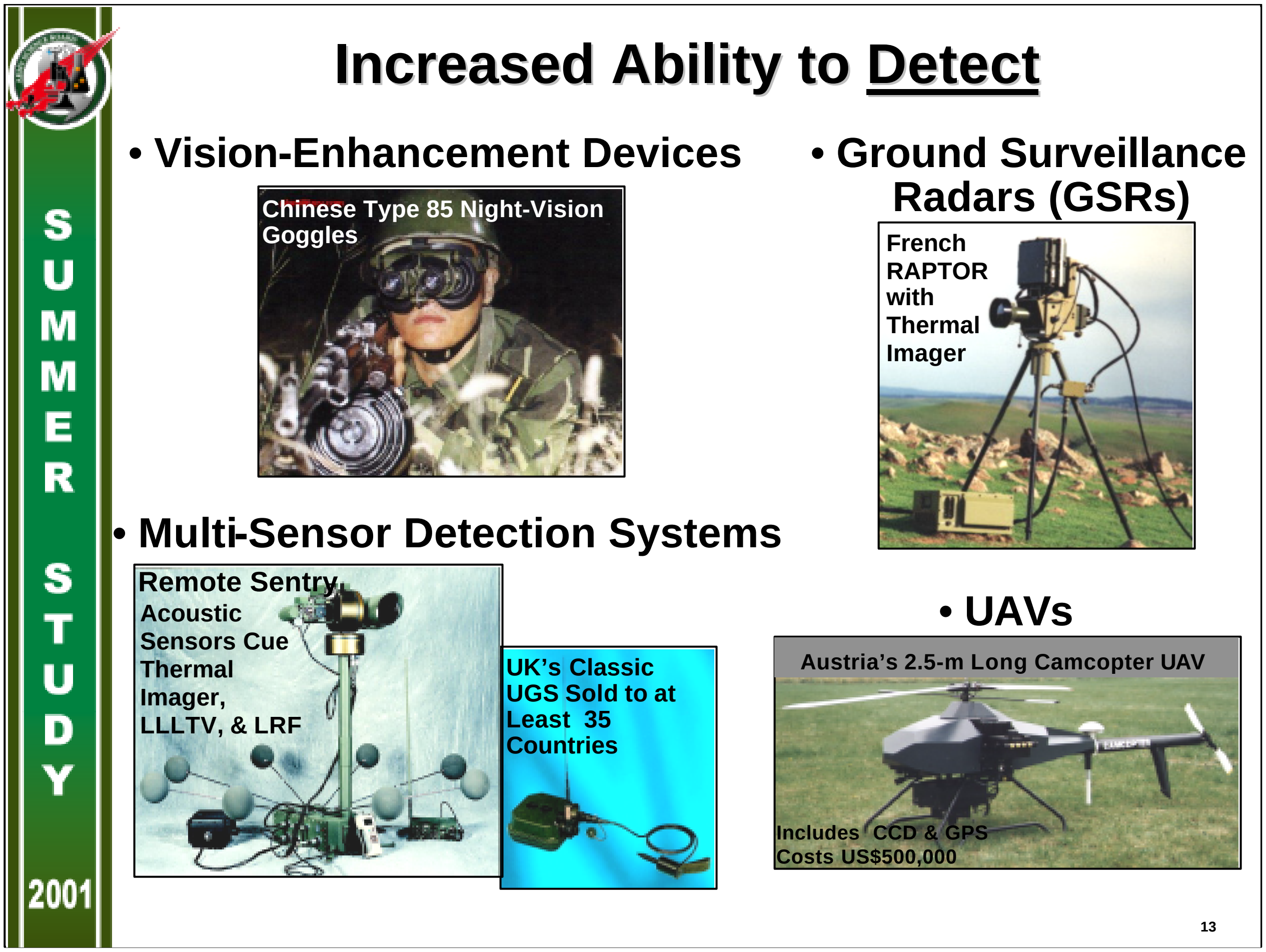
Potential adversaries recognize the emphasis placed by the United States and its allies on “situational awareness.”

These adversaries see our dependence on sensor systems as a potential weakness and are developing ways to take advantage of this perceived shortcoming. As an example, digital communications will be vulnerable to future RF weapons.

They will track improvement in our capabilities with improvements in theirs.

In short, EW and IW will be facts of life.



These detection systems are representative of those currently available to adversaries around the world.

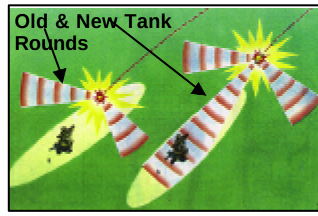
Our longstanding asymmetric advantage in night vision is being eroded. By the time of the Objective Soldier, we will no longer own the night.

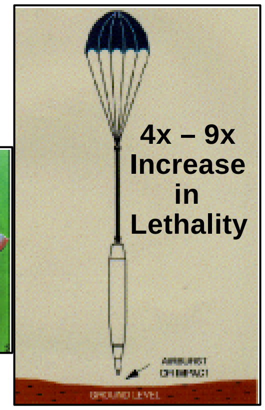
Whether it is night vision, radar with thermal imagers, multisensor detection, or UAVs, the equipment is readily available and sales are brisk.

SUMMER STUDY 2001

Increased Ability to Hit

- Sighting Devices

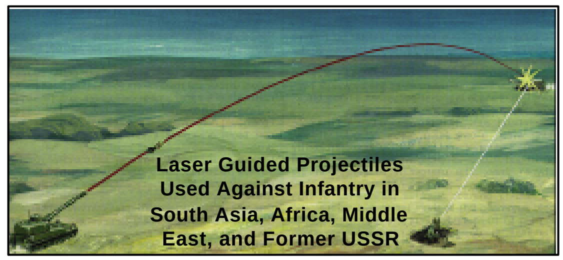




- Fuzing & Orientation Technologies

- Fire Control Systems

- "Smart" Munitions



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Precision targeting was once the purview of only the most advanced armies. This is no longer the case. A range of technologies now enhance the capabilities of weapons systems, from small arms to artillery, to place their munitions "on target."

These advances come from improvements such as simple magnification and laser range finders with programmable fuzes, to systems that provide the full ballistic solution

The adversary will also continue to take advantage of advances in fuzing, and orientation technologies to improve hit probabilities.

For example, a simple grenade launcher fitted with a laser range-finder and air-burst fuzing mechanism can increase its hit probability by as much as a factor of five.

Advances in both fabrication techniques and materials have increased the ability of enemy projectiles to kill their targets

Improvements in the manufacture of pre-formed fragments, bullet sizing and shaping, and more energetic explosives provide higher fragment velocities and increased projectile penetration.

Thermobaric warheads, enhanced-blast weapons developed for use in cave fighting in Afghanistan, were later found to be highly effective in urban warfare in Chechnya.

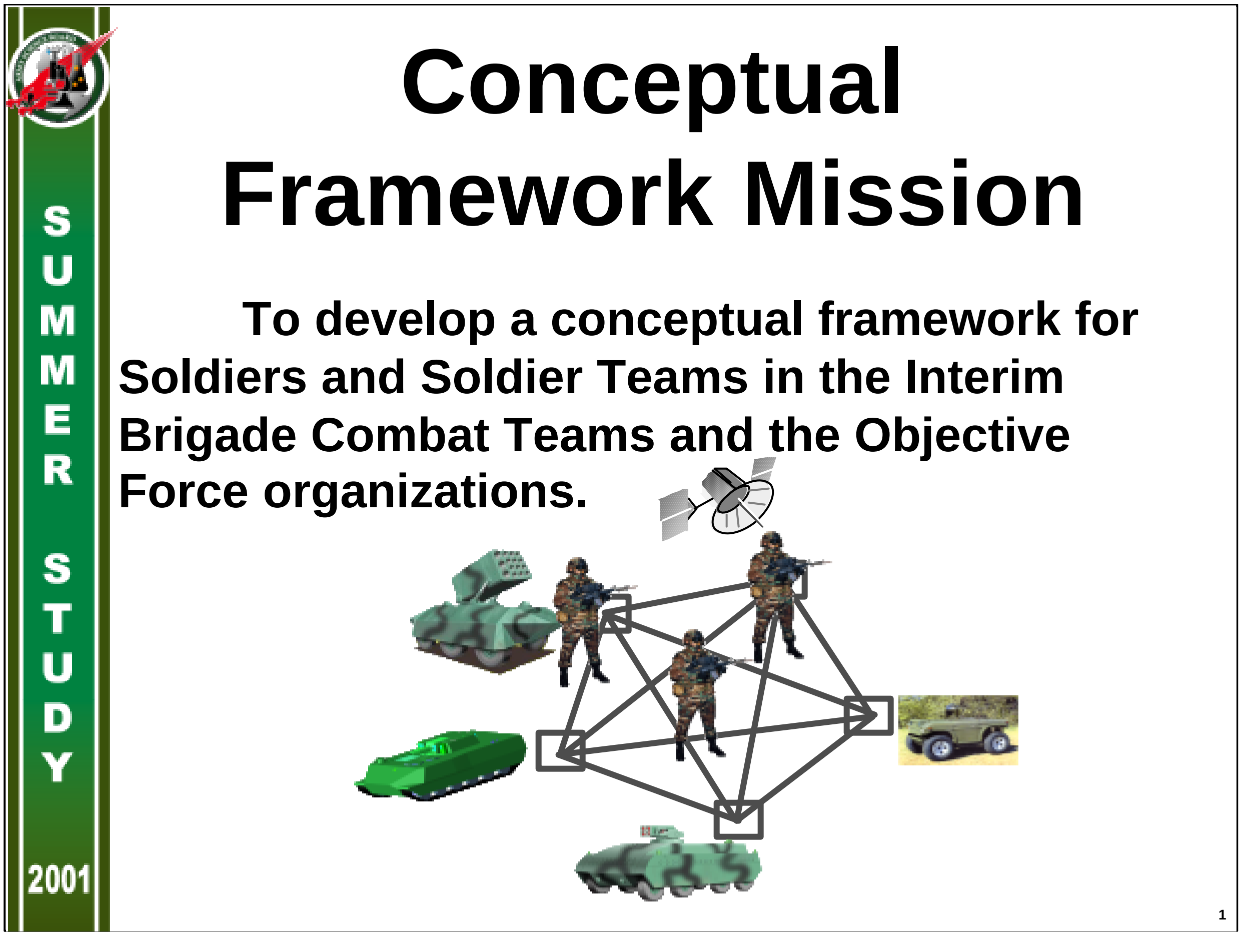
Thermobaric rounds for the smallest grenade launcher (RPG-7) to the largest multiple rocket launcher (Smerch) are now available.

The Objective Force soldier faces a formidable future.

We must equip him to respond to crises and conflicts across the spectrum. This is not a new message.

But unfortunately, something is new. No longer is a country dependent upon the weapons that they produce. Advanced weapons are readily available in the arms marketplace.

This creates the possibility of a sophisticated enemy who can exploit U.S. vulnerabilities using a formidable array of modern weapons and technologies.



CONCEPTUAL FRAMEWORK

1. Introduction

a. Purpose and Scope- This document describes a conceptual framework for soldiers and soldier teams operating within Interim Brigade Combat Teams and the early Objective Force organizations which will be introduced into the force during the 2015-2025 time frame.

b. Mission- The mission of the soldiers and soldier teams in the time frame of interest are not totally predictable, but will probably be very similar to the combat missions of today's infantry forces. The extent to which technological augmentation will be used to modify the execution of the missions is the focus of this concept. Soldiers and soldier teams will continue to have the primary mission to close with and destroy the enemy in mid-intensity ground combat. Technology will help the soldiers remain at an advantageous range from the enemy soldiers when "closed with the enemy" and should also make it less necessary to close with the enemy to break his will to fight or to destroy him. Secondary missions of the soldiers and soldier teams will extend across the full spectrum of conflict including small-scale contingencies, peacemaking, peacekeeping and stability operations, and humanitarian operations. Soldiers and soldier teams must have the capability to accomplish these missions including all the explicit and implicit sub-tasks of these missions with "boots on the ground".

(Source: TRADOC)

2. Rapid Decisive Combat

Soldier and Soldier Team Overview

a. Future soldiers and soldier teams will operate in an environment of highly enhanced situational understanding. They will be transported rapidly via strategic and operational airlift, and fast sealift, to the operational area. They will move via lightly armored tactical vehicles to the engagement areas. Engagement areas may require humanitarian operations, peacekeeping operations, peace-making operations, or full scale mid-intensity combat. Because it must be prepared to enter early and survive first engagements in lightly armored vehicles, the force must know where the enemy forces are and must be able to engage effectively beyond line of sight to kill a high percentage of the enemy forces before the range closes to that of the direct fire fight with small arms and other direct fire weapons.

b. Soldiers will generally move about the battlefield in their armored vehicles using tactical mobility to enhance survivability. Since operations in complex terrain and the urban environment will likely be common, soldiers must be able to send strong dismounted elements into cities and complex terrain when the situation dictates. Soldiers and soldier teams must then fight on foot and retain their dominance over enemy forces, even in these harsh conditions. The emphasis in our Conceptual Framework is on these "Dismounted Warriors" who move about the battlespace in the fighting vehicle/troop carrier variant of the FCS, but must dismount and fight on foot over "…the last 100 meters."

What's New

In overview, we looked at these kinds of "new things" to improve the performance of our soldiers in the 2015-2025 time frame.

a. Network connectivity down to the individual soldier level is absolutely essential to provide increased situational understanding and reachback to fire and logistic support systems for the soldiers

b. Proliferation of effective night sighting devices and cheap smart sensors will be necessary for the required situational understanding enhancement

c. Special purpose equipment required for special situations will be available on demand

d. Robotic devices will play a role, with both UAVs and UGVs

e. New ways to do signature management will be available

f. New fire support and logistic support systems and concepts will be operational

g. And a number of others which are mentioned in the full Conceptual Framework document included in this report at Appendix XX.

SUMMER STUDY 2001

Facts and Assumptions

- Transformation Program brings in 5-8 IBCTs in next ten years
- FCS Program successfully produces system of systems
- Objective Force will be full spectrum force
- New O&O Concepts required for Soldiers and Soldier teams
- Forced entry Soldiers/Marines will have joint fire support
- Technology and reduced requirements will assist in improved sustainability
- Operations may occur under austere conditions

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4. Facts and Assumptions

a. The Army Transformation Program will go forward and will succeed in bringing at least 5-8 Interim Brigade Combat Teams (IBCT) into the Army force structure in the next ten years.

b. The Future Combat System (FCS) will be successful in producing a system of systems that will include a class of lightly armored vehicles with enhanced survivability and lethality for fielding to at least a limited number of units IAW the Transformation Program schedule.

c. The Objective Force including FCS units will be a "full-spectrum force", capable of engaging adversaries throughout the spectrum of conflict from Major Theaters of War, through Stability and Support Operations.

d. The combination of IBCT and FCS equipped forces will form a potent early entry force which will require a new and somewhat different O&O Concept for soldiers and soldier teams operating in these forces.

e. Forced entry by airborne, air assault, or Marine forces will be supported by joint fire support means.

f. Technological advances, precision munitions, and decreased weights of combat systems will improve capabilities to accomplish logistical support requirements. Improved systems reliability, reduced fuel requirements, and reduced consumption will occur allowing the logistics footprint in theater to be further reduced. All logistical operations will focus on enhancing fightability of the Objective Force soldiers and organizations. Mobility and adaptability are essential elements for survival of support forces on the future battlefield. Logistics footprints must be minimized while support operations are transparent to the customer.

g. Operations must be conducted under any conditions, especially within austere environments.

SUMMER STUDY 2001

Key Organizational Parameters

- **Embedded unit based capabilities**
- **Internetted combined arms in the company**
- **Direct sensor to shooter links – "Net Fires"**
- **Focused on dismounted operations**
- **Full-spectrum internetted operations and support**

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5. Key Organizational Parameters

a. Embedded unit based capabilities. The Brigade level organization will possess a full mix of direct and indirect fire weaponry consistent with the requirement for rapid strategic deployment of early entry forces.

b. Internetted combined arms to company level. The units will be organized as a complete combined arms team down to company level units.

c. Direct sensor to shooter links. Internetted fires will support the soldiers and soldier teams as all soldiers will function as sensors.

d. Focused on dismounted operations. The emphasis on training and operations at the company level and below will be on dismounted, close combat operations and their systematic support.

e. Full spectrum internetted operations and support. Situational understanding at all levels will greatly enhance operations including responsive sustainment operations. Internetted operations and support capabilities will allow reach back for net fires and net-based, assured logistics.

SUMMER STUDY 2001

Key Operational Capabilities

- Overmatching mobility at the tactical level
- Overmatching lethality, with embedded capabilities, and reach back for netted fires
- Highly enhanced situational understanding with robotic device augmentation
- Advanced force protection and survivability through active and passive capabilities
- “Never too late logistics”

6

Key Operational Capabilities

The force capabilities must include exceptionally high levels of mobility, lethality, situational understanding, survivability, and sustainability in order to possess the ability to dominate any enemy.

a. Overmatching mobility at the tactical level. The FCS family of vehicles and the IAVs that will be in the force will provide the soldier system the ability to gain maneuver dominance through speed over the ground. This enhanced mobility will also positively impact on the ability to accomplish rapid, direct resupply on the future battlefield.

b. Overmatching lethality, with embedded capabilities. The soldier system and its combined arms team at the company level, backed up by direct and indirect fire support at the battalion and brigade levels, must provide an overmatching lethality capability to the maneuver forces through greatly enhanced situational understanding and long range fires.

c. Highly enhanced situational understanding. The organic RSTA elements and the internetted intelligence means available from higher headquarters, to include the numerous networked sensors, must be effective to allow this force to be effective in both lightly-armored vehicles and in the dismounted mode.

d. Advanced force protection and survivability through active and passive capabilities. Technology must provide enhanced survivability for the lightly armored vehicles through ceramic and composite armors, electromagnetic armor protection, and active and reactive protection systems. Soldiers and soldier teams will be protected to a greater degree through enhancements to the soldier systems and enhanced tactical situational understanding.

e. Improved sustainability. Reduced consumption of fuel and expendables, enhanced systems reliability, and reduced munitions requirements allow rapid deployment and effective sustainment of the force. The soldiers and teams must have complete confidence that logistical support is assured and “never too late”.

SUMMER STUDY 2001

Mounted Operations

- Rapid movement in offense exploits mobility for advantage
- Full situational awareness using common relevant operating picture
- Engagement at range with multiple means to destroy major portions of enemy force
- Soldiers plan and prepare for the "close fight" enroute exploiting information dominance to maximize surprise on key targets.

7

7. Mounted Operations

The purpose of mounted operations is to gain rapid positional advantage on the enemy as a prelude to decisive operations. Decisive operations are military operations that compel the enemy to submit to the will of the friendly force coalition. Objective Force soldiers equipped with the Future Combat System family of vehicles will habitually operate with the vehicle and crew as an essential part of the team. The soldiers will routinely operate in the mounted mode when the enemy situation is relatively well known and speed of movement is paramount. When road networks and rolling terrain allow, mounted tactical movements of great rapidity will facilitate decision at the tactical level. In a mounted phase of an operation, soldiers and soldier teams who form the dismounted component of the force are basically passengers enroute to a dismount point. They may perform certain essential functions while being transported such as getting situational understanding updates and rehearsing actions upon dismount, but they are essentially passengers in an armored carrier for the most part.

SUMMER STUDY 2001

Mission Tailored Loads

- **Modular loads**
- **Vehicular Arms Room**
- **Shared Mission-specific items**
- **Plans/ Options for supply**
- **Basic load options for 24-72 hours**

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8. Mission Tailored Loads

The unit that dismounts from the FCS carrier must possess a degree of self-sufficiency for limited periods of time. Soldiers and soldier teams will move on foot ahead of and to the flanks of their vehicles to provide local security in close terrain, or when the enemy situation is not clear. They will need only a minimum of equipment and should travel with basic ammunition and a day's supply of rations and water. These troops should be able to move easily through difficult terrain and fight with the loads on their backs, with possible assistance from robotic followers/mules. They will be able to use the vehicle as a base of resupply when they need additional rations, water, ammunition or special equipment.

Soldiers dismounting to conduct operations away from their vehicles for longer periods will necessarily augment the loads they carry. There will certainly be occasions when the roads and trails will not support vehicular movement along the desired avenue or route of approach. Commanders may wish to leave vehicles behind during an infiltration movement to enhance the stealth of a surprise maneuver and have the vehicles join the foot troops later by a different route after seizure of some objective or some key piece of terrain. In such instances, soldiers will carry heavier loads that must be of modular design so that they may drop the heavier load when engaging the enemy and fire and move with the basic combat load until the engagement is over and they can then be reunited with their heavier loads for continuation of the mission. The 1st Brigade of the 101st Airborne Division, as well as other units, operated in this mode routinely in Vietnam. The troops routinely moved on foot for four days at a time carrying four days of food and ammunition in their rucksacks. On the fourth day, they would rendezvous with a resupply helicopter that would bring in the next four days of supply of batteries, rations and any ammo resupply needed. When firefights developed, the soldiers would "drop rucks" and maneuver to destroy the enemy. Sometimes the firefights went on for several hours or even a few days. Normally the troops were able to gather up their rucksacks in time to get necessary items to support their activities.

In the future, soldiers should have the modularized SOP load options to conduct dismounted operations away from their vehicles for anywhere from 24-72 hours.

SUMMER STUDY 2001

Dismounted Operations

- Situational Understanding enhanced by robotic devices
- Assured connectivity
- Collaboration and decision support
- Reach back to precision fire support

- Finish decisively with enhanced individual and crew-served weapons
- Overwatching, combined arms fire support by FCS with links to Joint fires
- Direct sensor-shooter link to employ networked fires
- Robotic support vehicles

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9. Dismounted Operations

In difficult terrain such as mountains, heavy forests and jungle, rapid mounted movement may be impossible or too dangerous. Soldiers must then dismount to make tactical movements and to insure security during movement. In certain situations, it may be beneficial to conduct dismounted movements by infiltration to achieve surprise.

Despite the type of terrain in which operations are conducted, the final act of the offensive maneuver is necessarily performed by dismounted infantry soldiers and soldier teams when they close with and destroy the remaining enemy forces in the direct fire fight, as part of a final assault. Soldiers must have the benefits of all the attributes in the upper right quadrant of this chart in order to finish decisively with enhanced individual and crew-served weapons.

The FCS family of vehicles and other systems will provide overwatching fire support for the dismounted soldiers and provide links to Joint fire support. Quick reaction fire support is crucial to dismounted operations. Dismounted soldiers and soldier teams will habitually operate within range of responsive fire support assets. Whether it be Net Fires, conventional artillery, Naval gunfire, close air support, or attack helicopters, soldiers conducting dismounted operations must have responsive fires capable of engaging close-in enemy forces with speed and precision when the tactical situation demands. This means that the soldiers must have that assured connectivity into the network as well as the assets available within range to apply the fires where they are needed. There should be no difference in the fires available to mounted forces or to dismounted forces. The seamless connectivity of the tactical internet must insure that the enemy and friendly situations, as well as all varieties of friendly fire support, are equally available to all friendly elements whether mounted or dismounted.

Dismounted soldiers should have direct sensor to shooter links so that a target designated is a target hit by organic or supporting fires.

The soldier should operate with as little load as necessary on his back and employ the FCS vehicles and robotic vehicles to help carry additional loads as far forward as possible.

Urban Operations

SUMMER STUDY 2001

- **Close and vicious fight**
- **Reduced situational understanding**
- **Fire and log support from vehicles**
- **Robotic support vehicles, ground and air**
- **Direct sensor/shooter links**

10

10. Urban Operations

Urban combat will be a special case of dismounted operations. Urban combat is normally dictated when the enemy chooses to make a fight in the urban environment and our soldiers must fight in the urban environment to destroy those enemy forces and regain control of the urban terrain for tactical, operational or strategic reasons. In this case, it is expected that the soldiers and soldier teams will operate dismounted, but to the maximum extent possible, in close cooperation with the vehicles which will provide direct and indirect reinforcing and complementary supporting fires. Soldiers engaged in this most stressful environment will fight with the lightest possible loads and may be fairly closely supported by their vehicles. Resupply and casualty evacuation will be conducted by vehicle as far forward as possible—in the last covered and concealed position. As the fight begins, this position may be at some distance from the engaged forces. As the fight moves through the city environment, the vehicles should be able to move forward and operate in support while remaining in relatively covered positions, close behind the forward line of their own troops. Soldiers may expect to be resupplied often with necessary ammunition, batteries, and rations through periodic access to their own vehicles or to resupply vehicles moved into nearby covered positions behind the forward fight.

Communications and individual friendly force locations become problematic in the "urban jungle", but technology should solve that problem by the time frame 2015-2025. Absent some breakthrough technology, however, it will not be possible to have anything approaching 100% situational understanding of where all the enemy soldiers are located in the urban environment. We will be forced to fight these engagements without knowing everything about the enemy locations, but with a more powerful suite of sensors to help find them. The enemy will often be discovered only when he fires on our soldiers, and he may be a fleeting target - firing and moving quickly to engage from a different position. This will still be a very tough business to root the enemy out of a built up area. There will be friendly casualties and there will be collateral damage and attendant civilian casualties. There is no getting around these facts. New technology may reduce these adverse impacts, but it is hard to imagine that there will be enough great tools to make these issues of no consequence.

Enhanced situational understanding should provide a much-improved assessment of the enemy situation in an urban fight from a "big picture" level. That is to say, we should have the ability to determine relatively accurately the type formations and the approximate strength of the enemy forces engaged in a particular urban fight by monitoring enemy movements into and out of the city preceding the fight using a variety of available sensors. Once the enemy enters the urban complex, his movements are easily concealed from overhead means by moving underground and through holes knocked in the walls between buildings or by blending in with the local population. Thus detailed tactical information about specific enemy locations within the urban complex will remain a difficult problem.

Friendly offensive operations to clear and secure urban terrain will be the most demanding urban warfare task because soldiers will be fighting on terrain of the enemy's choosing and they will not have the advantage of placing hidden sensors throughout the battle space before the combat is joined. Soldiers will have to overcome the barriers the enemy builds, the fortified positions he creates within the rubble and the intact structures, and the human shields the enemy may employ. This is one of the most demanding combat environments imaginable because our advantages of dominant maneuver and total situational understanding are reduced significantly. The only way to root out a determined enemy who is willing to fight and die behind hasty and deliberate fortifications in a city shielded by civilians is to clear the city block-by-block and building-by-building until the enemy either loses the will to continue or is a casualty.

Support by direct and indirect fire from the FCS vehicles will be essential as will logistics support such as resupply and casualty evacuation. Robotic air and ground vehicles will be essential to augment situational understanding. Direct sensor/shooter links will be extremely useful in the urban fight.

Stability and Support Operations (SASO)

SUMMER STUDY 2001

- Increased situational understanding
- Common Relevant Operational Picture
- Low lethality weapons
- Human identification friend, foe, neutral capabilities

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11. Stability and Support Operations (SASO)

Stability and Support Operations—"the use of military capabilities for any purpose other than war"—cover a broad range of military activities. These include combating terrorism, support to counter drug operations, nation assistance, noncombatant evacuation, peace operations, show of force, support to insurgencies or counterinsurgencies, humanitarian assistance, and domestic support operations. These operations can be carried out in a permissive, relatively benign environment; or they can involve the threat or actual conduct of tactical combat operations. As a rule, these operations are governed by restrictive rules of engagement (ROE) and are more sensitive to political considerations than higher-end military operations. These operations require a very high level of situational understanding and a clear common relevant operational picture down to the individual soldier for greatest effectiveness.

When committed to SASO on a mission that involves the threat of the use of deadly force, the Objective Force is expected to take the role of a "combat guarantor force" that provides security and protection to forces and agencies charged with the core SASO mission. In this role, the activities of the soldiers and soldier teams are more complex. They will routinely operate both mounted and dismounted under very strict ROE. Ready access to non-lethal weaponry will be required. Training in the employment of these weapons must be added to the training requirements for the soldiers well before the situation demands use of the weapons. Certain of the SASO missions demand a great deal of discipline and good judgment at the lowest echelons of soldier teams. It may be necessary to deploy soldiers in the urban environment with a mixed load of lethal and non-lethal capabilities. ROE and good on-site judgment will dictate when one means should be used and when a switch should be made to the other means. The burden on the soldier can be reduced if technology will produce simple non-lethal devices that can be deployed easily on the FCS vehicles and can be employed readily by our soldiers and soldier teams when the mission dictates.

Significant augmentation of the Objective Force Brigade will be required in certain SASO missions. Often there will be more requirements for engineering services and police capabilities than the organic capabilities can provide. There will likely be augmentation needed to aviation assets, intelligence assets, possibly chemical defensive assets, and even command and control to deal with non-governmental agencies involved in the SASO mission. The specific situation must be analyzed using METT-TC to determine the amount and type of augmentation needed.

SUMMER STUDY 2001

Soldier Support Operations

- Netted Joint, Combined, and Commercial
- Seamless pull-push system
- Transparent to Soldier
- Enabling tools
- Customer focus
- 72 hours of support

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12. Soldier Support Operations

The Army should take the lead on developing a seamless, DoD-wide industrial logistical system of systems. The Army can begin to set the standard by developing a structure that easily functions in a joint, combined, and commercial environment. The objective force soldier and organization must have access to vital requirements from any source to assure maximum support effectiveness.

The Army should focus on logistical support structure and capabilities that are designed to link to commercial industrial systems and platforms. These capabilities and services must be leveraged as far forward as possible while organic systems within the Army and the Department of Defense must possess a robust capability to provide the services to the end users in the forward areas. Our support systems must be an integrated component of the logistical infrastructure and information systems of our industrial base. This linkage will allow us to better integrate the civilian acquired skills of our Reserve Component personnel who may then provide our best expertise for logistical mission execution. Further, unlike contractor support, these soldiers are trained and ready to perform their specialized functions in a combat environment possibly at the most forward areas of the fight.

The Army should not assume logistical problems will disappear without proper analytics. Modeling, simulations, and real world missions may be employed to test both current and future support concepts. It is imperative to address the hard issues of exactly when, where, and how the required support will be provided.

Employment of robotic devices, UAVs, mules, caches, micro-logistics, and other emerging, enabling concepts can certainly enhance support operations. Regardless of the means, all future support should be transparent and immediately responsive to the supported soldiers.

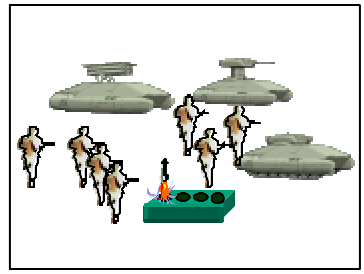
Logistical operations should focus on the perspective of the Objective Force Soldier and his needs. He is the customer and his satisfaction must be the Army's objective. Enablers must be available and organizational redesigns should address the focus of the war fighting commanders and their soldiers. An agile logistical support system will constantly adjust to the changing requirements of the supported soldiers.

SUMMER STUDY 2001

The Way Ahead

Army Transformation

Objective Force Soldier



Future Combat System

- **Keep the development of the Objective Force Soldier and the Future Combat System closely coordinated as we go forward in their development**
- **The soldiers must win and survive in either the mounted or dismounted role**

See First, Understand First, Act First, Finish Decisively

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13. The Way Ahead

Army Transformation has at least these two major components. The Army must work both of these programs under the oversight of a single General Officer so that they are coordinated and complementary.

The Objective Force Soldier System, operating within the context of the Future Combat System, will enable our soldiers and soldier teams to win and survive in either mounted or dismounted combat in the future. They will indeed be able to "See first, understand first, act first, and finish decisively!"

This briefing provides a summary of the major findings and recommendations of the Analysis Panel of the 2001 ASB Summer Study of Dismounted Operations in Complex Terrain. The Analysis Panel's membership is listed on the above slide. The Panel drew heavily on the skills of FFRDC participants who performed many of the analyses discussed in this briefing. The individuals who are designated as members of the Core Team actually participated in the report writing session that was conducted at the Beckman Center, Irvine, CA, during the period 16 - 26 July 2001.

Outline of Presentation

SUMMER STUDY 2001

- Introduction
- Assessment of M&S capabilities for dismounted operations
  - Limitations
  - Recommendations
- Analyses to support this study
  - Data mining
  - Simulation based analyses
  - Recommendations

Kosovo, 2000

This is an outline of the presentation. First we will provided a context for the briefing. We will describe the Panel's mission and identify the organizations that we visited. Second, we will discuss our findings and recommendations on existing and planned tools to support the assessment of dismounted operations in complex terrain. Finally, we will summarize the results of the analyses that were performed or adapted in support of this summer study.

The Main Report is supported by four appendices. Appendix A provides a chronology of the visits that the panel made. Appendix B provides supporting analyses about the tools to support the assessment of dismounted forces in complex terrain. Appendix C provides additional detail on the mission effectiveness analyses that the panel performed. Appendix D provides a list of references and useful web sites.

SUMMER STUDY 2001

Analysis Panel Mission

Hue

1968

Grozny

2000

- **Recommend initiatives to enhance assessment tools and capabilities**
- **Explore mission effectiveness to identify needed operational enhancements**

3

We had two related jobs to perform. First, we were charged with assessing the capabilities of existing analysis tools to support the assessment of dismounted operations in complex terrain. Based on that assessment we were asked to recommend initiatives to enhance these tools. Second, taking advantage of appropriate tools, we were asked to perform analyses to highlight those operational capabilities that were needed to enhance mission effectiveness appreciably. These latter results were provided to the other Study Panels to focus their efforts to identify relevant technological and system initiatives to achieve those operational capabilities.

SUMMER STUDY 2001

Key Visits

- Government sites (e.g., TRADOC, STRICOM, Natick, Ft. Benning, Ft. Bragg, Ft. Polk)
- Los Angeles (RAND, ICT, TRAC-Monterey)
- Washington, DC (IDA, MITRE, DMSO, AMSO, JVB, NVL, USMC MCWL)
- Albuquerque (Sandia, TRAC WSMR, LANL)

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In order to achieve the objectives of the Panel, the Panel members traveled widely to a number of sites and engaged in discussions on assessments and tools to analyze dismounted operations in complex terrain. A detailed chronology of the sites that the Panel visited is summarized in Appendix A. In addition, the Panel has assembled a compact disk containing copies of the presentations that were provided to the Panel at those sites.

The visits can be broadly divided into two categories: visits to operational sites (e.g., Ft. Benning, Ft. Bragg, Ft. Polk) and visits to analytical organizations. During the visits to operational sites the Panel members were exposed to the tactics, techniques, and procedures (TTPs) and operational issues associated with dismounted operations in complex terrain. During the visits to analytical organizations, the Panel members were sensitized to the capabilities and limitations of existing and planned assessment tools. In particular, the Panel became more conversant with a broad range of existing and planned analytic and training tools. The capabilities and limitations of these tools are discussed in the the next section. In addition, the Panel was briefed on the insights that the community has derived from the application of these tools and other experiences.

SUMMER STUDY 2001

Outline of Presentation

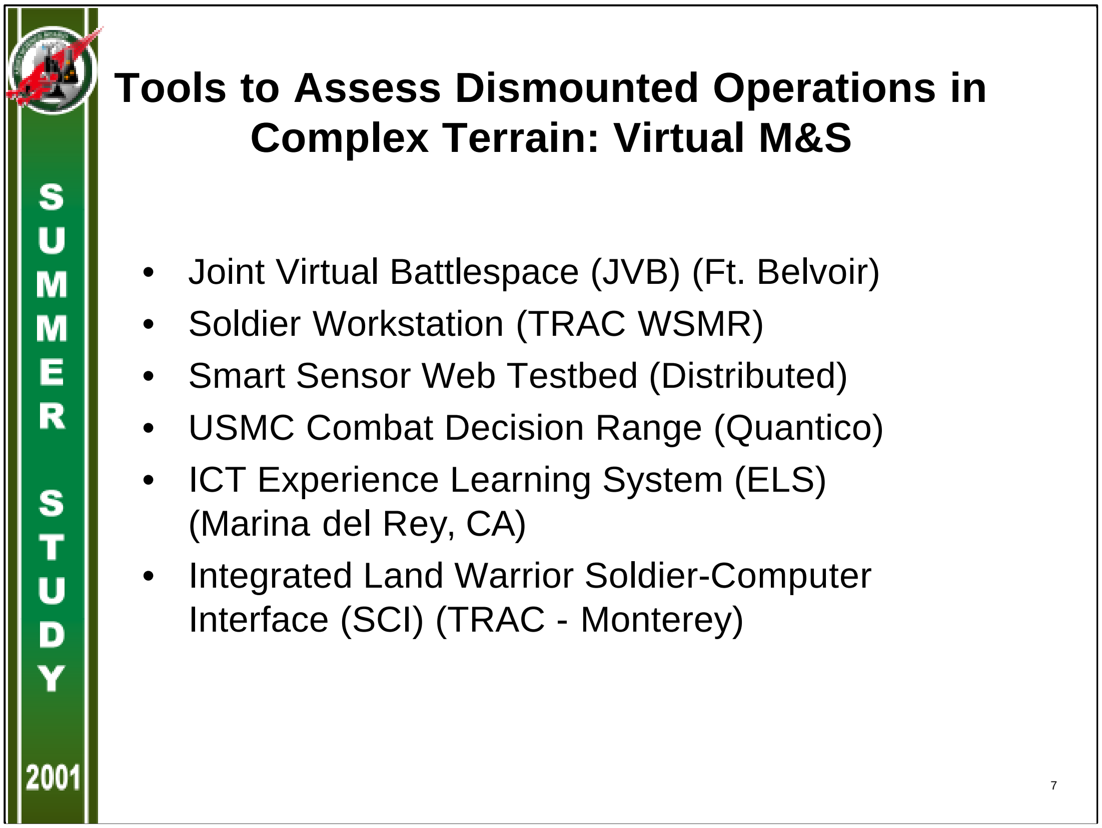
- Introduction
- **Assessment of M&S capabilities for dismounted operations**
  - **Baseline**
  - **Limitations**
  - **Recommendations**
- Analyses to support this study
  - Data mining
  - Simulation based analyses
  - Recommendations

Kosovo, 2000

In this segment of the briefing we will discuss our findings and recommendations on existing and planned tools to support the assessment of dismounted operations in complex terrain.

There are relatively few tools that exist in the analysis community that are well suited to address the issues associated with dismounted operations in complex terrain. However, there are several tools that, if used by skillful analysts, can provide valuable insight into those issues.

There are six constructive M&S that the Analysis Panel encountered that are of particular interest [Note: in constructive simulations, simulated individuals interact with simulated systems in the context of simulated operations]. The Joint Conflict and Tactical Simulation (JCATS), controlled by JFCOM and developed by LLNL, is widely used by the analysis community to analyze military operations over urban terrain (MOUT). It is capable of providing very high resolution simulation in three dimensions. It has been used in several of the analyses described in this report. JANUS, a simulation that has evolved extensively over the last 20 years, was used by RAND to analyze operations in complex terrain (i.e., a treeline). Since it is limited to simulation in two dimensions, it is of limited utility in analyzing operations in urban areas. The Panel was also briefed on the capabilities and limitations of the Integrated Unit Simulation System (IUSS) and the Close Action Environment (CAEn). Although each of these tools has desirable attributes (e.g., inclusion of the effects of human factors), the difficulty in using them made it infeasible to employ in our analyses. The Panel was also briefed on STRICOM's emerging OneSAF model. Preliminary versions of this model have been employed to support the Panel's deliberations. Finally, the Panel was briefed on the agent based modeling work that is being performed in the USMC Project Albert. In particular, the Panel was able to interact with the Humanitarian Assistance assessment being performed by the US, Germany, and New Zealand using the model MANA. The results of that analysis are discussed in the body of this report.



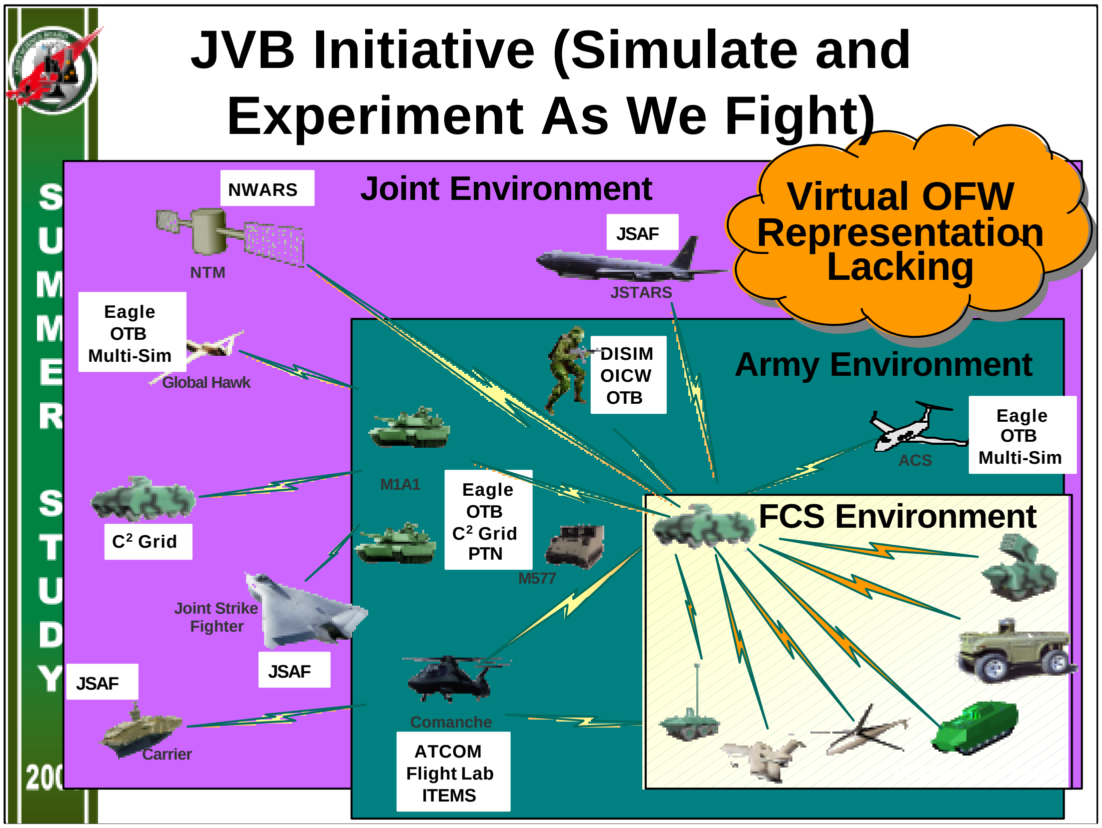
There are six virtual M&S that the Analysis Panel encountered that have utility in evaluating dismounted operations in complex terrain [Note: in virtual simulations, real individuals interact with simulated systems in the context of simulated operations]. One of the most interesting of those simulations is the Joint Virtual Battlespace (JVB), a facility that is being created drawing on the infrastructure of the Joint Precision Strike Demonstration (JPSD), Ft. Belvoir. This evolving facility is discussed in greater detail below. Second, the Panel was briefed about the effort at TRAC White Sands Missile Range (WSMR) to create a Soldier Workstation, extending existing JANUS technology to address dismounted operations more credibly. This effort is currently in hiatus. Third, under the leadership of DMSO, a distributed Smart Sensor Web Testbed is being assembled with key facilities at Ft. Benning, GA. The current plan is perform a series of experiments using this facility during the course of the next year. However, the long term support for the distributed facility is in doubt. Fourth, the USMC has created a PC-based Combat Decision Range to support the training of dismounted squads for a variety of SASO operations. This tool was demonstrated at the Summer Study and it was shown to provide a relatively simple but powerful capability to expose the participant to the challenges of dismounted operations when foes and neutrals are intermingled. With some disciplined, creative application, it is conceivable that this tool could be used to evaluate the value of alternative materiel options for dismounted forces. Fifth, the Panel visited the Institute for Creative Technologies (ICT) to observe their efforts to create an Experience Learning System for dismounted operations. This facility is seeking to advance the state-of-the-art in several technologies (e.g., artificial intelligence, natural language interfaces, visualization) to provide a more emotionally potent training experience. The existing facility is in a preliminary prototypical stage. Finally, the Panel was exposed to the efforts of TRAC-Monterey which has been supporting the PM-Soldier Systems in the adaptation of commercial gaming products to the development of training tools for dismounted operations (i.e., the Integrated Land Warrior Soldier-Computer Interface).

Tools to Assess Dismounted Operations in Complex Terrain: Live M&S

- Shughart-Gordon Range (Ft. Polk)
- McKenna MOUT site (Ft. Benning)
- USMC ranges
  - George MOUT site, CA (soldier training)
  - Yodaville, AZ (CAS experiments)

There are four live M&S that the Analysis Panel encountered that have utility in evaluating dismounted operations in complex terrain [Note: in live simulations, real individuals interact with real systems in the context of simulated operations]. Representatives of the Panel attended exercises conducted at the Shughart-Gordon Range at Ft. Polk, LA. Although this facility is extremely valuable for training small dismounted units in urban terrain, it is somewhat limited in its utility for analysis. This is a consequence of its small size (restricting consideration of operations to a village), its limited instrumentation, and the sheer difficulty of gaining access to the facility to perform experiments. Although data are collected on training activities at the facility, adequate resources have not been allocated to support the in-depth exploitation of those data. The McKenna MOUT site at Ft. Benning shares many of those limitations, although the presence of the Smart Sensor Web Testbed ameliorates many of the instrumentation issues.

The USMC has taken advantage of the 1000 low rise buildings left with the closing of George AFB, Victorville, CA, (currently called Southern California Logistics Airport) to conduct relatively large scale urban dismounted training and experimentation events. The results of the experiments conducted during Project Metropolis are discussed below. Although the size of this facility has enabled the USMC to explore TTPs for Battalion level combined arms operations, it is still not adequate to address the issues posed by the urban canyons of contemporary cities. In addition, the USMC explores the role of air in support of urban operations in Yodaville, AZ. However, they have no single facility that enables them to conduct air-land experiments



As noted above, the Army has recently undertaken a very important initiative called the Joint Virtual Battlespace. This facility draws upon the infrastructure assembled and developed by the JPSD and key M&S developed by other organizations (e.g., the Army's RDECs, Department of Energy National Laboratories). Initial activities with this facility have focused on assessing alternative candidates for the Aerial Common Sensor (ACS) system. Currently, the capability is being broadened to support the acquisition of the Future Combat System (FCS), using the SMART paradigm [note: SMART is a process in which we capitalize on Modeling and Simulation technology to address the issue of system development and life-cycle costs through the combined efforts of the requirements, training and acquisition communities]. However, there is no effort underway to create an adequate representation of the Objective Force Warrior (and its ancillary systems and subsystems) in this virtual environment. This is a serious shortfall that requires immediate attention.

SUMMER STUDY 2001

Challenges in “Analyzing” Dismounted Operations

- **Key constructive and virtual model research is missing or inadequately resourced**
- **Core physical and behavioral models are inadequate**
- **Unit effectiveness models have key limitations, particularly in urban scenarios**
- **Little agreement on representative scenarios**
- **Current models are resource intensive and inflexible**
- **Data are difficult to acquire**

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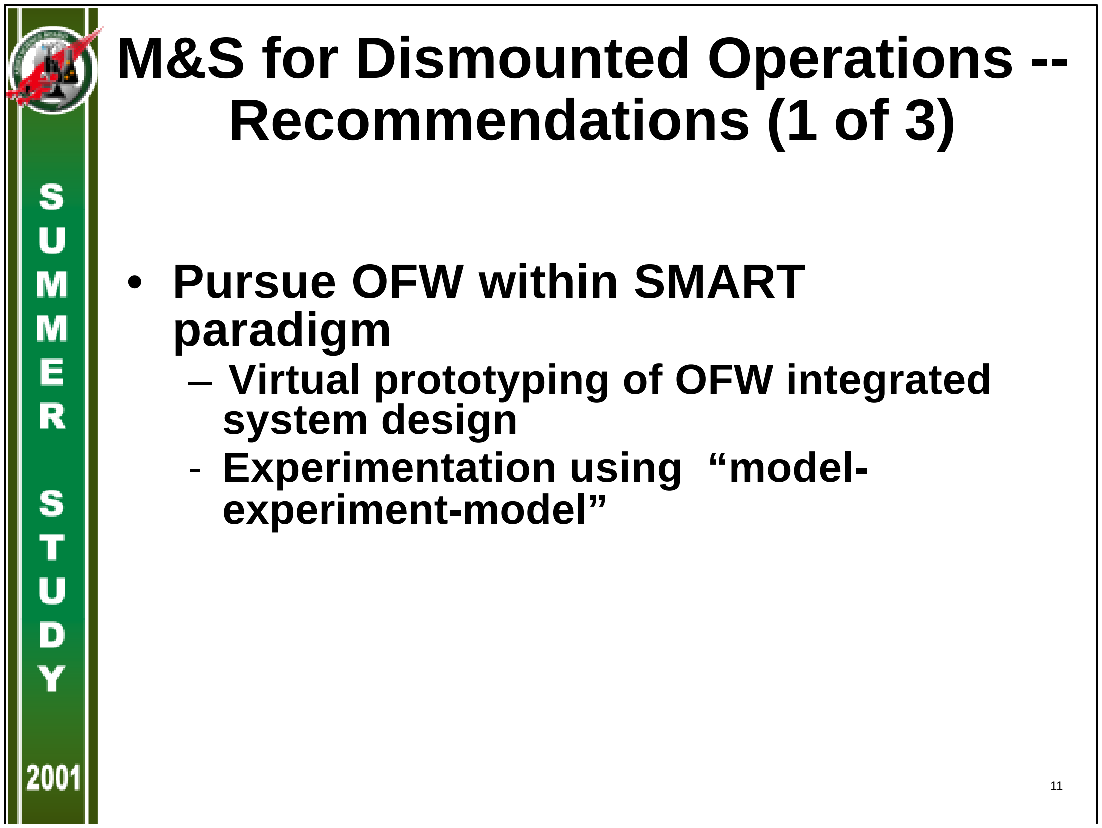
Based on our review of existing and planned tools to evaluate dismounted operations in complex terrain we have concluded that the community has a number of important limitations. We have identified six specific challenges that warrant immediate attention. First, we have concluded that key constructive and virtual model research is missing or inadequately resourced. This conclusion is broadly consistent with the preliminary findings of the recently formed MOUT Functional Area Concept Team (FACT). Our only sense of disagreement with that group is that we believe that they are overly optimistic in their assessment of the state of the research base. Second, we rate core physical and behavioral models for complex terrain as inadequate. For example, as pointed out by Mike Bauman, Director, TRAC, we lack an understanding of the process by which an individual performs the search process, either unaided or with a sensor, in an urban environment. Third, we have key limitations in unit effectiveness models particularly to address complex and urban scenarios. In the analyses that we performed to support the Summer Study, the inability to represent innovative TTPs easily and the lack of credibility of existing unit effectiveness models became quite apparent. Fourth, we have little agreement across the community about what these representative scenarios should be. During the Cold War, we had the comfort of dealing with the Fulda Gap and SCORES 6A. We have yet to replace these scenarios with a set of conditions that people understand and believe to be representative of future conflict. Fifth, we have found current models to be highly resource intensive and relatively inflexible. This means that it takes extensive time and resources to do focused analysis in this arena. As a consequence, current analyses are often limited to a very restricted set of conditions. Finally, the data that are available is very difficult for analysts to acquire and assimilate into existing models. As an example, simulations of MOUT generally require very high resolution terrain data (e.g., 1 meter resolution or DTED level 5). Currently, the regions of the world where DTED level 5 data are available is extremely limited and extremely time consuming to acquire and adapt to the needs of the models. It is even more challenging if subterranean features (e.g., sewer systems) are needed for the models. In addition, valuable data that have been acquired at the Combat Training Centers have not been made available for research.



Our first recommendation is to recognize and adopt two key paradigms for the analysis of dismounted operations. As a variant of Simulation Based Acquisition, the Army has begun to adopt the SMART paradigm to support the acquisition of new capabilities. This approach sees M&S (and ancillary tools) as key enablers to enhance communications across traditional stovepipes (e.g., requirements generation, design, development, T&E, training) as well as across program lines. We believe that it is vital to adopt this approach for the Objective Force Warrior (OFW). We believe that virtual prototyping of an integrated system design is crucial to the success of this undertaking and that it must be resourced adequately.

Second, the effective creation and evolution of tools that are credible for dismounted forces in complex terrain will require experimentation using the "model-experiment-model" paradigm. In this approach, the initial design of the experiment is facilitated by the creative application of existing models. Once the controlled experiment has been conducted (employing a sound experimental design, varying across the full set of DTLOMS), the results should be used to create or refine M&S. This process should lead to the development of a credible tool set.

Second, we need a major S&T program for M&S to create the necessary intellectual foundation to build upon for the future. Selected pieces of that program are listed in the slide, including knowledge acquisition, experimentation, data collection and warehousing, and new computation techniques (e.g., use of agent based models in conjunction with genetic algorithms to perform generative analysis). The scope of this activity needs to range from individual soldier behavior to the effectiveness of larger forces. Although it has proven difficult to include factors such as C4ISR and robotics in existing models, efforts should be made to build these factors into the very core of future M&S for dismounted forces in complex terrain.

In the realm of constructive M&S it has been observed that key tools for analyzing dismounted operations in urban terrain (e.g., JCATS, IUSS) are cumbersome to set up and exercise. We can do a great deal to enhance the usability of these existing models and we should do so. Historically, the source code for these models has been restricted in its access. We recommend that open access to the source code be given to authorized analysts in all parts of the community including industry. Finally, we recommend that partnerships be fostered to undertake a variety of community products. These would include the creation and sustainment of M&S standards and relevant bodies of knowledge that the community can exploit and augment.

SUMMER STUDY 2001

M&S for Dismounted Operations -- Recommendations (3 of 3)

- **Live Simulations - Establish Laboratory for Urban Combat to:**
  - **Characterize representative future urban battlespaces**
  - **Implement appropriate instrumentation**
  - **Conduct experimentation, support acquisition and T&E**
- **Virtual Representation**
  - **Create virtual representations of OFW units, systems, …**
  - **Represent OFW in Joint Virtual Battlespace scope**
    - **Resource adequately**
    - **Clarify customer base and align management structure**
  - **Develop *in situ* Mission Training and Rehearsal Tools**

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In the area of live simulation we highly recommend that a national laboratory be created specifically for urban combat. This laboratory does not need to be located in a single geographic place but it does need a designated leader. That individual should take the lead in characterizing an appropriate set of representative future urban battlespaces (e.g., villages through metropolises) and formulating and implementing a plan to establish appropriate instrumented testbeds for experimentation in these key urban environments. We are concerned that excessive attention is being focused on diminutive segments of urban terrain and inadequate attention is being given to the challenges associated with conflict in major cities. Ultimately, we recommend that the full range of urban assessment facilities be dedicated to experimentation and support to acquisition. Historically, when they have been used for both training and experimentation, the training function has adversely affected experimentation. In addition, the leadership of the laboratory should ensure that adequate resources are programmed and distributed and that a strategic campaign plan for experimentation is formulated and implemented. It would be appropriate to make the laboratory a joint resource with extensive participation by the USMC

In the area of virtual representation, we need to create the virtual representation of Objective Force Warrior unit systems, sub-systems, and ancillary products that are analytically important factors and include those in the scope of the JVB . Steps must be taken to ensure that the JVB is resourced adequately to support this vision. In addition, it is important that the JVB clarify its customer base and align its management structure accordingly.

Finally, we also need to develop a transportable set of mission training and rehearsal tools. These would provide "simulation on demand" and would be deployable with the troops. This is important because the troops are frequently not at their home base. Consequently, having a permanent training and rehearsal facility at the home base is inadequate to do skill maintenance and training up for missions as they change.

SUMMER STUDY 2001

Outline of Presentation

- Introduction
- Assessment of M&S capabilities for dismounted operations
  - Limitations
  - Recommendations
- **Analyses to support this study**
  - **Data mining**
  - **Simulation based analyses**
  - **Recommendations**

Kosovo, 2000

We are going to switch now from the subject of assessment tools and approaches and turn to analyses that supported the summer study. First, we will summarize some of the lessons learned from data mining activities. Then we will summarize the insights that we derived from analyses of selected vignettes.

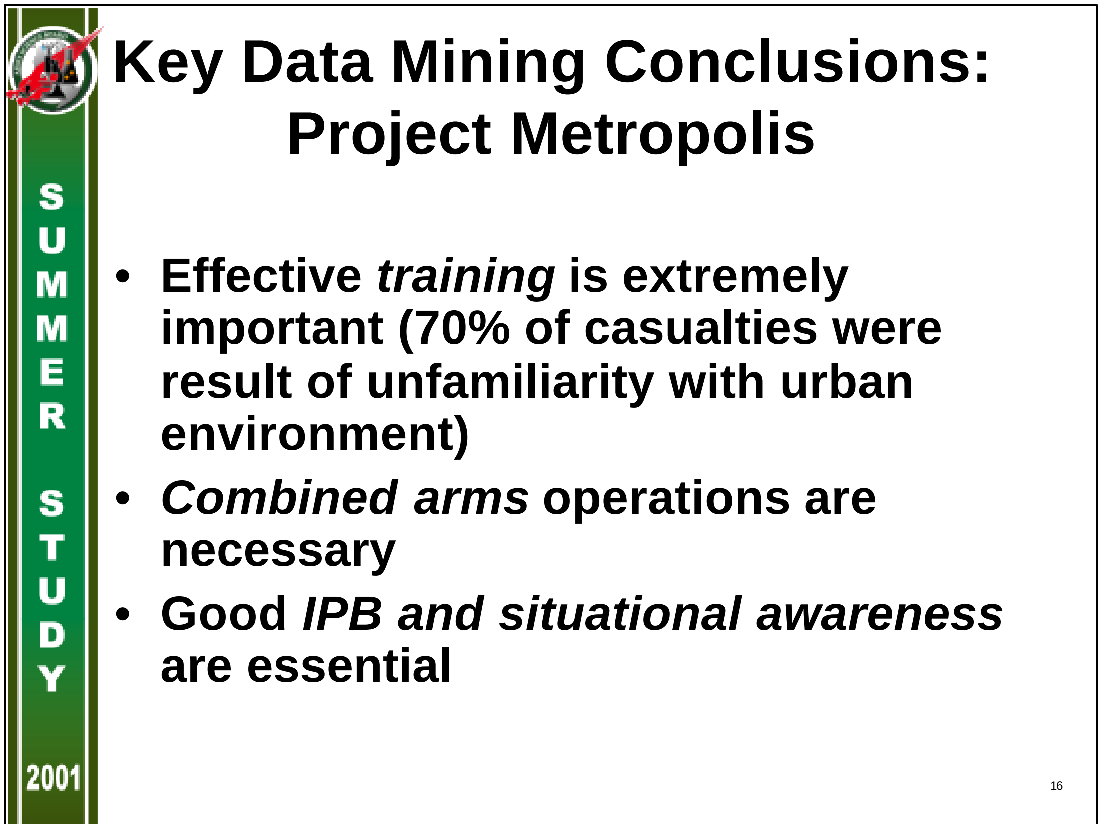
In the Joint Urban Operations Handbook (ww w.dtic.mil/doctrine/jel/other pubs/juoh.htm), case studies are summarized for seven urban operations: Grozny, Panama, Haiti, Mogadishu, Belfast, Bosnia, and Monrovia (non-combatant evacuation operation (NEO)). In these case studies, a series of cross-cutting needs were identified. Of these needs, four were associated with a substantial number of these operations.

• The need to recognize political and social realities. In particular, "Operations in Mogadishu demonstrated the importance of understanding the political, historical, and cultural context for violence in an urban area before defining operational objectives and the value of recognizing the limitations of humanitarian intervention."

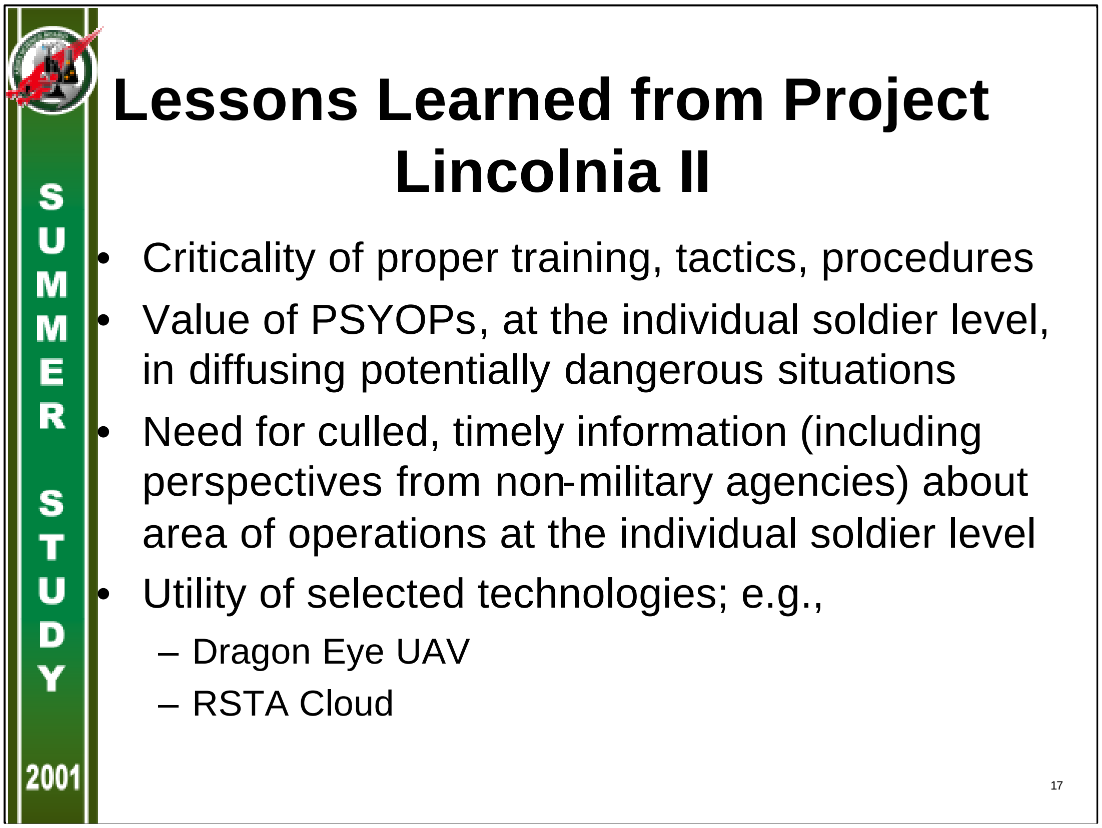
• The need for a C2 structure that can be adapted to urban environments. In particular, in Operation Just Cause, Panama, "streamlined command and control and identification of critical nodes allow(ed) the US to leverage all its capabilities."

• The need for adequate intelligence and knowledge of local terrain. This lesson was highlighted for Grozny, Panama, and Mogadishu. The value of HUMINT was emphasized for Panama and Mogadishu.

• It is important to recognize the value of Special Operations Forces (SOF), psychological operations (PSYOP), and Public Affairs (PA). In particular, in Operation Just Cause, Panama, it was noted the "SOF capabilities are force multipliers before, during, and after an urban operation."



In addition, we looked at a number of relevant studies and have selected two that are particularly interesting. The first one, the USMC Project Metropolis, is a multi year focused effort looking at MOUT. They found that training was one of the most important aspects of MOUT. They concluded (Reference 1) that "Experiment results showed that up to 70% of casualties were taken as a direct result of a lack of familiarity with the urban environment. This can be overcome with better, more focused training." [note: their emphasis]. Second, they observed that "Urban Warrior results clearly showed us that -- after focused training -- the highest payoff for improved MOUT performance is employment of combined arms" (Reference 1). They also found out that when they conducted urban combined arms operations that, although troops and leaders frequently thought they understood them, they really didn't know how to implement them effectively. Finally, conducting effective operations in an urban area puts a premium on having a good intelligence planning of the battlespace effort prior to entry. It also makes it essential to achieve excellent situational awareness. Although enhancements in Blue situational awareness are being derived from enhanced communications and position fixing capabilities, Red situational awareness is much more complex than in many other situations and extremely difficult to achieve. As a benchmark, it was estimated that experimental forces in Project Metropolis were able to achieve Red situational awareness at the 10 - 20% level (Reference 2).



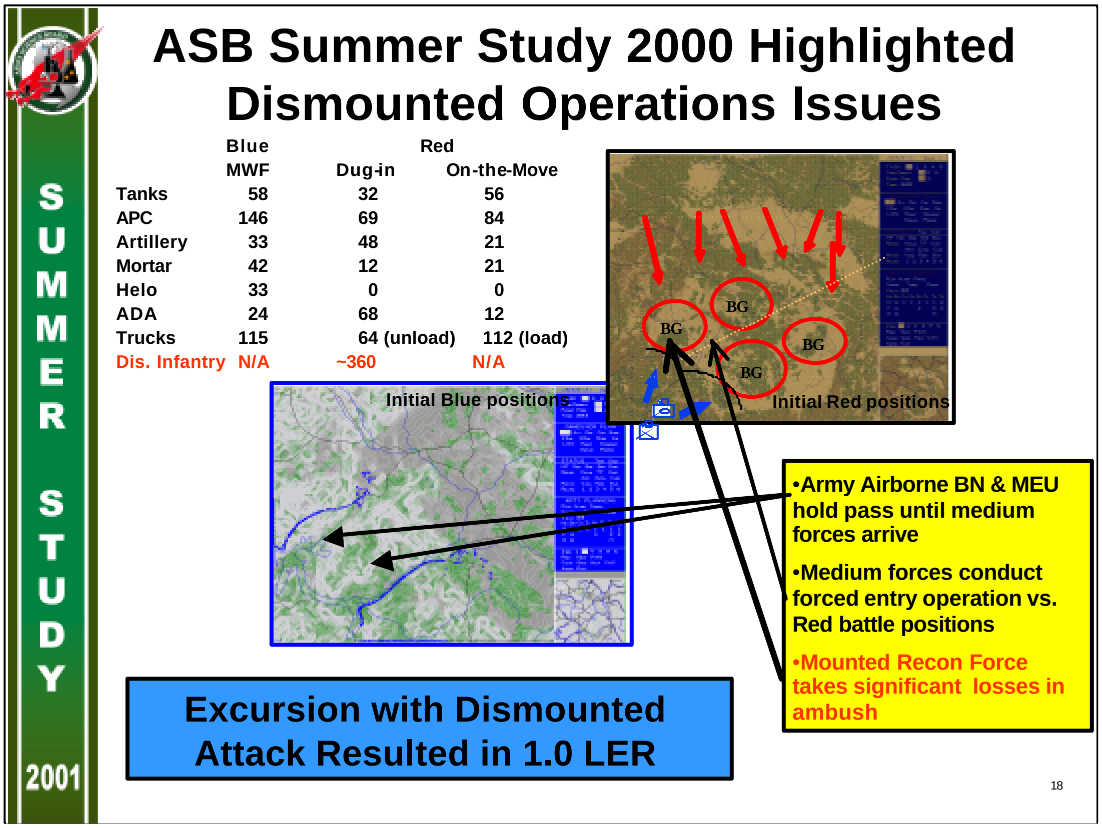
On 17 - 18 August 2001, the USMC and the Potomac Institute for Policy Studies conducted the Lincolnia II urban war game. The game assumed a scenario in which three factions were vying for control while a UN-led force tried to maintain order (including enforcing a heavy weapons confiscation agreement). Based on that experience, the following lessons were recorded.

• Value of training, tactics, and procedures. As cited in Inside the Navy (August 20, 2001), "… without the proper training, as well as tactics and procedures, all the technology in the world cannot make operations in urban areas any easier."

• PSYOPS. "… for the military to be successful at controlling a crowd and preventing tension from escalating into violence, it is necessary for the individual Marine or soldier to be trained and competent in using the technology and communicating a message to the civilian crowds." (opsit).

• Information. "… fighting in cities requires getting useful information culled from the raw data down to the warfighter. The Dragon Eye unmanned aerial vehicle proved to be useful for that function, as did the Reconnaissance, Surveillance, Target Acquisition Cloud…" (opsit)

• RSTA Cloud. This is a postulated network of unmanned ground robots and sensors, loitering UAVs, remote operators and national assets to hunt down time critical targets. "In order to make this concept practical, it will require smaller vehicles and sensors, as well as a more robust over-the-horizon relay that connects operators with the network." (opsit)



The 2000 ASB Summer Study focused on the FCS platforms and examined the effectiveness of a force in a stressing “Kosovo II” scenario. Here the Blue force is inserted through Albania, fights its way into Kosovo, and must evict Serb forces from locations in treelines and cover. Additional Serb battle groups are moving from the North to support the defense. Many different excursions were run with different technologies and tactics.

The focus of this work was on mounted Blue operations with FCS platforms, and showed the importance of armed unmanned ground vehicles (UGVs), active protection systems, and enveloping maneuver. The work also showed the need for dismounted operations by the Blue force because the 360 Red infantry in the treelines were not countered well by the mounted attack. In addition, a special Blue dismount excursion with current generation equipment did not fare well in the scenario (i.e., it resulted in a loss exchange ratio of approximately 1). These results provided the point of departure for RAND’s analyses in support of the 2001 ASB Summer Study.

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SUMMER STUDY 2001

Our Analyses Considered Five Vignettes

- **Complex Terrain**
  - **Reverse slope, treeline attack in Kosovo context (RAND analyses employing JANUS)**
- **Urban Operations**
  - **Convoy in an urban (Sarajevo) environment (RAND analyses employing JANUS and JCATS)**
  - **Low Collateral Damage Weapon technologies in complex terrain (JFCOM/SNL & LLNL analyses employing JCATS)**
  - **MOUT ACTD floor clearing operations (Dismounted Battlespace Battle Lab / IDA analyses employing JCATS)**
  - **Humanitarian assistance in a small village (Project Albert/Mitre analyses employing MANA)**

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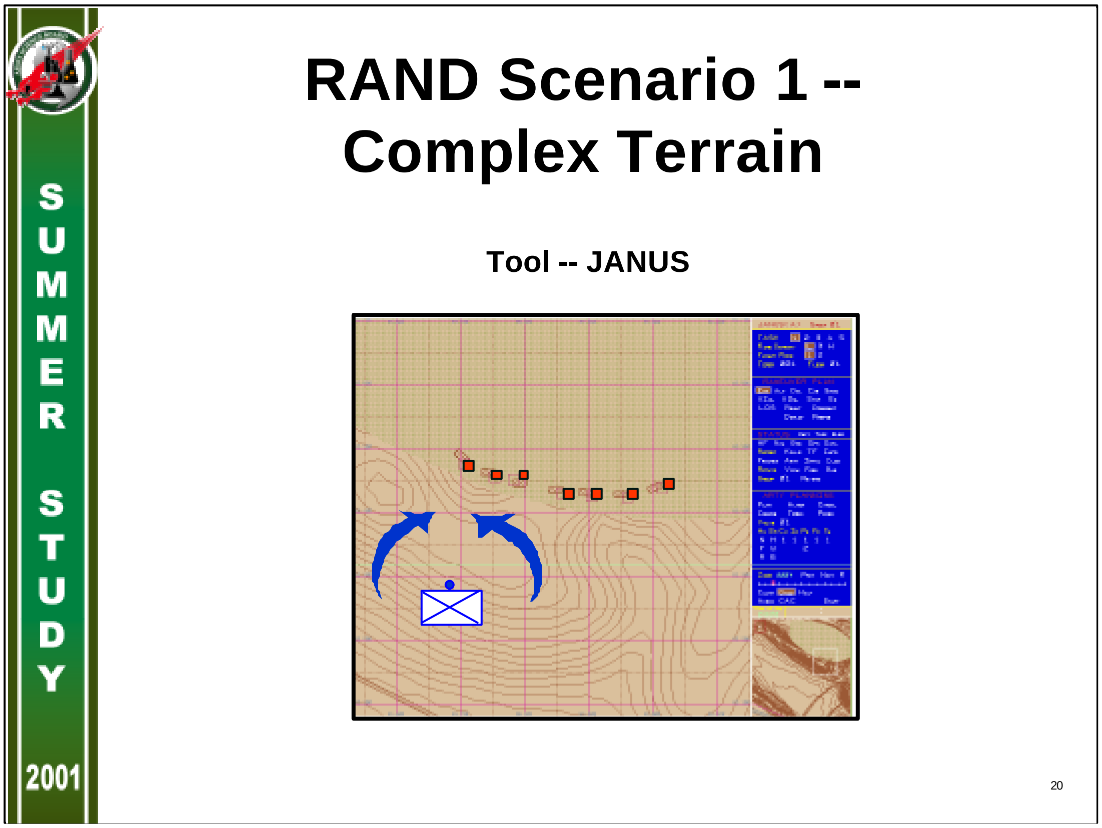
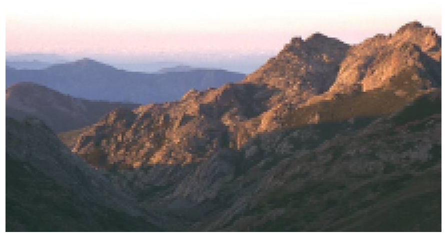
This year we considered five vignettes. Two of these vignettes were analyzed by RAND. The first of these vignettes focused on conventional operations in complex terrain. In particular, it considered a reverse slope tree line attack, taken out of the previous scenario, using the JANUS model. Next, RAND analyzed an urban convoy environment using both JCATS and JANUS. Subsequently, we spent some time considering a Sandia and Lawrence Livermore National Laboratory (LLNL) analysis of low collateral damage weapons (LCDW) in support of JFCOM, using JCATS. Fourth, IDA recently completed an analysis of floor clearing operations in support of the Dismounted Battlespace Battle Lab (DBBL). This follow-on to the MOUT ACTD was performed using a mix of tools (e.g., Subject Matter Experts (SMEs), an actual live walk through of the McKenna MOUT site, and JCATS). Finally, MITRE has been doing an analysis, as part of the USMC's Project Albert, of humanitarian assistance in a small village using MANA, an agent based model.



The slide depicts a JANUS screen for the complex terrain scenario. The icon depicts a blue platoon coming up over the top of the hill to a reverse slope position beside a tree line. In these analyses it is vital to get high resolution terrain and data to understand properly the interactions at the individual soldier level. Since DTED level 5 for Kosovo was not available for general analysis, it was decided to transpose the scenario into a data set from Hunter Liggett, CA, and then impose a forest on it to create a tree line.

Complex Terrain Results – Base Case

- **Blue-Red force ratio -- 3:1**
  - **Red in very strong defensive position**
  - **Blue moves in overwatch/sprints**
- **Blue Force accomplishes immediate objective, but unable to proceed further -- *both sides lose roughly 50% of forces***



Bosnia, 1999

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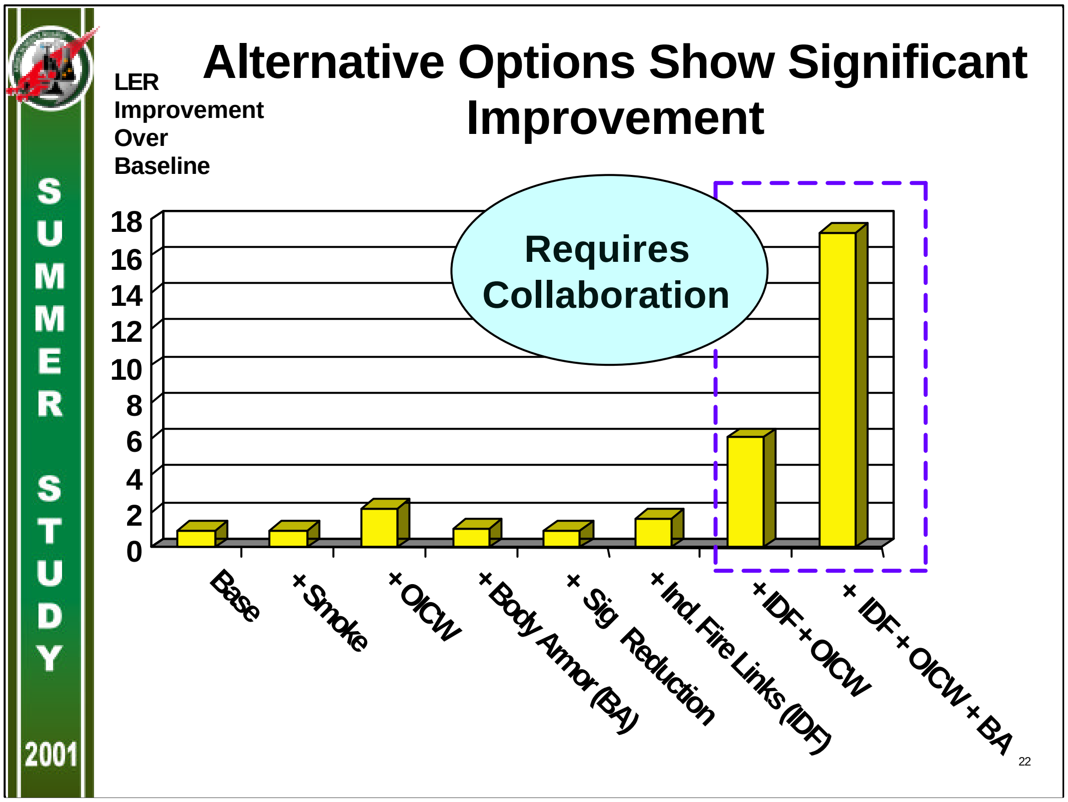
In this scenario, it is assumed that Red forces consist of a squad with small arms and several machine gun teams on the flanks. They are in stationary defensive positions, in defilade, with good lines of fire. It was assumed that Red does not have mines or UAVs. It was further assumed that Red expects but has no advance knowledge of Blue attack.

Blue forces consist of three squads of dismounted infantry. In the base case it was assumed that they are equipped with M-16s, semi-automatic weapons (SAW), and grenadiers. Tactically, Blue launches its attack in early morning, using overwatch/sprints, under covering fire, across relatively open terrain.

The JANUS runs revealed that Blue had substantially higher detections of Red (by a factor of roughly 2.5) and took more shots at Red (by a factor of roughly 1.5). However, because of Red's superior defensive position, the Red/Blue Loss Exchange Ratio was approximately .25.

Ultimately, the Blue force accomplishes its military objective but is unable to proceed further. Both sides lose roughly 50% of their forces.



Five different analytic studies were undertaken in this effort. Most of the focus was on urban operations but one looks at complex terrain where the dismounted soldiers must attack across 300 meters against dug in red soldiers hidden in a woodline. The scenario evolved from RAND research in Kosovo. This slide depicts the results. Options are added one at a time as indicated.

We then moved to the next phase of the analysis and considered adding combinations of these options into the base case. The first variant added indirect fire with the OICW. That served largely to nullify the effect of Red's machine guns (which were the major killer of Blue Forces, even when they were equipped with body armor). Subsequently, when we added the body armor to the mix we got a substantial improvement in effectiveness (i.e., a 17 fold improvement in LER over the base case). At this stage, with the elimination of Red's machine guns, Blue's body armor provides extremely effective protection against Red's small arms, substantially reducing Blue's losses. Although it is not explicit in the model, you need the ability to communicate and collaborate amongst the Blue forces in order to conduct this type of activity.

These analyses suggest that there is a substantial potential for synergy among materiel and tactical options if they are implemented in a synchronized fashion.

SUMMER STUDY 2001

Selected Excursions

- **Limited impact**
  - **More ambitious levels of individual movement**
  - **Enhanced stealth**
- **Appreciable Impact**
  - **Augmented body armor**
  - **Partial fielding of OICW**
  - **“Junkyard dog”**
  - **“Junkyard dog” + partial OICW force**

A number of excursions were performed by RAND to identify promising technologies to pursue. Recent parametric excursions have shown that more ambitious levels of individual movement (e.g., through exoskeleton mobility) and stealth add little to system effectiveness in this scenario.

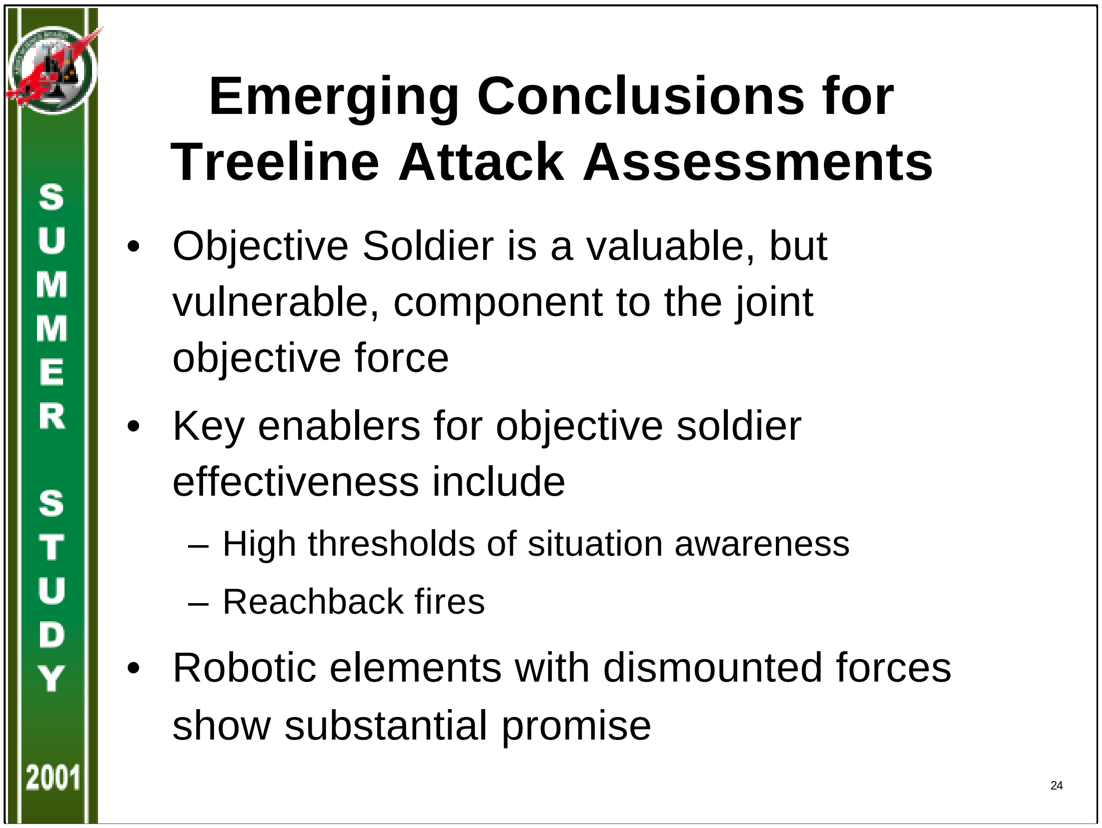
• Augmented body armor. Augmented body armor (up to 90% effectiveness against 7.62mm), increases force effectiveness by 50% compared to the baseline.

• Partial fielding of OICW. Much of the benefit from the OICW seems to be achievable by outfitting only a small portion of the force with the system. The baseline force equipped with M-16s would achieve a LER of 0.35, a force with 6 of the 40 Blue dismounts equipped with OICWs would achieve a LER of 0.55, while a force with 36 of the 40 Blue dismounts equipped with OICWs would achieve a LER of 0.75. In other words, the very limited fielding of OICWs manifested a 57% increase in LER over the base force, while the nearly fully equipped OICW force achieved a 114% increase in LER over the base force.

• “Junkyard Dogs”. The contribution of a small robotic element, termed a “junkyard dog”, was assessed. This UGV was assumed to have a Javelin-quality sensor, an OICW, be able to move at speeds up to 10 mph on good terrain, and send back images to the manned scout or C2 vehicles. Only six were added to the force, consistent with the presumed span of control for an attacking infantry unit. After some experimentation, it was concluded that an attractive option would be a small UGV with a 2 meter high mast-mounted sensor that stayed “on leash” with the force. Adding the “junkyard dog” to the baseline resulted in a 37% increase in LER. In addition, it resulted in a 20% increase in the survivability of the manned systems.

•”Junkyard dogs” with partial OICW equipped force. As an additional excursion, “junkyard dogs” were added to the partial OICW equipped force. This option resulted in a 35% increase in LER over the force without junkyard dogs (and a 102% increase in LER over the baseline, which is roughly equivalent to equipping all of the force with OICW). It also resulted in approximately a 20% increase in the survivability of manned systems.

In both the baseline and partial OICW equipped force, five of the six “junkyard dogs” were killed.

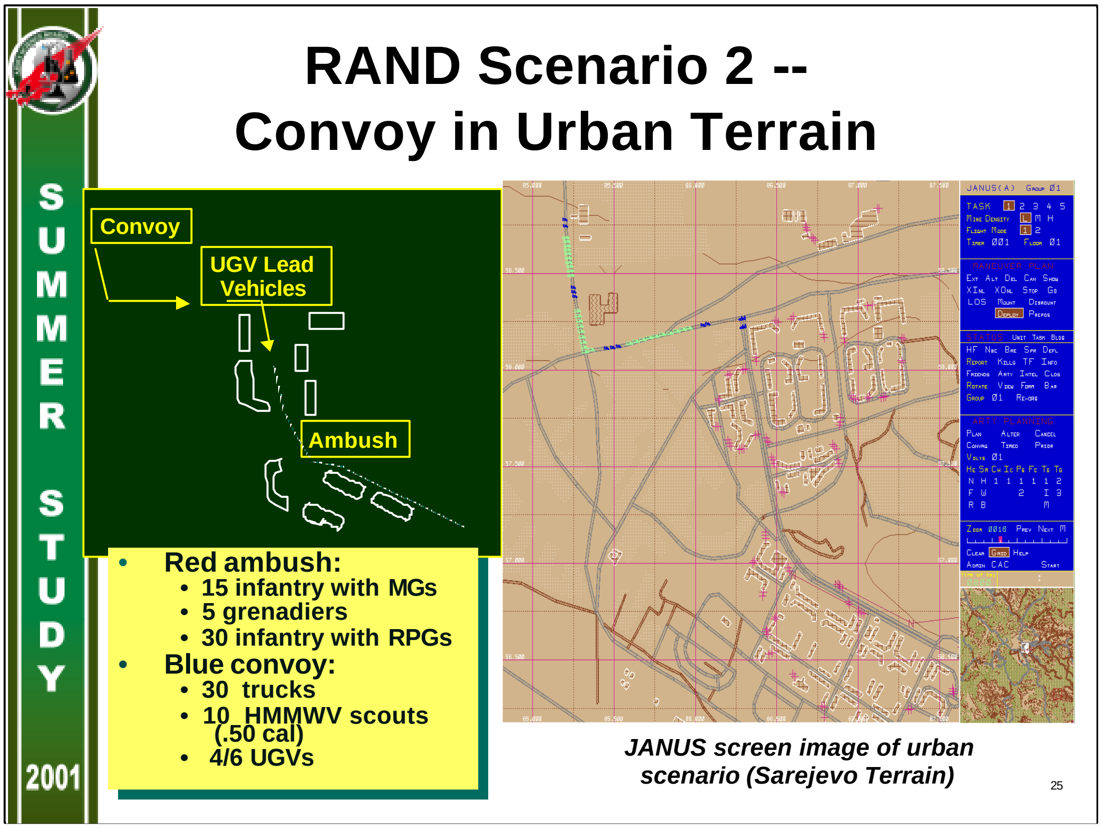


Based on the analyses that were performed by RAND, several conclusions are emerging. First, it is concluded that the Objective Soldier will be a valuable, albeit vulnerable, component to the joint objective force. It should provide substantial improvement in effectiveness over the baseline(as measured by LER) but still be subject to high levels of casualties in very stressing scenarios, similar to the one assumed for these analyses.

If the Objective Soldier is to be effective, he will require several key enablers. In particular, the analyses demonstrated the importance of having high thresholds of situation awareness for insertion, maneuver, and the engagement itself. In addition, the analyses demonstrated the contribution that is provided by responsive, reachback fires.

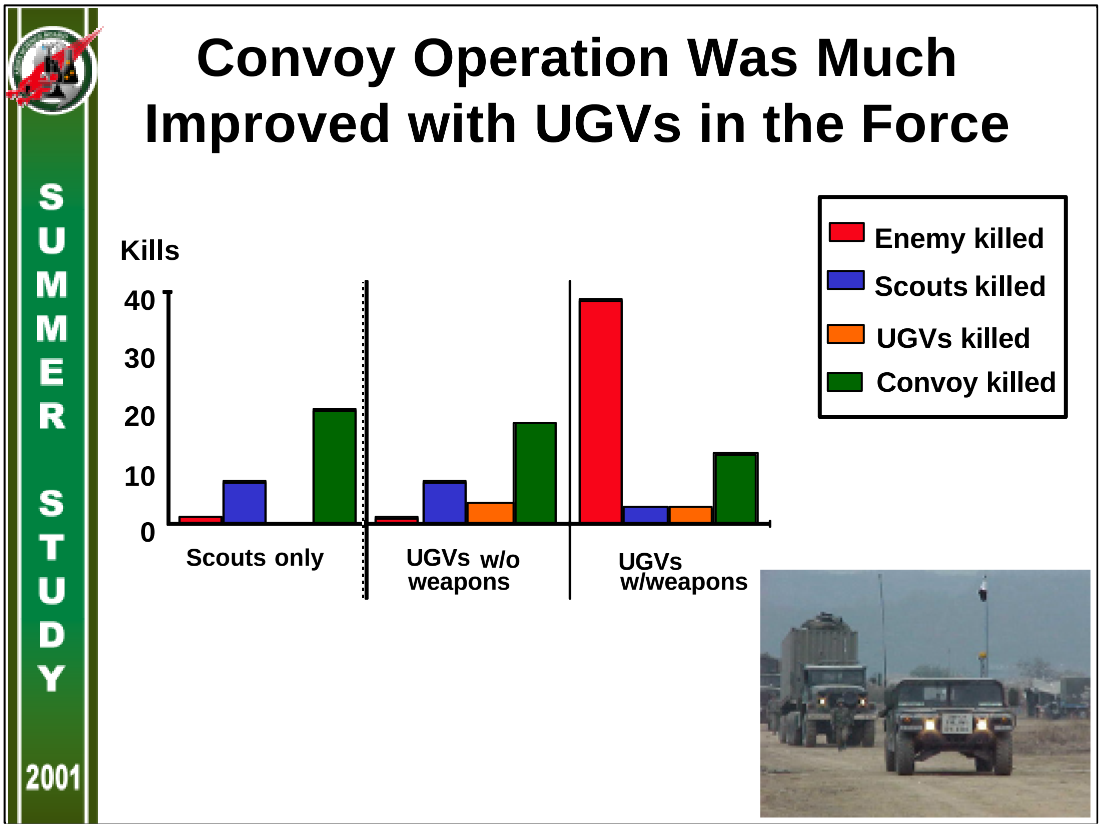
In addition, the excursions revealed that a small UGV equipped with an effective sensor and weapon can provide a substantial enhancement in LER and Blue survivability.

However, it must be emphasized that these analyses have been restricted to a very narrow range of scenarios. Additional scenarios must be assessed and appropriate organizations and concepts of operation will have to be tailored to cope with those scenarios.



In the urban convoy scenario in Sarajevo, the Blue convoy comes down the street where Red forces have a number of pre-prepared positions for snipers and ambushes.

In the initial force structure the Red ambush consists of 15 infantry machine guns, 5 grenadiers, and 30 infantry with RPGs. Blue has 30 trucks as well as 10 scouts in HMMWVs with 50 caliber weapons. In the base case the Blue force is ambushed and takes considerable losses. In the next case we add in a 4 to 6 unmanned ground vehicles (UGVs) to stand point and precede the convoy in.



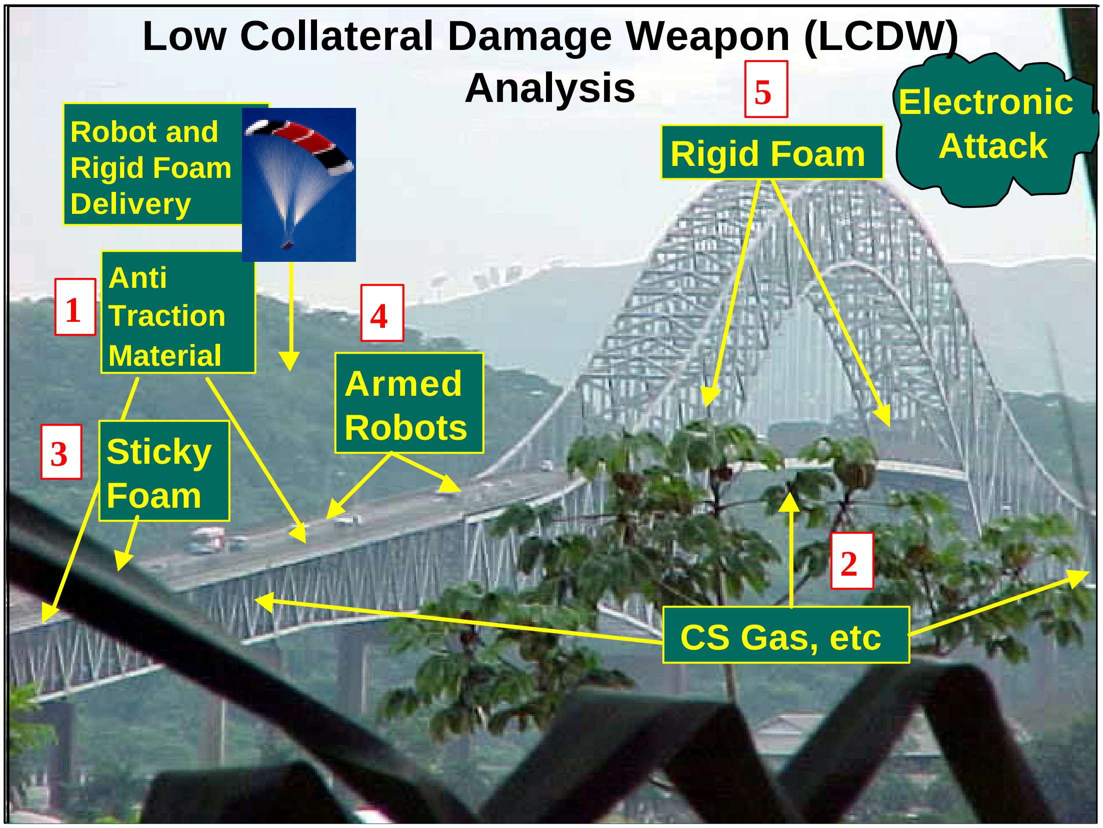
The left-most bar chart summarizes the results of the base case. As can be seen, approximately two thirds of the Blue convoy trucks are killed and 80% of the scouts. Enemy losses are negligible.

The middle bar chart summarizes the results when UGVs without weapons are added to the Blue Force mix. This provides only marginal improvement to survivability of Blue trucks in the convoy.

The far right bar chart summarizes the results when UGVs with weapons are added to the Blue Force mix. It can be seen in this option that there is a huge increase in the number of Red forces killed, as well as a significant reduction in the number of Blue trucks and scouts lost.

In addition, an excursion was conducted adding smoke to the mix (i.e., smoke that obscured Red's ability to see but was relatively transparent to Blue's FLIRs). For this scenario, substantial improvements were observed in the survivability of both Blue trucks (i.e., an average reduction in losses of 54%) and scouts (i.e., an average reduction in losses of 37.5%).

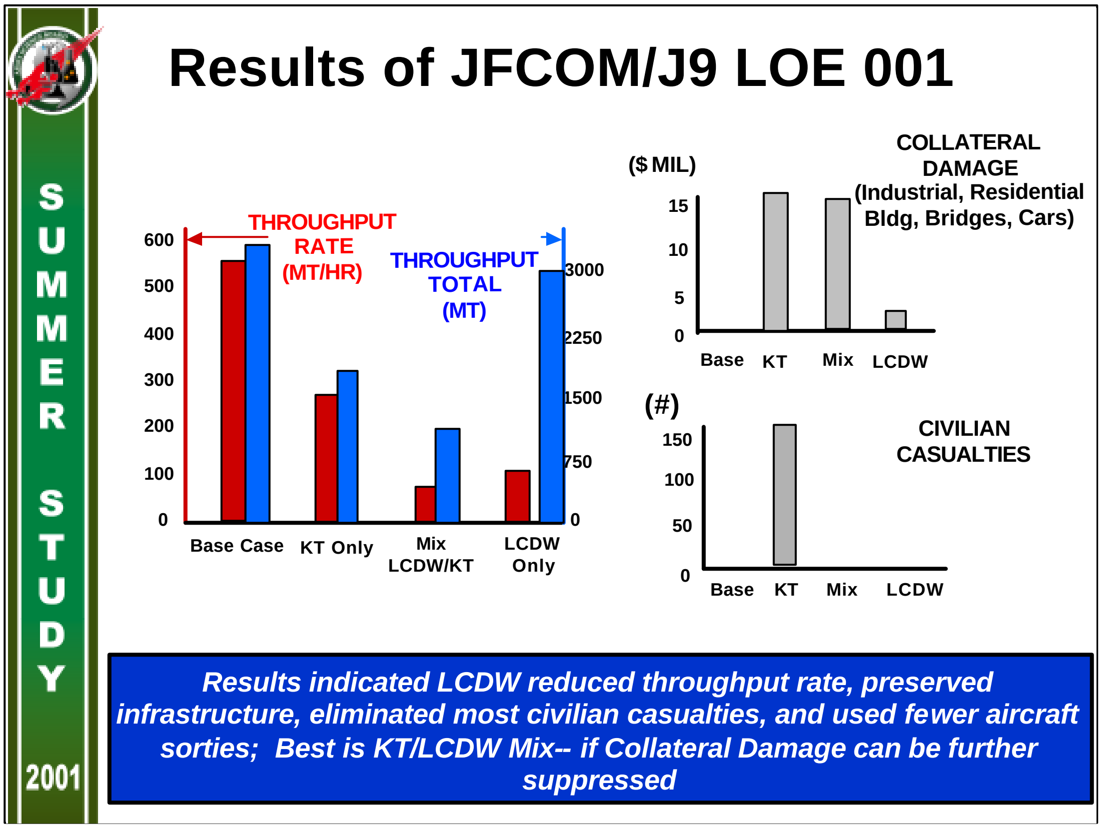
We have seen the results of the UGV analyses replicated in a number of alternative scenarios. If UGVs are unarmed, they serve as sensors and tend to improve situational awareness. However, these unarmed systems often appear to offer modest improvements in mission effectiveness. When you arm the UGVs, they essentially perform "reconnaissance by fire", causing the adversary to react to them. This reaction by Red tends to enhance the performance of other Blue sensor systems and allows us to bring other weapons in the combined mix to bear on him. However, it must be emphasized that such armed UGV operations are feasible only if the UGVs can perform the identification friend, foe, or neutral (IFFN) function reliably. This is one area that requires substantial attention by the S&T community.



Recently, Joint Forces Command (JFCOM) J9 sponsored a series of limited operational experiments that explored the utility of low collateral damage weapons (LCDW) in joint small scale contingency conflicts. Low collateral damage weapons are a category of military response focused on reducing potential impact on civilian personnel and infrastructure while achieving military objectives such as countermobility, area denial, and infrastructure denial. This category differs from Non Lethal Warfare in that it does not attempt to mitigate military casualties. LCDW solely attempts to limit post conflict reconstruction or the effect of warfare on innocents.

As an initial assessment of the effectiveness of LCDW, JFCOM investigated a vignette involving a bridge choke point. In support of that assessment, Sandia created a plausible, synergistic set of LCDW technologies, systematically applied to deny enemy use of a large bridge. Commander's guidance was that the bridge should be denied for 72 hours with no substantial loss of civilian personnel or assets, and should be reclaimed for use in less than 4 hours. LLNL used the technology information supplied by Sandia and assessed its impact on convoy throughput/rate and civilian loss metrics through use of JCATS. JFCOM assessed operational utility by soliciting comments from warfighters during the United Endeavor exercise.

The LCDW technologies supported three actions: clearing the bridge of civilians, creating a barrier to enemy mobility, and defending the barrier against enemy attempts to overcome it. The bridge clearing was accomplished through unattended ground sensors (UGS) to continuously monitor activity and non lethal technologies (e.g., CS, pepper spray, psyops, and tasers) on munitions or robotic platforms. Further disruption to civilian traffic would be achieved through electronic attack via High Power Microwave (HPM) devices. The second action involved barrier options of sticky foams, antitraction materials, and semi-rigid foam embedded with mines and entanglements. The barrier defense involved armed robots with guns or explosively formed projectiles or WAM submunitions supported by the UGS or UAV surveillance systems. Electronic attack technologies such as HPM also support barrier defense.

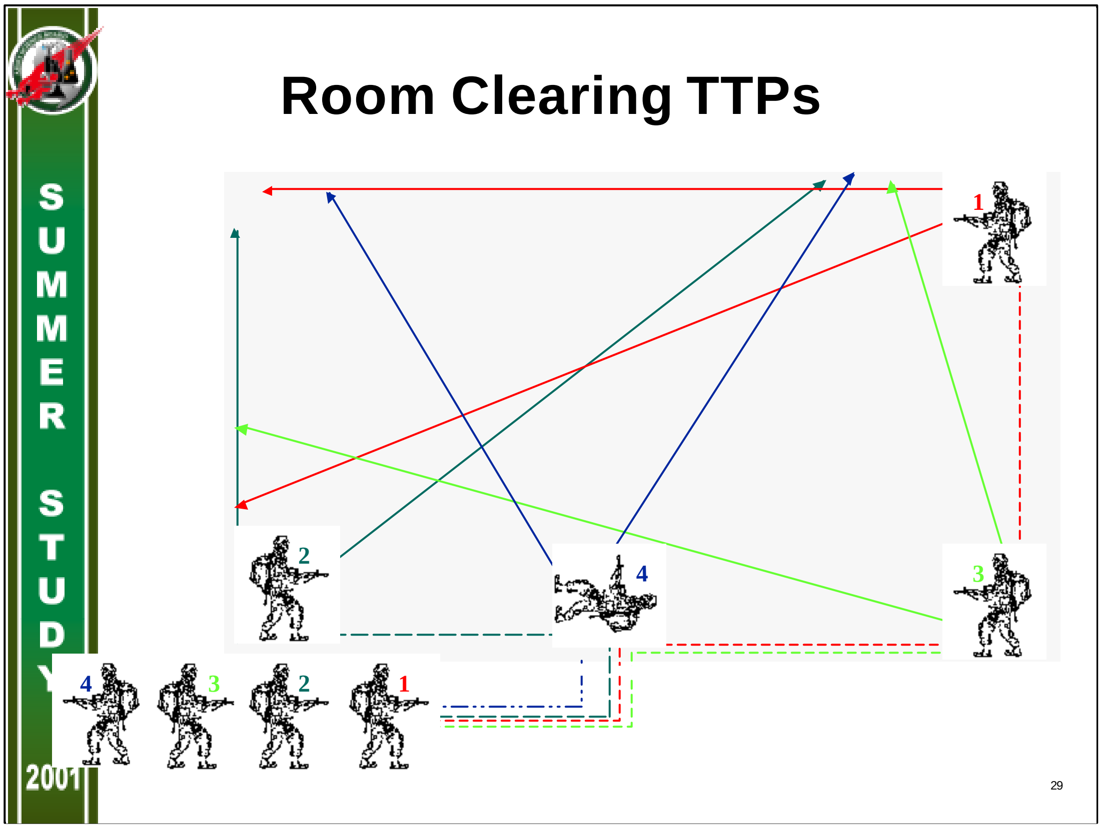


Key results of the analysis indicate LCDW was able to reduce throughput rate while preserving infrastructure and eliminating civilian casualties. However, because the mission was countermobility, not target defeat, the convoy eventually found other paths to the distribution point. Thus, total throughput did not diminish significantly.

With target attack through traditional munitions (i.e., Kinetic Technology (KT)) coupled with countermobility LCDW at choke points (KT/LCDW mix), civilian casualties can be significantly mitigated while reducing total convoy throughput. This can be achieved by selecting more advantageous places for attacking convoys where traditional munitions can be used with lower civilian casualties than at major bridges. However, civilian personnel, buildings, and other infrastructure are still at risk whenever traditional munitions are used in urban environments.

Therefore, more work is needed to improve traditional weapon precision and target location parameters and to reduce blast effects (e.g., 500 vs 2000 pound bombs). Another outcome of the analysis was that the countermobility effect was achieved with fewer sorties than would have otherwise been needed to destroy a large bridge.

These preliminary results suggest that significant synergies can be derived through a judicious mix of LCDW and lethal weapons.



The broad purpose of the floor clearing assessment was to determine the impact of proliferating squad-level radios throughout a division operating in a dense urban environment. More specifically, the objective was to determine the impact of such communications on combat effectiveness at the platoon level.

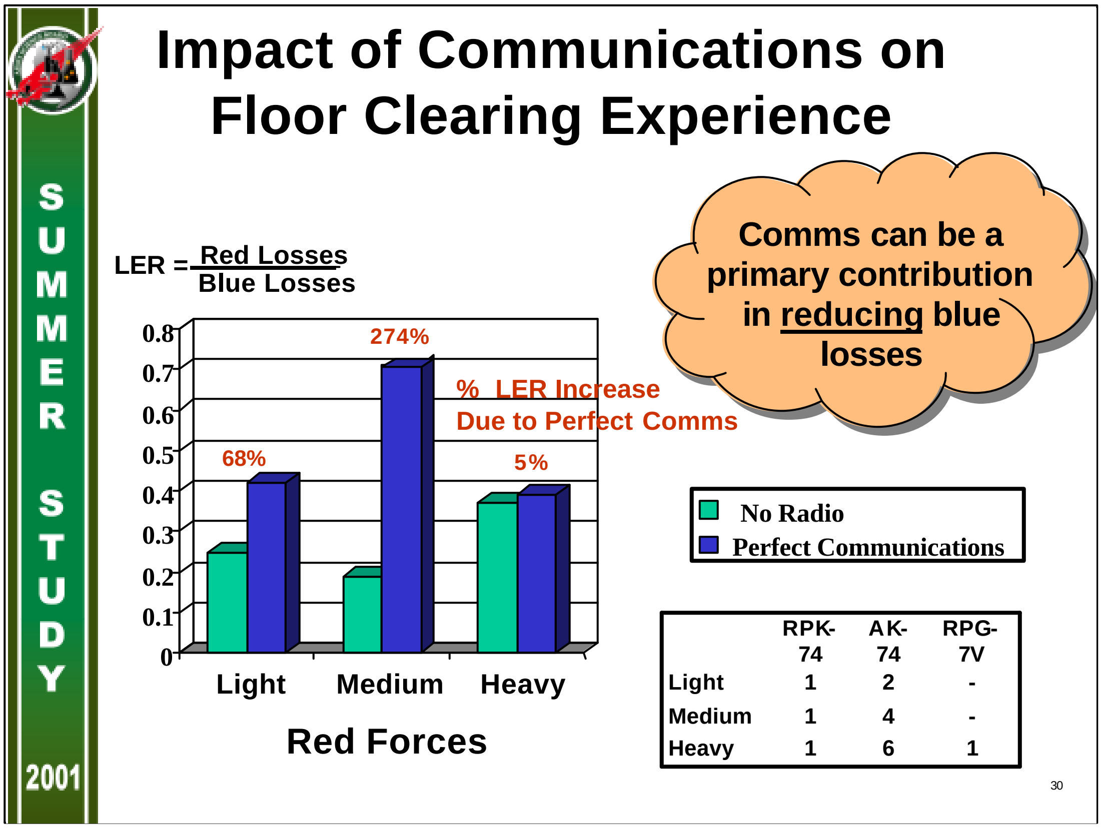
The work was originally performed in support of the MOUT ACTD by the Simulation Center of the DBBL. IDA supported the effort by providing oversight, and analyzing and integrating the results.

To address this issue, this analysis focused on floor-clearing in an urban environment featuring high rise buildings. The Blue forces were organized into canonical platoons, squads, and fire teams. Two basic Blue conditions were assessed. In the first condition, Blue fire teams and squads were not provided with radios. They performed their communication either verbally or using hand signals. In the second condition, it was assumed that the participants were provided with intra- and inter-squad communications that were "perfect" (e.g., perfect connectivity; immunity from adverse effects such as enemy jamming).

Four levels of threats were considered in the floor-clearing operation. These subsumed no threat (e.g., the Blue encountered no adversaries in conducting floor clearing), and light, medium, and heavy levels of threats. The personnel and material levels associated with those threat levels are summarized in the following slide.

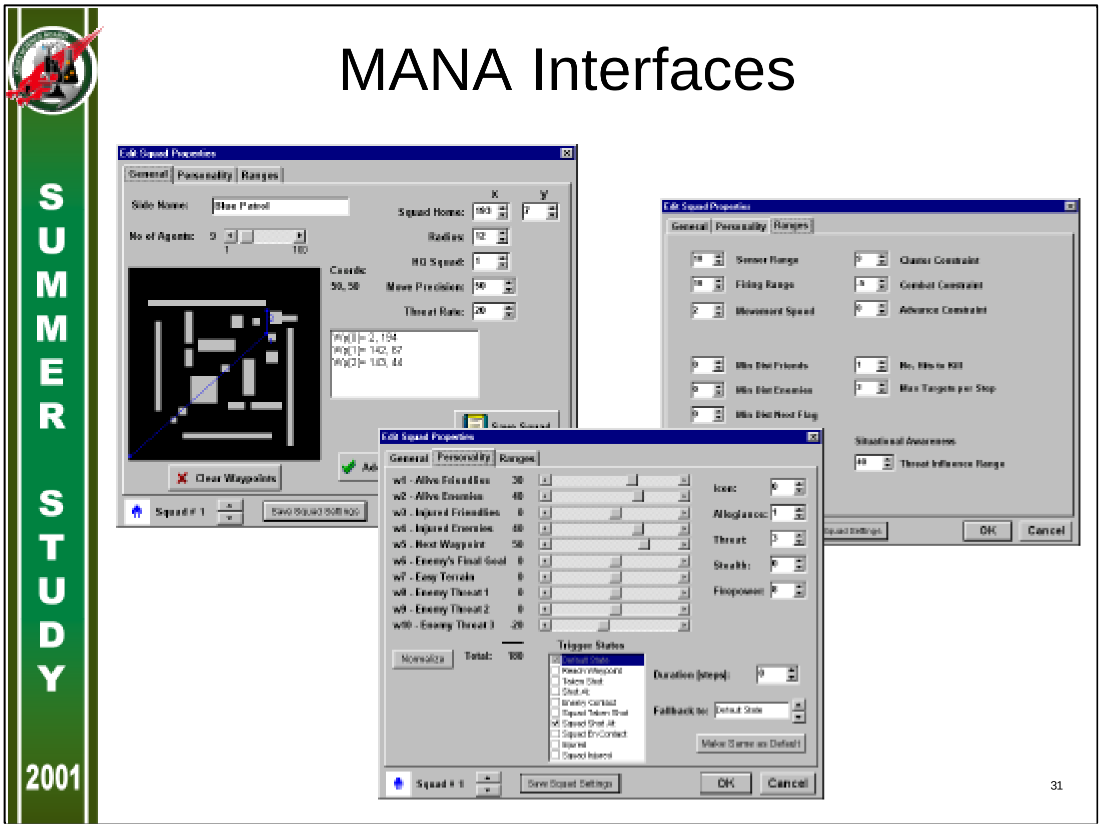
The complexity of this problem is such that there is no single tool that can readily be employed to support this analysis. To compensate for this shortfall, JCATS, SMEs, and man-in-the-loop simulation techniques were employed and orchestrated.

This animated vugraph illustrates the room clearing tactics, techniques, and procedures (TTPs) used by the Blue fire teams as they cleared the floor. The operation begins with the explosive breaching of the door, followed by the entry of the fire team in the order shown. The dashed lines represented the movement of each team member, while the solid lines/arrows illustrated their fields of fire. The tactics are based on standard U.S. infantry TTPs and demonstrate the level of detail and tactical realism possible in JCATS.



The above slide summarizes the difference in LERs that were observed for the three different Red Force levels. This perspective highlights two key observations. First, the estimated LERs are always less then one. This underscores the level of risk that the attacker incurs in performing this extremely hazardous mission. Second, it reveals that the contribution of perfect communications to mission effectiveness is extremely sensitive to the scenario conditions. For example for Medium Red Forces, LERs are increased by 274% while for Heavy Red Forces, LERs are increased by only 5%. In the latter case, it was concluded that the results were insensitive to communications performance because of the large number of losses and high conflict intensity. Although it is unlikely that imperfect communications will result in such dramatic enhancements in operational effectiveness against Medium Red Forces, it does suggest that for selected scenarios, the benefits associated with enhanced communications can be significant.

The "bottom line" is that the contribution of communications to operational effectiveness is strongly scenario dependent. When benefits are significant, they are largely associated with reduced Blue losses. It would be valuable to perform additional assessments to extend these results to a broader set of urban scenario conditions.



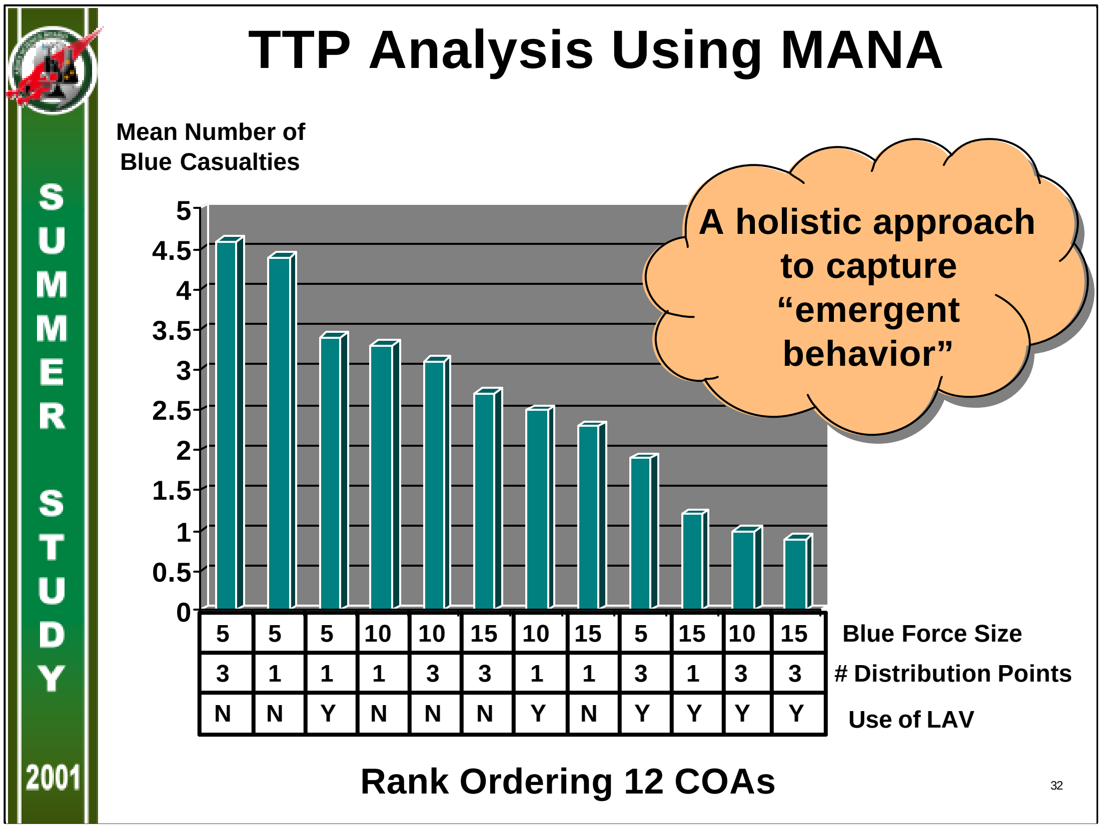
In 1995, the USMC began Project Albert, based on the so-called “New Sciences”, to provide quantitative answers where feasible, to significant issues confronting military decisionmakers. As one segment of Project Albert, MITRE is applying MANA, an agent based simulation that is being developed by the Defence Operational Technology Support Establishment (DOTSE), New Zealand. They have evolved the tool in concert with operational forces in New Zealand assigned to support UN activities in East Timor.

MANA is being employed to assess the following Humanitarian Assistance vignette. A Blue Force is assigned the mission to distribute food to hungry, local people. The Blue Force has a defined patrol route that leads them to the local people and out of the immediate city/village area. Locals are friendly to the Blue Force while hungry (Blue is a food source), but once they receive food, the locals become aggressive/hostile towards Blue. If Blue Forces distribute the food to a single distribution point, the locals are arrayed into a squad of 60. Conversely, if the food is delivered to three distribution points, the locals are arrayed into three squads of 20.

From an operational commander’s perspective, this issue can be perceived as a question of formulating and evaluating alternative courses of action (COAs). These COAs can be decomposed into three subordinate decisions:

- What size of Blue Force should be employed (i.e., 5, 10, or 15)?
- How many food distribution points should be employed (i.e., 1 or 3)?
- Should a LAV accompany the Blue Force (i.e., yes or no)?

Cumulatively, these questions give rise to 12 candidate COAs.



This chart rank orders the 12 COAs with respect to the mean expected value of Blue Force casualties. As can be seen, the preferred COA is to select the largest squad (i.e., 15), the largest number of food distribution points (i.e., 3), and to include a LAV. Although this result is intuitively reasonable, it is interesting to note that the rank ordering of many of the sub-optimal COAs is not so obvious (e.g., using a very large force with only one distribution point is better than having a small force with three distribution points). This is important because resource constraints and operational demands may compel the operational commander to revert to a sub-optimal COA.

These results suggest that agent based models may have an important role to play in the area of COA formulation and selection. They are relatively flexible and not particularly resource intensive. Thus we may have the option of running a fairly broad number of cases in a timely fashion, with the potential to discover interesting, synergistic emergent behaviors. In addition, they may prove useful in helping to evaluate and refine TTPs that take advantage of advances in technology. In order to enhance the quality of these tools, and our confidence in their utility, it is critical that they continue to be used with operational forces and refined to reflect lessons learned.

Key Capabilities (Transformative)

- Foundation
  - Operational Preparedness (e.g., Training)
  - Experimentation
  - Integrated System Design (e.g., System of Systems)
- Lethality / Effects
  - Responsive Reach Back
  - Non-Lethal
  - Room Clearing Weapons
  - Small, Desired Effects Weapons
  - LCDW (e.g., SASO)
  - Counter Sniper
  - Direct and Indirect Fires
- Survivability
  - Detect/Avoid Surprise Threats
  - Signature Management
  - Active Protection
  - Passive Protection
- Mobility
  - Transport Heavy Load
  - High Sprint Speed
  - Vertical Tactical Mobility
  - Soldier Vehicle Support Interfaces
  - Enhanced Endurance
- C4ISR
  - IPB for Complex Terrain
  - Detect, Classify, IFFN, Track and Fuse (e.g., Rooms, Tunnels, Jungles)
  - Decision Aids for Planning, Execution
  - Information Operations
  - Simulation on Demand (e.g., Novel COAs, Realistic Rehearsal)
  - Complex Terrain
    - * Comms (Intra/Inter Echelon)
    - * Precision Navigation/Tracking
- Sustainability
  - "Never Too Late" Supply
  - Fault Tolerant Systems
  - Power Management

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Our analyses suggest that there are several capabilities that have the potential for transforming warfare in the next ten years. However, these capabilities show major gains primarily through synergistic application. Therefore, we conclude that it is necessary to have an integrated system design to create a true soldier system of systems. Moreover, it will require continuous experimentation to develop the TTPs that optimize the components of the soldier system. In addition, as demonstrated in Project Metropolis, enhanced realistic training in urban environments can give rise to forces that are substantially more effective and survivable.

In the area of lethality/effects, the attributes of responsive reach back and organic indirect fires were singled out. It is anticipated that higher echelons will have access to information that is essential to enhance the lethality of the OFW (e.g., data on time critical targets). Mechanisms must be established to ensure that the OFW has access to the right information at the right time.[Note: This issue was the subject of a companion ASB study on Knowledge Management and Information Assurance]. In addition, numerous studies have concluded that the infantry needs organic indirect fire support, particularly in complex terrain.

In the area of survivability, the attribute of detecting/avoiding surprise threats was singled out. Analyses of operations in Sarajevo and Kosovo have demonstrated that avoiding surprise threats (e.g., ambushes, mines) can dramatically enhance survivability.

Key Capabilities (Transformative)

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- Foundation
  - Operational Preparedness (e.g., Training)
  - Experimentation
  - Integrated System Design (e.g., System of Systems)
- Lethality / Effects
  - Responsive Reach Back
  - Non-Lethal
  - Room Clearing Weapons
  - Small, Desired Effects Weapons
  - LCDW (e.g., SASO)
  - Counter Sniper
  - Direct and Indirect Fires
- Survivability
  - Detect/Avoid Surprise Threats
  - Signature Management
  - Active Protection
  - Passive Protection
- Mobility
  - Transport Heavy Load
  - High Sprint Speed
  - Vertical Tactical Mobility
  - Soldier Vehicle Support Interfaces
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  - Simulation on Demand (e.g., Novel COAs, Realistic Rehearsal)
  - Complex Terrain
    - * Comms (Intra/Inter Echelon)
    - * Precision Navigation/Tracking
- Sustainability
  - "Never Too Late" Supply
  - Fault Tolerant Systems
  - Power Management

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In the area of mobility, the attribute of vertical tactical mobility was singled out. Complex terrain such as forests and cities are 3-dimensional environments that restrict ground maneuver and reconnaissance. Direct assault can be daunting in these conditions. Aggressive maneuver that flanks the enemy (using vertical tactical mobility) may be the key to success. The importance of this type of maneuver was demonstrated in the ASB 2000 Summer Study.

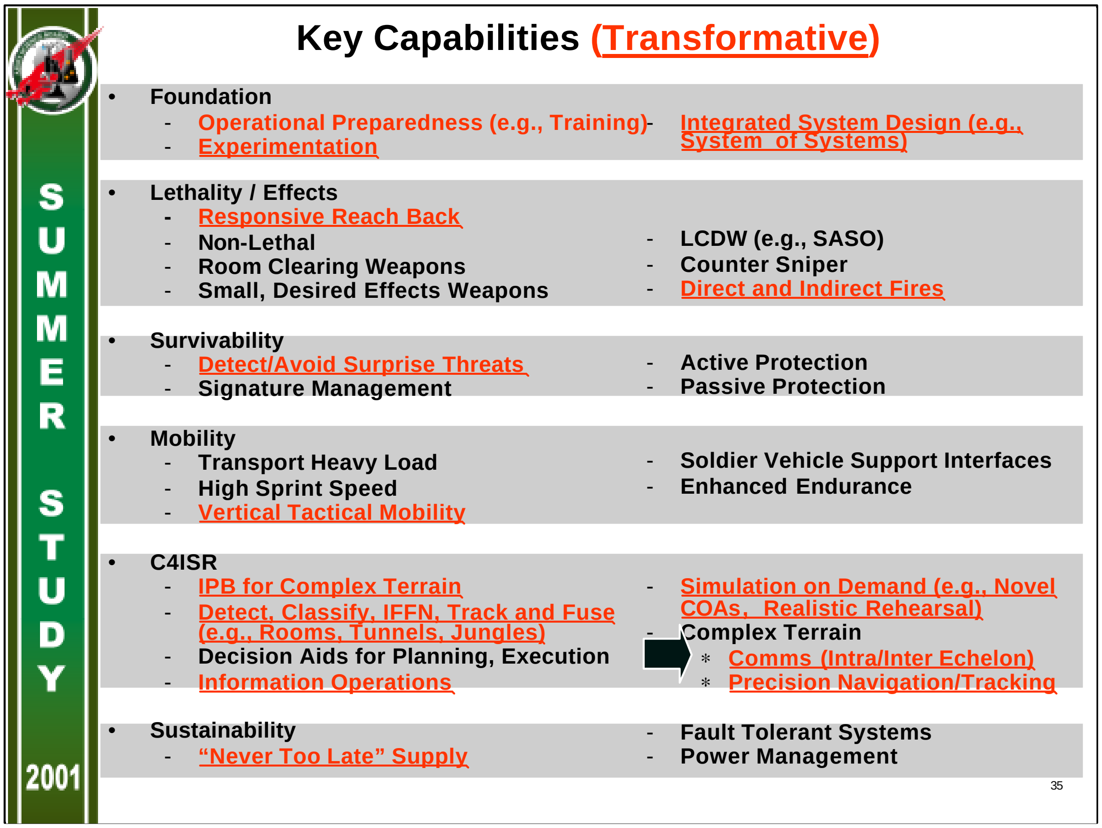
The area of C4ISR was identified as the category with the largest number of transformative attributes.

• In the area of Intelligence Preparation of the Battlespace, we are currently limited in our ability to perform this function in urban areas because of the complexity of the topology (e.g., sewers, large buildings).

• In order to provide effective situational awareness to the OFW, it is critical to perform a complex set of functions in a timely fashion (e.g., detection, classification, IFFN, tracking, fusion). For complex terrain it is particularly challenging to be able to detect targets in buildings, classify targets at beyond visual range range (e.g., is it a tank or a tractor?), perform IFFN (e.g., is it a foe or a neutral party?), and fuse information from multiple sources into a coherent picture of the battlespace.

• As demonstrated recently in the USMC's Project Lincolnia, Information Operations will be a critical activity. This includes the ability for the OFW to support tactical PSYOPs.

• Simulation is a powerful tool to support course of action analysis, training, rehearsal, and planning. "On Demand" means that the capability is always available to soldiers and leaders and databases are constantly being updated with the current situation.



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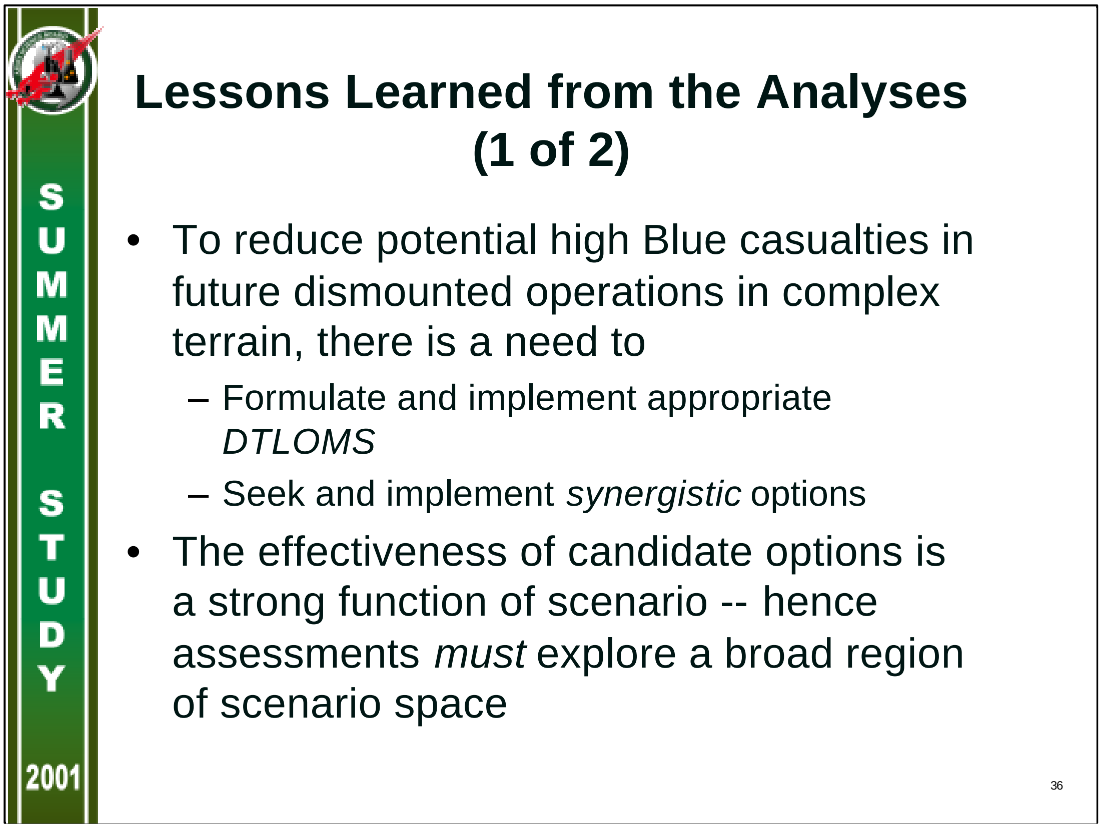
• Analyses and exercises demonstrate that communications in urban environments is a major challenge because of physical obstruction and multi-path interference. Network Centric Warfare requires high bandwidth, assured communications. The DBBL Simulation Center Floor Clearing Study showed the contribution to force effectiveness that could be derived from high data rate communications within cities.

• Dismounted soldiers require high precision navigation in extensive, complex terrain. However, GPS can be obstructed in cities and does not provide sufficient precision for close-in fights. In addition, we need a capability to track soldiers within structures to maintain situational awareness.

Finally, in the area of sustainability, Customer Relationship Management (CRM)/"FedEx" resupply stood out as a transformative characteristic. Commercial firms are using CRM to target and determine customer needs. The OFW similarly needs to have logistics tailored specifically to his immediate needs through constant monitoring of mission, activity, and logistics state. For example, a soldier's ammunition supply should be monitored and when used, reordered and delivered in a timely manner.



Our data mining and analysis activities highlight the dangers associated with dismounted operations in complex terrain. In most of the baseline cases explored, the LER is expected to be less than one. In order to reduce potential high Blue casualties for such operations, materiel solutions alone will not surfice. Our assessments reveal that innovative, consistent mixes of new doctrine, training, logistics, operational concepts, materiel, and soldier factors (DTLOMS) must be developed and implemented. In addition, the challenge to the community is to seek and implement synergistic options. Our analyses have revealed that these synergies come about by identifying and implementing mixes that compensate for the weaknesses of individual systems. For example, the LER for attacking dug-in forces in a treeline was enhanced dramatically through the use of OICW, indirect fire support, and body armor, while the contributions of individual improvements in isolation were modest. In addition, in order to interdict movement across a bridge with low collateral damage, it proved highly desirable to employ a mix of LCDW and lethal weapons.

In addition, our assessments demonstrated that the effectiveness of many candidate options is a strong function of the assumed scenario. As an example, the application of smoke in the treeline attack served to degrade the LER. Conversely, the use of smoke in support of the defense of the urban convoy appreciably reduced Blue losses. As a second example, the addition of perfect communications to the floor clearing operation decreased Blue losses by a factor of three against Medium Red Forces but had almost no impact against Heavy Red Forces. These experiences suggest that assessments must explore a broad region of scenario space systematically before concrete conclusions can be drawn.

Lessons Learned from the Analyses (2 of 2)

- Steps must be taken to make the existing set of tools more *usable*
- To compensate for deficiencies in existing tools it is important to *orchestrate* an appropriate set
- Major benefits can be derived from *harmonizing* assessment activities with other Services, Allies

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In performing the assessments summarized in this report, we found existing tools to be very cumbersome and inflexible. Since we will have to live with these tools for the foreseeable future, it is important to make them more user-friendly. This should include the implementation of simpler, more powerful interfaces, including pre- and post-processing. In addition, these tools would be far easier to use if critically needed data could be acquired and made available to the community (e.g., DTED Level 5 terrain data).

To compensate for the deficiencies of existing tools it is important to orchestrate an appropriate set. For example, it might be useful to employ an agent based model like MANA to explore a broad segment of scenario space rapidly. Based on those results, JCATS could be used to systematically explore a narrower set of “interesting segments” of scenario space more deeply. Those results, in turn, could drive a progressively narrower, deeper set of experiments using live M&S. Finally, the results of the experiments could be used to refine and calibrate the constructive M&S. This process would serve to efficiently and effectively explore issues in a credible fashion while simultaneously enhancing the quality of our tools.

Finally, major benefits can be derived from harmonizing assessment activities with other Services and Allies. We have been impressed with many of the assessment initiatives that the USMC has undertaken in the area of dismounted operations in complex terrain (e.g., Project Metropolis, Combat Decision Range). Clearly, they should be an integral part of any National Laboratory for Urban Combat. In addition, preliminary activities with Allies in NATO have been helpful in developing common Measures of Effectiveness (Reference 4). These discussions should be encouraged since it is likely that we will have to conduct urban operations in concert with them in future SASO.

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Annex A: Recommended Web Sites

- Center for Army Lessons Learned (CALL) Homepage
  - http://call.army.mil
- The MOUT Homepage
  - http://www.geocities.com/Pentagon/6453
- CSS Support of MOUT Homepage
  - http://www.cascom.army.mil/multi/mout
- OneSAF Homepage
  - http://www.onesaf.org
- Project Albert
  - http://www.projectalbert.org
- Blackhawk Down Homepage
  - http://www.philly.com/packages/somalia/sitemap.asp

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ASB 2001 Summer Study
Analysis Panel

Appendix A: Visits & Briefings

 

25 July 2001

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This Appendix provides a chronological listing of the visits that the Analysis Panel made and the subjects of those visits

Visits & Briefings (1 of 4)

SUMMER STUDY 2001

- Fort Benning (30 Oct - 1 Nov); visit to Infantry School
- TRADOC (16 - 18 Jan); including briefings on
  - CASTFOREM
  - JANUS
  - Soldier Station
- IDA (26 Jan)
  - Summary of RAND FCS work (drawing on JANUS)
  - IDA experience with
    - Joint Conflict and Tactical Simulation (JCATS)
    - MOUT ACTD

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SUMMER STUDY 2001

Visits & Briefings (2 of 4)

- STRICOM (1 - 2 Feb); overview of a variety of programs; e.g.,
  – JSIMS/WARSIM
  – OneSAF, DI-SAF
  – Engagement Skills Trainer (EST)
  – Military Operations on Urbanized Terrain (MOUT)
- Natick (14-15 Feb); emphasis on
  – Integrated Unit Simulation System (IUSS)
  – Advanced materials modeling
  – Land Warrior/Objective Soldier
- Los Angeles (26 - 27 March)
  – RAND, Santa Monica (JANUS modeling)
  – Institute for Creative Technology (ICT) (e.g., Experience Learning System)

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Visits & Briefings (3 of 4)

- **Fort Polk, LA (22 - 23 April) -- View exercise at Shughart-Gordon**
- **Washington, DC (1 - 2 May)**
  - DMSO (MOUT assessments, Smart Sensor Web)
  - AMSO (plans for MOUT assessment tools)
  - IDA (JCATS)
  - MITRE (Agent Based modeling; e.g., MANA)
  - Natick (IUSS)
  - Joint Precision Strike Demonstration (JPSD) (e.g., Joint Virtual Battlespace (JVB))
  - Night Vision Laboratory (sensor models, simulations for complex terrain)
- **Quantico, VA (4 May)**
  - USMC Combat Decision Range (CDR)
  - JCATS applied to non-lethal weapons assessments

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Visits & Briefings (4 of 4)

- **Albuquerque (21, 22 May)**
  - Sandia National Labs (e.g., robotics, generative analysis, genetic algorithms)
  - TRAC WSMR (M&S)
  - LANL (agent based modeling)
  - Theater Air C2 Simulation Facility (TACCSF)
- **Washington, DC (4 June)**
  - JPSD (JVB redux)
  - JWFC/LLNL (JCATS analyses of non-lethal weapons)
- **Santa Monica, CA (12, 13 July)**
  - RAND analyses
  - TRAC Monterey activities (e.g., MOUT FACT, Land Warrior Training Initiative)

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ASB 2001 Summer Study
Analysis Panel

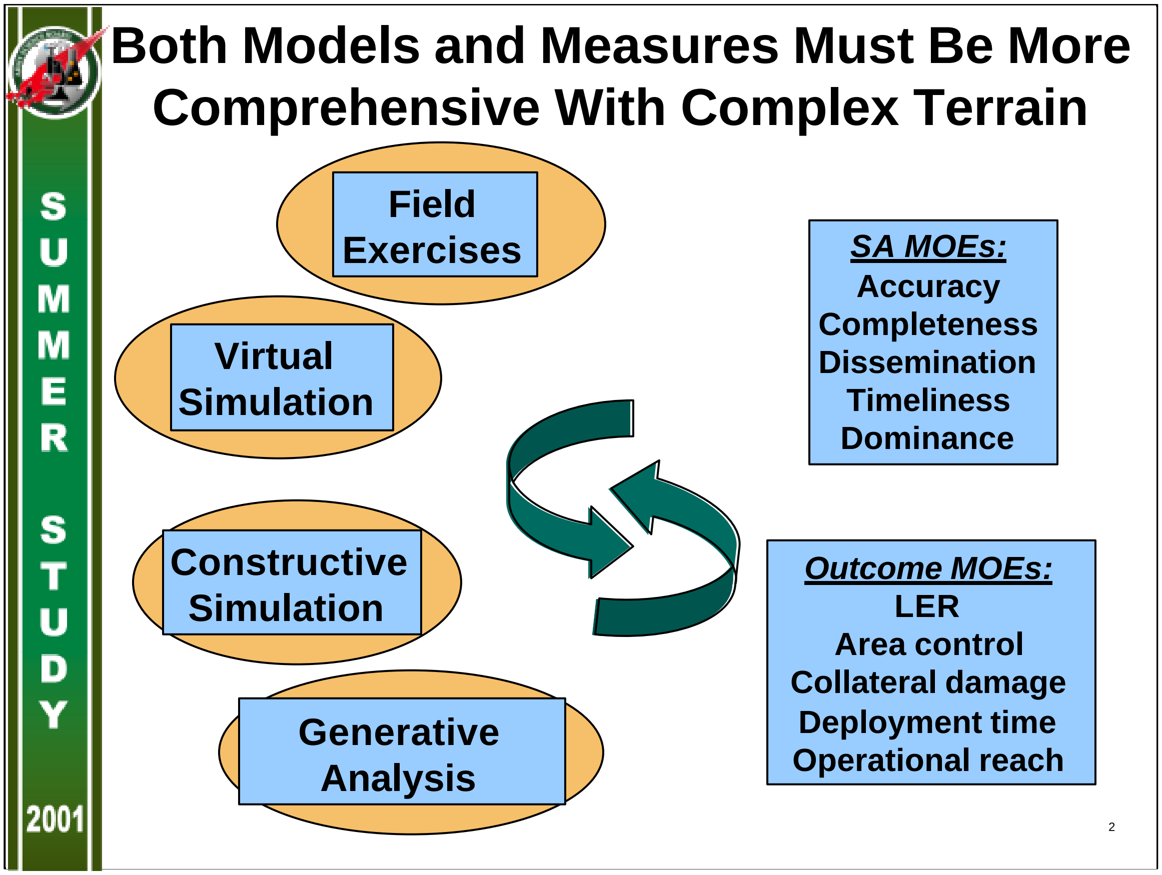
Appendix B: Tools

25 July 2001

1

The Tools Appendix describes the Panel's deliberations on tools and ancillary products to enhance the quality of future assessments of dismounted operations.

The Appendix begins by identifying the challenges that confront the analysis community in performing assessments of dismounted operations in complex terrain. This is followed by an identification and description of existing and planned tools and techniques for performing such assessments. Emphasis is placed on key constructive, virtual, and live M&S that the Panel encountered in their visits and discussions. The Panel then identified residual deficiencies that will limit the analysis community's ability to perform critical assessments of dismounted operations in complex terrain. The Appendix concludes with a set of recommendations to ameliorate those perceived deficiencies.



Most analytic studies of ground force operations examine operations in relatively open terrain, with relatively conventional weapons, straightforward tactics, and simple rules of engagement. Simulation of future operations in complex terrain is much more demanding. As a result, it requires a more comprehensive set of models and measures of effectiveness. Models must be able to represent three-dimensional environments, interspersed noncombatants, non-lethal weapons, and a host of other complications. At the same time, outputs must provide insights on a wide range of issues and measures of effectiveness. Situation awareness must be more complete and timely in a MOUT mission than the equivalent engagement in open terrain. Outcomes must include non-combatant losses and infrastructure damage along with LER and area control.

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Challenges in “Analyzing” Dismounted Operations

- **Key constructive and virtual model research is missing or inadequately resourced**
- **Core physical and behavioral models are inadequate as a foundation for simulation**
- **Limited ability of unit effectiveness models, particularly in urban scenarios**
- **Little agreement on representative scenarios**
- **Current models are resource intensive and inflexible (e.g., frequently operational doctrine and TTPs are embedded in the code)**
- **Data are difficult to acquire (e.g., very high resolution terrain data, human performance data)**

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Based on our review of existing and planned tools to evaluate dismounted operations in complex terrain we have concluded that the community has a number of important limitations. We have identified six specific challenges that warrant immediate attention. First, we have concluded that key constructive and virtual model research is missing or inadequately resourced. This conclusion is broadly consistent with the preliminary findings of the recently formed MOUT Functional Area Concept Team (FACT). Our only sense of disagreement with that group is that we believe that they are overly optimistic in their assessment of the state of the research base. Second, we rate core physical and behavioral models for complex terrain as inadequate. For example, as pointed out by Mike Bauman, Director, TRAC, we lack an understanding of the process by which an individual performs the search process, either unaided or with a sensor, in an urban environment. Third, we have key limitations in unit effectiveness models particularly to address complex and urban scenarios. In the analyses that we performed to support the Summer Study, the inability to represent innovative TTPs easily and the lack of credibility of existing unit effectiveness models became quite apparent. Fourth, we have little agreement across the community about what these representative scenarios should be. During the Cold War, we had the comfort of dealing with the Fulda Gap and SCORES 6A. We have yet to replace these scenarios with a set of conditions that people understand and believe to be representative of future conflict. Fifth, we have found current models to be highly resource intensive and relatively inflexible. This means that it takes extensive time and resources to do focused analysis in this arena. As a consequence, current analyses are often limited to a very restricted set of conditions. Finally, the data that are available is very difficult for analysts to acquire and assimilate into existing models. As an example, simulations of MOUT generally require very high resolution terrain data (e.g., 1 meter resolution or DTED level 5). Currently, the regions of the world where DTED level 5 data are available is extremely limited and extremely time consuming to acquire and adapt to the needs of the models. It is even more challenging if subterranean features (e.g., sewer systems) are needed for the models. In addition, valuable data that have been acquired at the Combat Training Centers have not been made available for research.

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Army MOUT FACT* Findings (Current Capabilities)

Focus Area	Basic Knowledge	Algorithms	Data
Indirect Fire	Green	Green	Yellow
Tactical Communication	Yellow	Yellow	Yellow
Mobility	Yellow	Yellow	Red
Direct Fire	Yellow	Yellow	Red
Wide Area Surveillance	Red	Red	Red
Search and Target Acquisition	Red	Red	Red

***Functional Area Concept Team**

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As noted on the prior page, the Army Modeling and Simulation Office (AMSO) has created the MOUT FACT to review shortfalls in current M&S capabilities.The above slide summarizes the MOUT FACT's preliminary estimate of current capabilities. We believe this chart is optimistic. For example, the only areas given as "green" are basic knowledge and algorithms for indirect fire. However, very little is known about indirect fire effects in urban environments with new weapons such as the Objective Individual Combat Weapon (OICW).

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Baseline Elements of the Toolset (1 of 2)

- **Operations Analysis tools (which can be adapted to provided insight into dismounted operations in complex terrain); e.g.,**
  - **Expert elicitation with groupware**
  - **Multi-criteria Decision Analysis**
  - **Causal mapping**
  - **System dynamics modeling**
- **Modeling & Simulation**
  - **Constructive M&S**
    - **Joint Conflict and Tactical Simulation (JCATS) (LLNL)**
    - **JANUS (e.g., RAND)**
    - **Integrated Unit Simulation System (IUSS) (Natick)**
    - **Close Action Environment (CAEn) (UK)**
    - **OneSAF Test Bed (OTB)/DISAF (STRICOM)**
    - **Agent based modeling (e.g., ISAAC,MANA) (Project Albert)**

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There are four categories of tools needed for OFW analyses: Operations Analysis tools, Constructive, Virtual, and Live M&S.

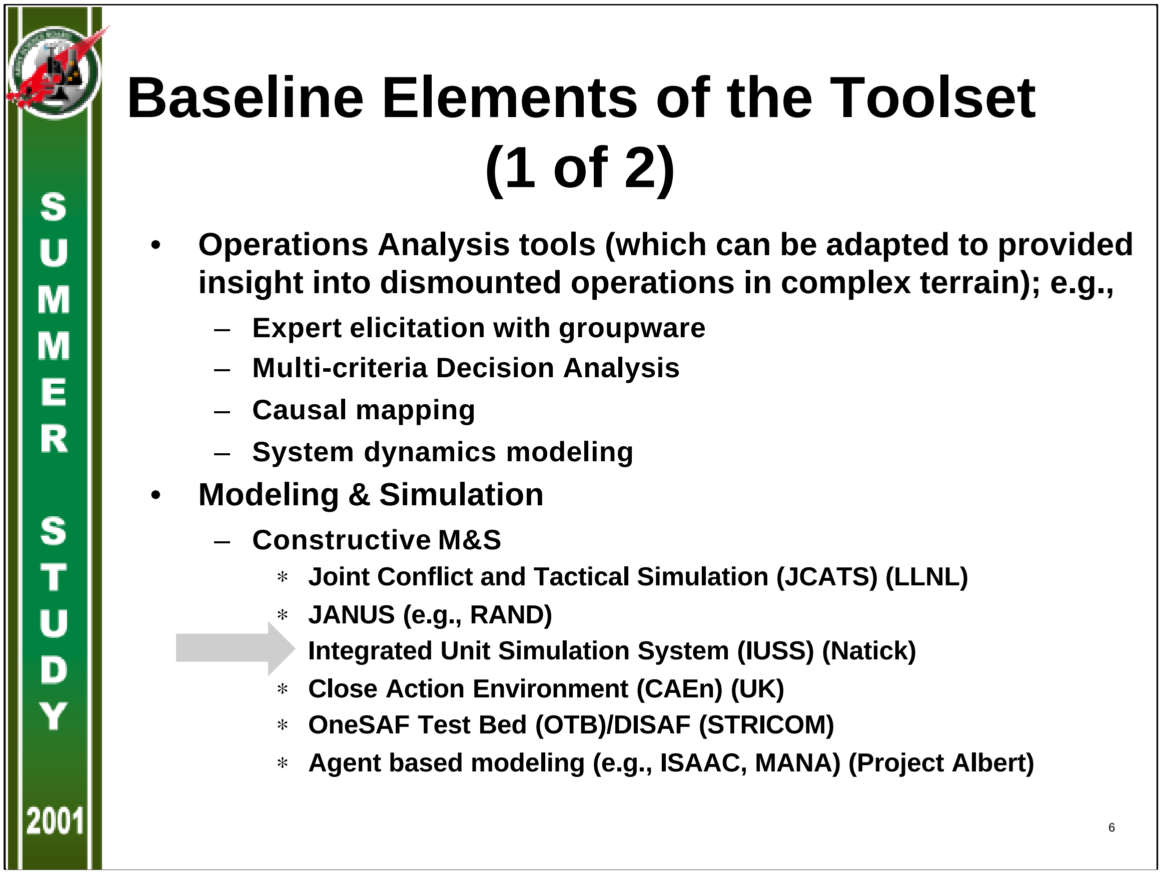
Selected Operations Analysis tools are often borrowed from the social sciences to provide insight into complex and dynamic problems. For example, expert elicitation is used to provide an understanding into human decision making.

Constructive simulations can give insight across a wide range of conflict, particularly operational and strategic levels of war. Three simulations of note are JCATS, IUSS, and OneSAF Test bed (OTB). In addition, our analyses made extensive use of JANUS, which is widely used in the tactical analysis community.

The Joint Conflict and Tactical Simulation (JCATS) is being developed as a multi-sided interactive entity level conflict simulation to be utilized by military and site security organizations as an exercise driver and a tool for training, analysis, and mission planning. One of the unique capabilities to be provided by JCATS is very detailed modeling of small group tactics in rural or urban terrain modeling, in day or night operations with artificial lighting.

JCATS has no autonomous entity behavior such as route planning, tactical movement, or selection of covering terrain. There is no unit-level behavior that automatically coordinates the actions of the entities in the unit; all such unit behavior must be directed by the user in much the same way that DISAF's Clear Room behavior currently works. Entities cannot move in a unit formation except as the user directs them to move in proximity to other entities in the same unit.

Units can be controlled in JCATS by aggregating individuals. The treatment of aggregated units places JCATS between an entity and aggregate level simulation. The aggregate movement algorithm largely ignores terrain effects on individual entities. JCATS moves aggregated units from the unit's center of mass, then disperses the entities according to a formation template. Entities within aggregates do not acquire targets. The aggregate's sensors are pooled.

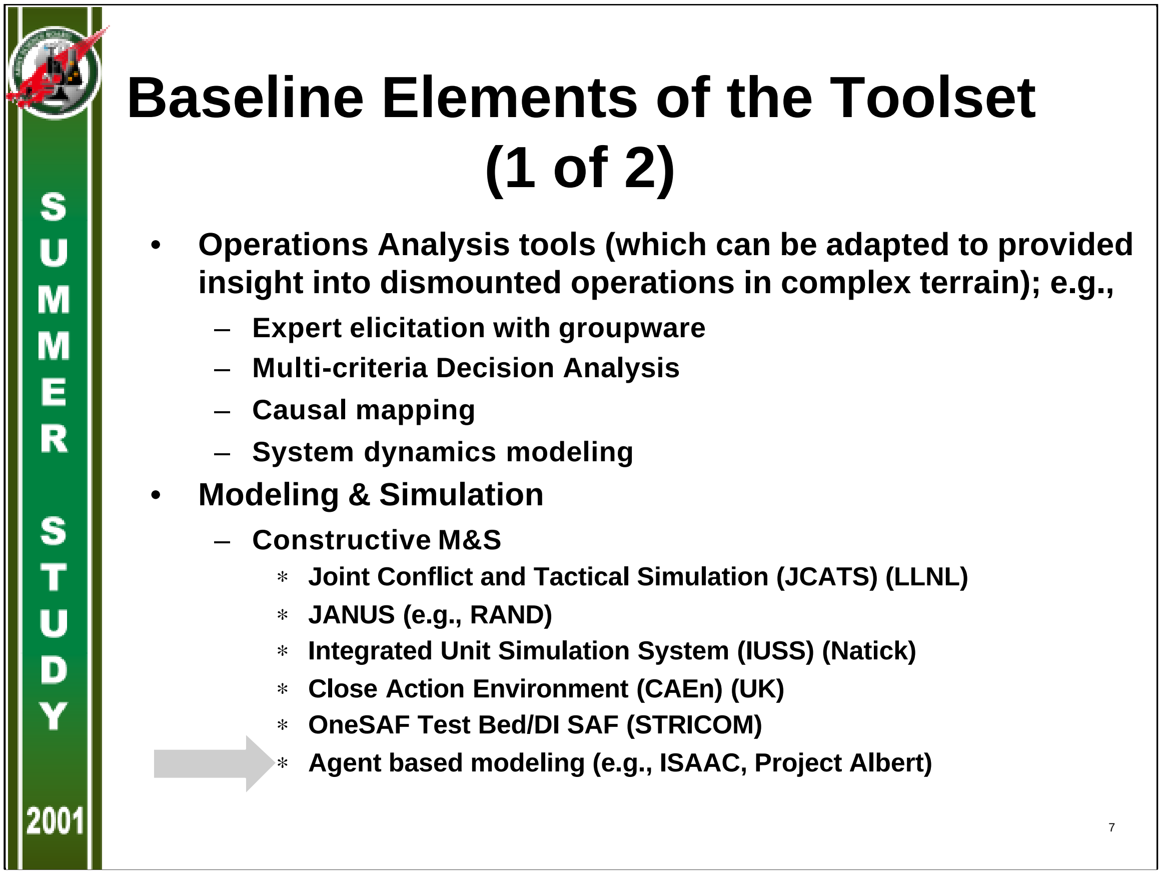


IUSS (Integrated Unit Simulation System) is a small unit analytical simulation that models components of the dismounted combatant's equipment, training, and organization and the interaction with the battlefield environment. IUSS explicitly models the effect that soldier load, conditioning, acclimation, environment, and terrain have on the accomplishment of small unit Army Training Evaluation Program (ARTEP) tasks. These ARTEP tasks are connected in a sequential task network to describe a small unit's mission. IUSS dynamically models ballistic, chemical, and thermal casualty mechanisms. A detailed physiological model relates these casualty mechanisms, soldier load, terrain and environment to the soldier's movement rate. This model also provides detailed information about the soldier's physical and medical status.

IUSS provides database tools to organize simulation inputs and provides formatted text file outputs which can be used by COTS software (e.g., spreadsheets) to support analysis. IUSS supports DIS protocols and is migrating to HLA.

ModSAF has continued to evolve and grow in its role as the Army's SAF development system of choice. ModSAF was developed to support large scale multi-Service exercises. Since the analysis at the beginning of the DWN program a number of new DI units and behaviors have been incorporated into ModSAF. However, none of these extensions provide high fidelity individual combatant models. For example, it is not possible for the operator (in ModSAF 4.0 or earlier) to direct an individual combatant to move along a precise route.

Most of DISAF, especially the enhancements for restricted terrain, was integrated into ModSAF and will be released with ModSAF 5.0. Additional extensions currently under development are being integrated into the OneSAF Test bed (OTB) in 2001. Basing DISAF on ModSAF/OneSAF allows DISAF to take advantage of all additional features and bug fixes applied by a large development team and makes DISAF available to a large simulation community.



One additional area of major interest for constructive M&S is agent-based modeling.

[Note: "An agent is an object in a computer program that encapsulates a particular behavior when interacting with other agents within an environment. The behavior may be simple or complex; deterministic, stochastic or adaptive; and the system as a whole may be homogeneous (all agents are of the same type) or heterogeneous (more than one type of agent present)." (http://www.brs.gov.au/social_sciences/kyoto/hood2.html)].

The Marine Corps is exploring agent based modeling with respect to urban operations in Project Albert

(http://www.mors.org/C4ISR_2000/Tutorials/Project_Albert.pdf).

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Baseline Elements of the Toolset (2 of 2)

- M&S (concluded)
  - Virtual M&S
    - Soldier Workstation (TRAC WSMR)
    - Smart Sensor Web Testbed (Distributed)
    - USMC Combat Decision Range (Quantico)
    - Dismounted Warrior Network (Ft. Benning)
    - VERTS (STRICOM)
    - Engagement Skills Trainer (STRICOM)
  - Live M&S
    - Shughart-Gordon Range (Ft. Polk)
    - McKenna MOUT site (Ft. Benning)
    - USMC ranges
      - George MOUT site, CA (soldier training)
      - Yodaville, AZ (CAS experiments)

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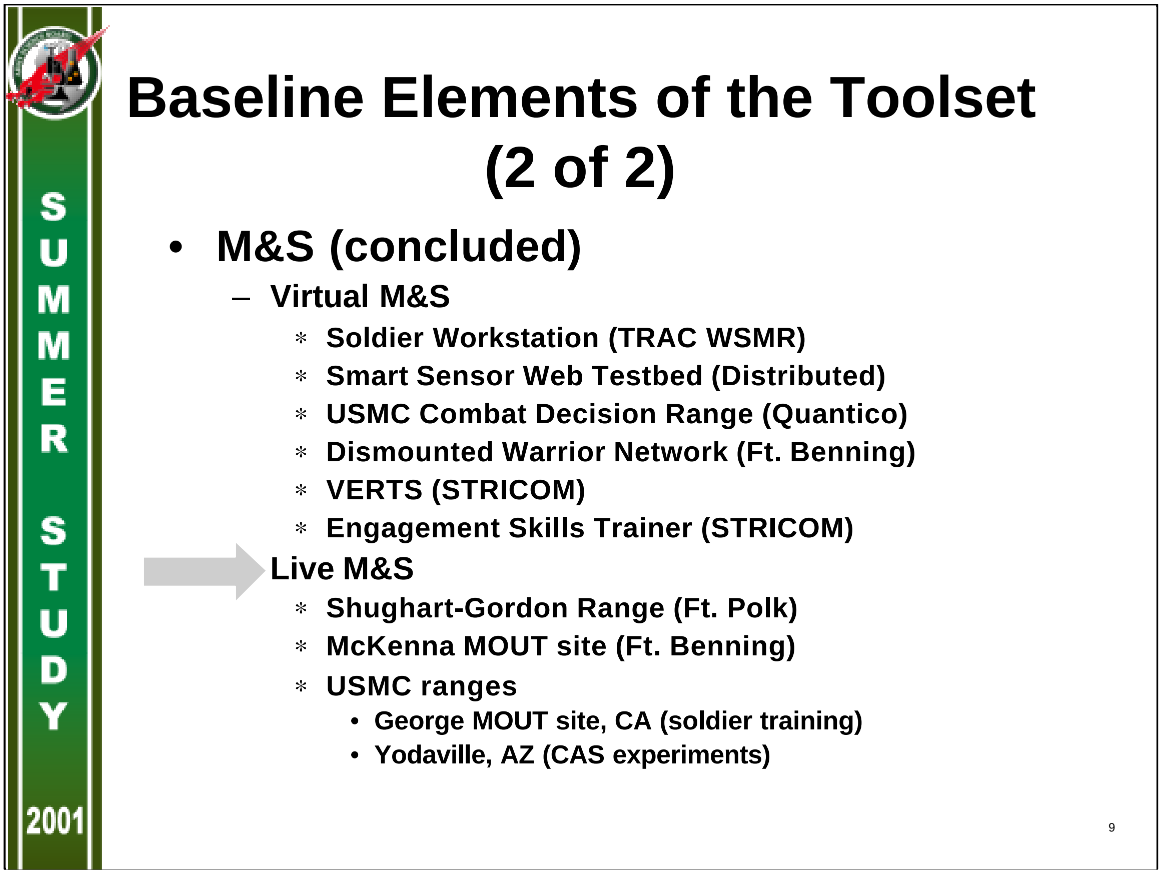
Virtual Simulation is a synthetic representation of warfighting environments patterned after the simulated organization and operations of actual military units. Unfortunately, we have not advanced in dismounted virtual simulation as we have in armor or mechanized simulation. However, there are some promising developments.

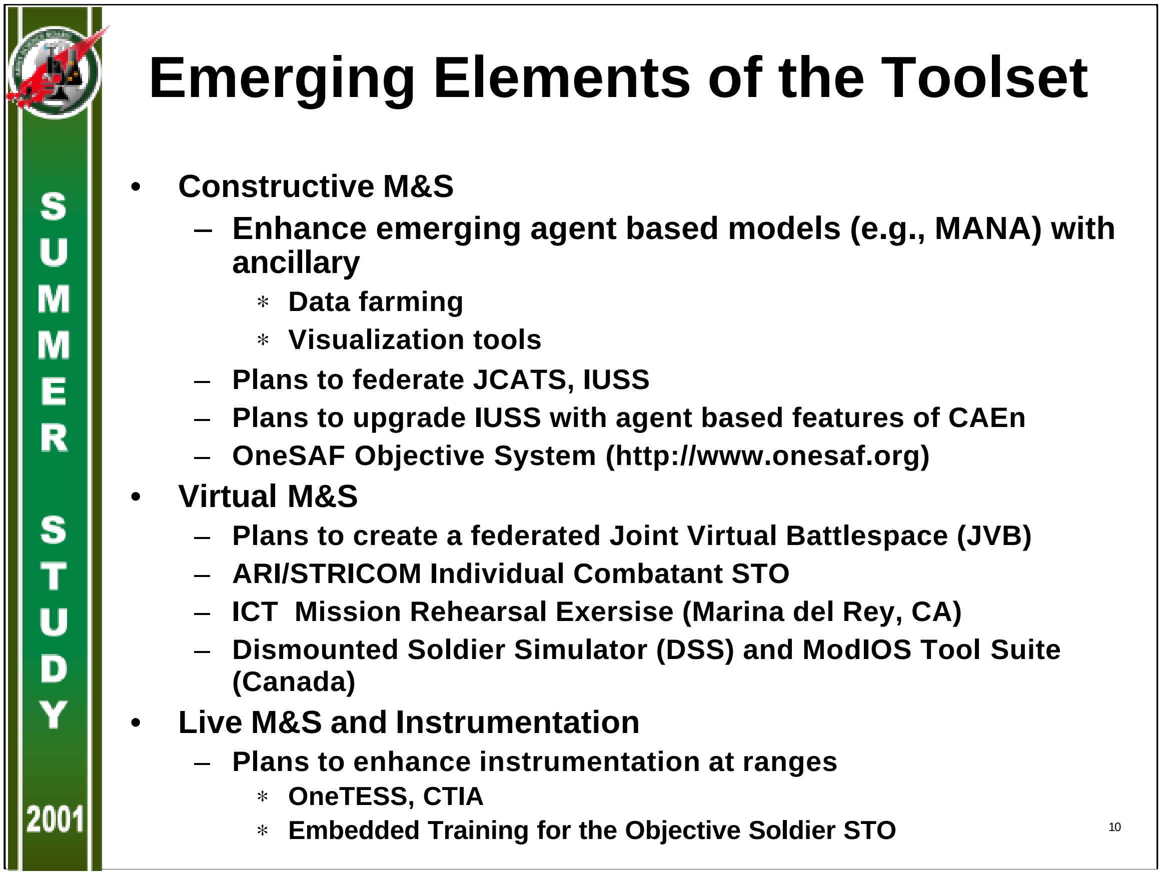
The Combat Decision Range (CDR) is a computer simulation and video program designed to hone decision-making skills in military operations. CDR intersperses videos that form a decision tree. The range can be tailored for training in various environments, from peacekeeping to combat. The Marine Corps has adopted this program for every regiment. One demonstrated use is to incorporate notional technologies in the decision process to see potential impacts.

Virtual Emergency Response Training System (VERTS) is developing, demonstrating, and fielding concept systems for use in training soldiers to respond to natural and man-made homeland emergencies. These immersive virtual systems use state-of-the-art technologies for motion tracking, visualization, and interaction with a synthetic representation of real environments (http://www.stricom.army.mil).



Live simulations are associated with operational testing, field exercises, training exercises, and force-on-force and force-on-targetry exercises. Live simulations include training events where soldiers physically deploy as units (usually against an OPFOR) and use simulators (e.g., weapons simulators) to replicate certain parts of combat. Live simulations can take place almost anywhere the maneuver space is available. The simulators used often replicate weapons systems interaction and damage.

Shughart-Gordon Range at the JRTC, Ft. Polk, and McKenna MOUT site, Ft. Benning, represent the state of the art in live MOUT simulation. Designed to support up to a battalion-level assault, this versatile facility consists of 27 multi-story buildings with a total of 295 rooms with realistic furniture and training props. The village, designed to replicate a key command, control, and logistical hub, contains a hospital, police and other government buildings, a radio station, a factory, warehouses, and administrative and civilian buildings. The buildings contain electrical and water supplies, blowholes for forced entry, and firing ports. The facility maintains an audio-visual capability consisting of external cameras providing 360-degree coverage of all mounted and dismounted avenues of approach to the town as well as complete coverage within the village. It is notable that the Marine Corps Warfighting Laboratory is conducting urban experiments at the former George AFB, Victorville, CA, which is substantially larger than any Army MOUT site (i.e., it contains approximately 1000 low rise buildings).



Several new efforts show promise in improving simulation for urban operations (see above slide). Some representative examples include the following.

• Constructive M&S. Some of the most interesting new forms of modeling involve agent-based systems in which low-level entities with relatively simple attributes and behaviors can collectively produce (or "generate") complex and realistic "emergent" system behaviors. This is potentially a powerful approach to understanding complex adaptive systems generally in fields as diverse as ecology, economics, and military command-control. A fundamental step in developing particular models and simulations is deciding which attributes and interactions to represent, and in what detail. This choice should be the one that most adequately describes the phenomena one is trying to observe, but that choice is often not known until the subsystems are connected and the simulation is run. Thus, methods should be developed to allow one to iterate on the choice of the initial representations of subsystem models, based on results of their use in interconnected systems. (http://www.nap.edu/html/simulation/)

OneSAF will be a composable, next generation computer generated force simulation that can represent a full range of operations, systems, and control process from individual combatant and platform to battalion level, with a variable level of fidelity that supports all M&S domains. It will accurately and effectively represent specific activities of ground warfare (engagement and maneuver), C4I, combat support, and combat service support. It will also employ appropriate representations of the physical environment and its effect on simulated activities and behaviors.

At a minimum, OneSAF must play the effects of weather and terrain (static and urbanized). This capability exists in one or more of the models OneSAF will replace and JCATS version 2.0 for urbanized terrain (http://www.onesaf.org).

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Emerging Elements of the Toolset

- Constructive M&S
  - Enhance emerging agent based models (e.g., MANA) with ancillary
    - Data farming
    - Visualization tools
  - Plans to federate JCATS, IUSS
  - Plans to upgrade IUSS with agent based features of CAEn
  - OneSAF Objective System (http://www.onesaf.org)
- Virtual M&S
  - Plans to create a federated Joint Virtual Battlespace (JVB)
  - ARI/STRICOM Individual Combatant STO
  - ICT Mission Rehearsal Exersise (Marina del Rey, CA)
  - Dismounted Soldier Simulator (DSS) and ModIOS Tool Suite (Canada)
- Live M&S and Instrumentation
  - Plans to enhance instrumentation at ranges
    - OneTESS, CTIA
    - Embedded Training for the Objective Soldier STO

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• Virtual M&S. The evolving Joint Virtual Battlespace (JVB) has the potential to play a critical role in assessing and acquiring the Objective Force. The following chart summarizes its key elements and identifies an important issue to resolve.

The USC Institute for Creative Technologies is developing a Mission Rehearsal Exercise (MRE) system (http://www.ict.usc.edu). The goal of the MRE system is to provide an immersive learning environment where the participants experience the sights, sounds, and circumstances they will encounter in real-world scenarios while performing mission-oriented training. To create such an environment, the ICT is performing research in creating interactive stories to engage the learners while achieving pedagogical goals related to the mission and the types of dilemmas that the participants are likely to face. The outcome of these stories will depend on the decisions and actions that participants take during the simulation. The ultimate goal is to prepare decision-makers who must think on their feet under realistically complex, stressing circumstances.

MRE also incorporates realistic virtual humans in key roles as characters, playing the roles of locals, friendly and hostile forces, and other mission team members. In addition, virtual humans may act as trainers in the immersive learning environment. To be realistic, the virtual humans will need to integrate motor skills, problem solving, emotion, gestures, facial expressions, and language.

Dismounted Soldier Simulator (DSS) and the ModIOS Tool Suite. Several Canadian defense agencies (e.g., the Defence and Civil Institute of Environmental Medicine (DCIEM)) plan to use these virtual simulations to explore the utility of new and existing technological enhancements for the urban battlefield. The DSS will feature technologies, such as moving map displays, heads-up displays, and fused sensors, which will be virtually prototyped and tested by Canadian Army soldiers. Motorola's ModIOS Tool Suite, which will be integrated into the DSS, will support such functions as the real-time, three-dimensional representation of the urban area, simulation management, exercise control, and after-action review.

SUMMER STUDY 2001

Emerging Elements of the Toolset

- Constructive M&S
  - Enhance emerging agent based models (e.g., MANA) with ancillary
    - Data farming
    - Visualization tools
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- Live M&S and Instrumentation
  - Plans to enhance instrumentation at ranges
    - OneTESS, CTIA
    - Embedded Training for the Objective Soldier STO

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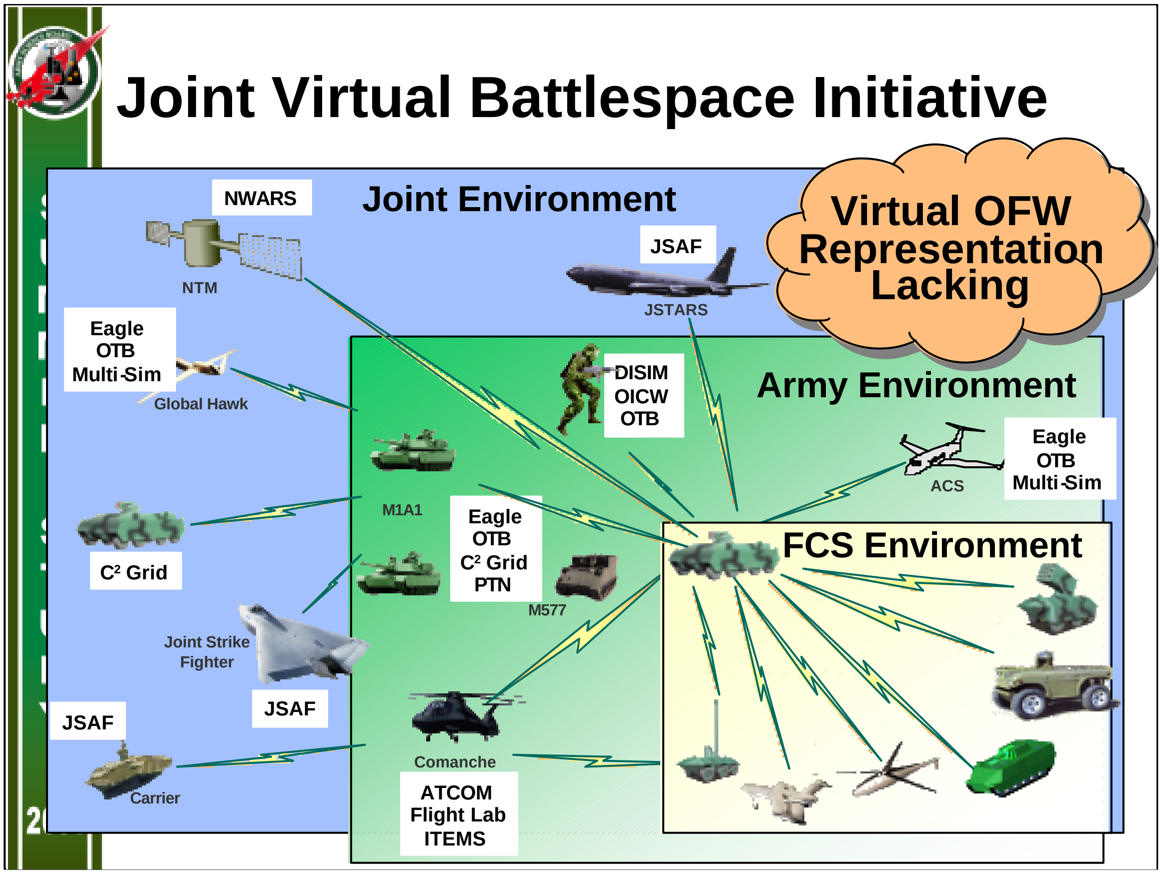
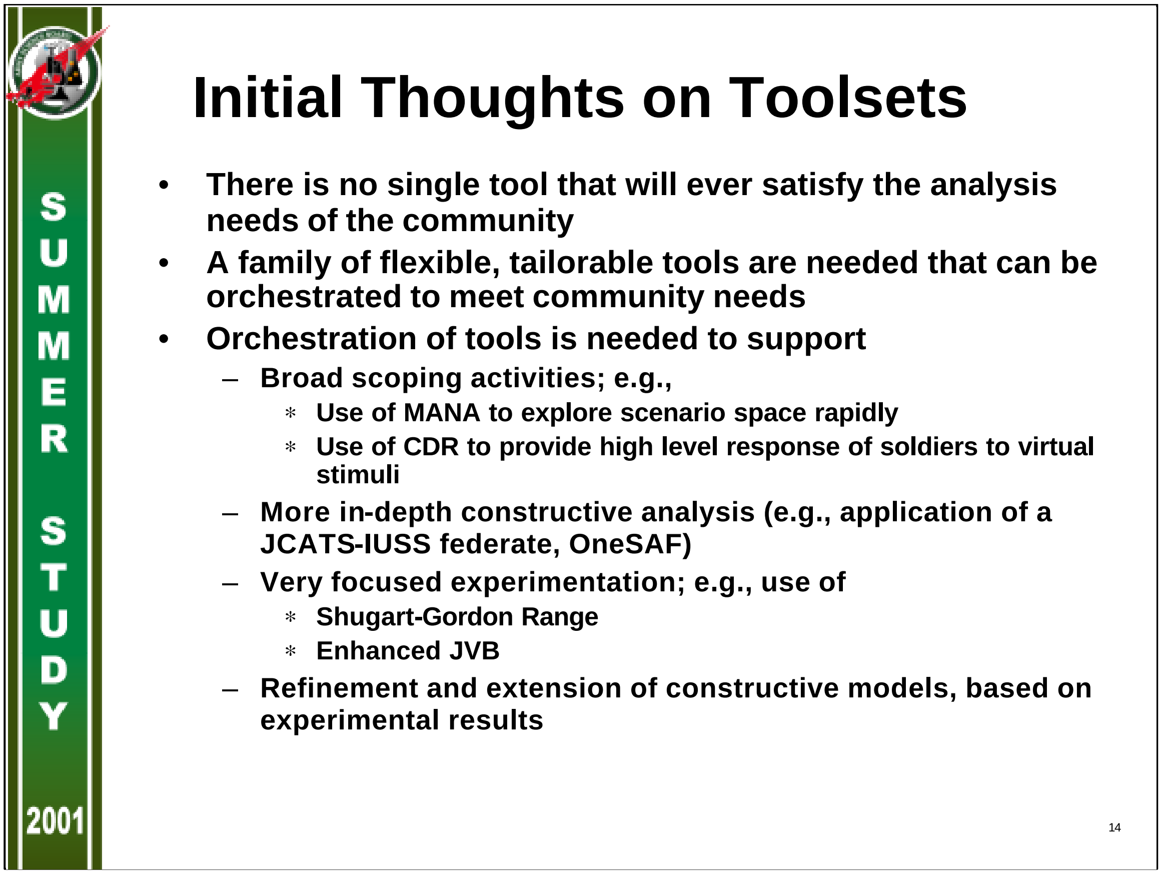
• Live M&S and Instrumentation. One Tactical Engagement System of Systems. (OneTESS) is a family of tactical engagement simulation systems that support Force-on-Force and Force-on-Target training exercises at Brigade and below. It will be deployed in all Battlefield Operating Systems at homestation, maneuver Combat Training Centers, and deployed sites. The system will require execution of proper engagement procedures, simulate weapon system's accuracy and effects, and stimulate detectors, sensors, monitors and countermeasures. OneTESS will use a common architecture compliant with the Common Training Instrumentation Architecture (CTIA).



The JVB was established by ASA(ALT) and is managed by the PEO IEW. The JVB is attempting to model the major elements of the Objective Force, particularly the Future Combat System (FCS). However, we believe the JVB does not satisfactorily represent the dismounted soldier. This is primarily because of the lack of tools/models available to integrate into JVB for this purpose. Consequently, the scope of the JVB should be broadened to develop and implement representations of dismounted soldiers.



We do not believe, given the wide variety of applications of M&S, that a single simulation can satisfy all the needs of analysts for OFW.

Therefore, we encourage the development of a family of tools that are flexible, open, and interoperate with each other.

In order to take advantage of the strengths of selected M&S and to compensate for their weaknesses, a broad orchestration strategy is recommended. As an illustration, it is recommended that an assessment be initiated with flexible tools that can provide a broad, shallow assessment of the scenario conditions of interest (e.g., use of an agent based model, such as MANA, to explore scenario space rapidly or use of a relatively simple virtual simulation, such as the USMC CDR to provide high level response of soldiers to virtual stimulii). Once the key issues and conditions of greatest interest have been identified, more in-depth, less flexible tools can be brought to bear (e.g., OneSAF or JCATS). Since the performance of distributed teams of individuals under stress is critical to most of the problems associated with dismounted operations in complex terrain, it would be highly desirable to explore the issues further using appropriate virtual M&S (e.g., JVB) or live M&S (e.g., Shughart-Gordon Site). To continue the cycle, data from these experiments should be used to refine/extend constructive M&S.

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M&S Advantages and Shortcomings

Exemplary Missions	Key Aspects	Janus Confederation Issues	JCATS/IUSS Issues	OneSAF Testbed v1.0 Issues	Man-in-the-loop Issues	Field Experiment Issues
Movement to Engagement	Long range fires, joint C4ISR, deconfliction, aggressive maneuver	Accredited, but scale limits, constrained reactive enemy	Can control individual and aggregate units, not accredited	Good scale and scope, some responsive rules questionable	Very limited in number of systems, problem with learning over interations	Expensive, learning issues, risk problems
Treeline Ambush	Penetrating sensors, IUGS, APS, dismount ops, robotics	Individual trees not modeled, effects parametric	Limited robotics models, no APS, has dismount postures, physiological modeling	Dismount movement more realistic, rules probabilistic	Allows highly reactive sides	MILES doe not penetrate foliage
Humanitarian/ Crowd Control	Non-lethals, ROE shifts, robotic control	Only Red and Blue, few nonlethals, need robotic planning models	Multiple sides modeled, some robotic modeling, nonlethals	Multiple sides modeled	Good presentation of stressing situation; liimited scale	Most realistic of methods, but scale, risk, and learning problems
Exterior MOUT	Visualization, counter-sniper, comm and position location	No 3-D model of terrain, degradation of comms and position	3-D LOS, but no 3-D visualization	3-D LOS and visualization	Scene limitations	MOUT complex limitations
Interior Fighting	Penetrating sensors, rubbling,, shooting through walls, ROE	No 3-D model of terrain,	3-D model of floors, but need visualization	Scripted interior fighting	Small unit onl y	Safety, learning, and scale issues

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This is a very compressed summary of the characteristics and issues of illustrative scenarios, component functions, and how well the different models represent key aspects. It reinforces the need to orchestrate these models to enhance their strengths and compensate for their weaknesses.

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Key Toolset Issues (1 of 2)

- **“Simulation on Demand”**
  - **Need for M&S that can readily import real time news, web databases**
  - **Appropriate capabilities are needed at all levels**
- **MOUT M&S, Data**
  - **Need for M&S that capture the dynamics of MOUT**
  - **Need for more detailed, 3 dimensional environmental data (e.g., DTED Level V)**
    - **Rapid Terrain Visualization may be a useful source of data (issue: access to collection resources)**
    - **Interior and subterranean data remains a problem**
  - **Need to mine accumulated data (e.g., Ft. Polk results)**
- **Representation of human behavior, C3I**
  - **A coordinated research effort is needed to illuminate the issue**
  - **Current research is fragmented, incomplete**

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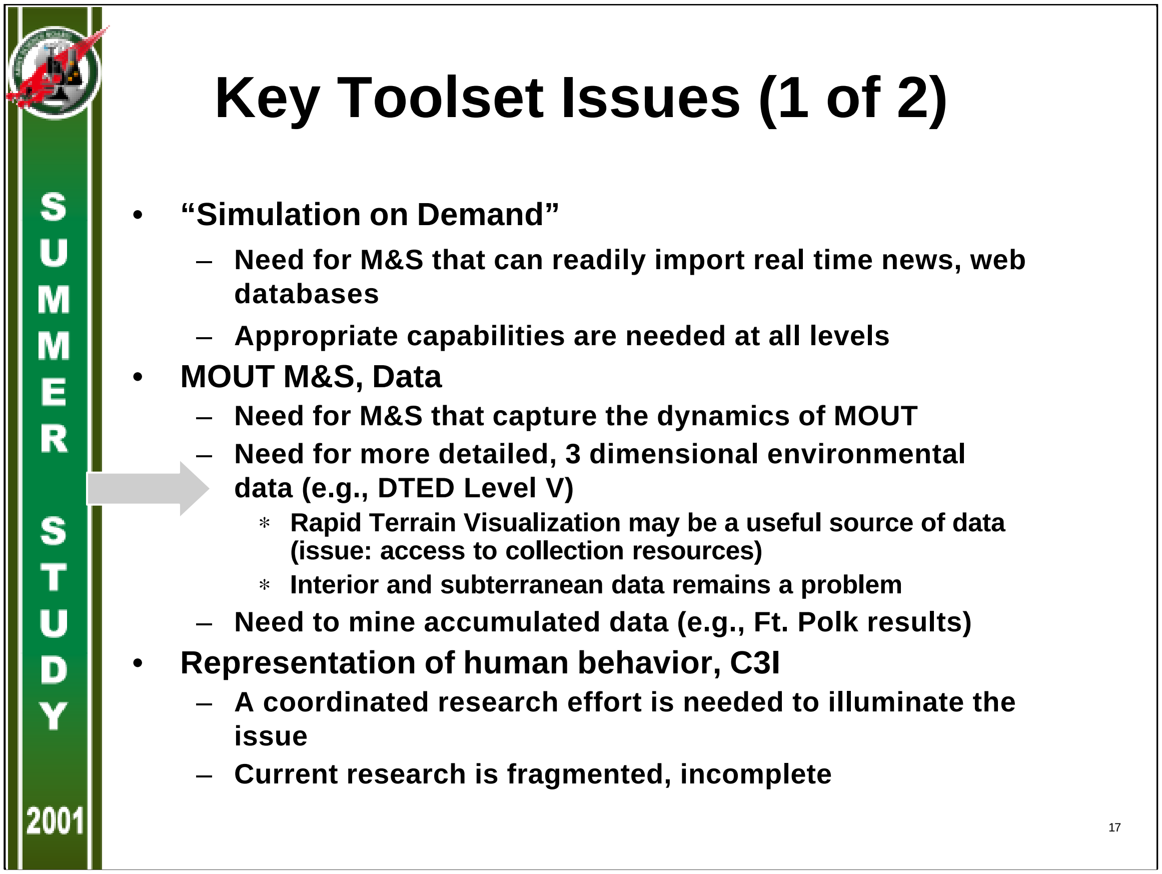
At the Spring 2001 Simulation Interoperability Standards Organization (SISO) Workshop, Dell Lunceford, the director of the Army Modeling Simulation Office (AMSO), called for the M&S community to ponder the Grand Challenges of M&S. This raises the question as to what we perceive as the Grand Challenges, regardless of resource constraints. Below is an incomplete list of some of the panel’s favorites and why:

• “Simulation on Demand”. Jim Dunnigan (www.jim.dunnigan.com), one of the foremost modern wargamers, has pointed out that in an era when we are swimming in information, we do not have military simulations that take advantage of real time news and web databases. For example, if the Commander-in-Chief of Central Command (CINCCENT) is faced with a crisis in the Indian Ocean region, he should be able to create rapidly a matching scenario in a war game that has its database automatically populated with both current and historical information. CINCs primarily need high level information and deal in both political and military worlds. They also need their simulations to give them rapid insight to emergent issues such as terrorism or economic stability (e.g., the price of oil). QuickSim would always be running, incorporating the latest changes of the world's state into the game. Comparable capabilities are needed at the operational and tactical levels of conflict.

• MOUT M&S, Data. MOUT show up on lots of people's lists, primarily because we do not have good models or simulations for urban combat. The world is becoming increasingly urbanized (e.g., over the next 25 years, it is projected that the percent of individuals in urban areas in Asia will go from 35 % to 50%). It is safe to assume that CINCs and Service commanders have to plan and train for these environments. However, urban areas have physical attributes (e.g., city blocks) that deny use of long range sensors and fires, slow the operational tempo to a crawl, limit communications, and impose the need to deal with non-combatants.

Fighting in cities is a three-dimensional problem. This calls for very different kinds of tactics and operational concepts than what traditional models assume. Moreover, a commander's instincts are to avoid cities, and few contemporary American commanders have extensive experience in them.



In particular, there is a substantial lack of data regarding urban environments, including high resolution terrain and GIS databases.

There are a number of efforts to tackle this problem. SAIC in Orlando has made substantial progress in simulating urban environments in a special version of ModSAF. They have been able to incorporate urban models (such as sewer systems and skyscrapers) developed by IDA into ModSAF and simulate urban operations. Army Research Institute (ARI) is building an After-Action Review capability for this type of simulation combined with instrumented live MOUT training. However, there are inadequate resources to exploit fully the data that are collected at MOUT sites (e.g., Fort Polk).

• General Models of Human Behavior, C3I. This is, in a sense, the Holy Grail of artificial intelligence (AI) since AI is an attempt to model and simulate human behavior with the result that we can be fooled into believing that a computer "thinks." To a limited degree, AI is starting to fulfill this promise. On the low end of the scale, we have computers that beat grandmasters in chess and checkers. On the other end, we have examples of computers that can have a limited dialogue with a human in a specific context, and exhibit emotion (www.ict.usc.edu/misreh.html).

Another intriguing idea is to use very simple models of human behavior, which--in the aggregate--give us insight into the behavior of a population. Representative examples include the commercial game, The Sims (www.thesims.com), which allows you to play God over a group of families, and the agent-based model Aspen (www-aspen.cs.sandia.gov/index.html), which looks at the impact of individual choices on economics.

However, the ideal would be to model command decision making for simulations that attempt to represent C2 systems. Though the technical properties of C2 equipment are well documented and implemented in many models, we still cannot replace human decision makers, with the exception of the lowest levels of combat simulation. What we need are synthetic humans that can "think," plan, and act as part of a C2 system, and agent-based simulations that provide insight into how information operations can impact large military and civilian infrastructures.

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Key Toolset Issues (2 of 2)

- **Holodeck**
  - **Make simulation compelling by having the user experience the problem**
  - **Be able to generate large scale MOUT environments**
- **Representation of robotic vehicles and their interactions with humans**
  - **Limited research is underway (e.g., DARPA's MICA)**
  - **Need to capture results, fold into evolving toolset**
  - **Proposed effort -- STRICOM Robotics Simulation STO**

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• **Holodeck**. Once we can generate synthetic people, then the Holodeck in Star Trek may be 5-10 years away. In the virtual simulation world, we can see rapid progress being made in new computer graphics techniques, such as image-based rendering and high-resolution displays. Similar advances will likely be made in spatial audio. The key is to integrate a wide variety of technologies in order to deliver a seamless, virtual experience of the world.

The Holodeck is a transforming technology. This is because a key problem of making simulation compelling to decision-makers is that we often lack the ability to let them experience the problem. Moreover, we expect to face future possibilities that none of us have experience with. For example, few American soldiers have direct experience in urban warfare. MOUT facilities are one form of simulation that allows them to experience the problems first hand. But the facilities are extremely small (a handful of buildings) and expensive. The Holodeck could let us build virtual cities inhabited by virtual humans. They would provide commanders with the ability to explore and experience a wide variety of issues related to urban warfare and provide a training environment for future operations.

• **Robotics.** Robots will be essential to the future OFW. However, we have little understanding about the interaction of robotics and soldiers together. Moreover, we need to develop TTPs that make sense in the context of a wide variety of robotic options. Several organizations, such as Sandia, TARDEC, STRICOM, and ARL, are exploring the use of simulation to develop engineering and operational concepts for robotics.

Preliminary Toolset Recommendations

- **Work with the Army's emerging MOUT FACT to**
  - **Help create a Vision for the objective toolset**
  - **Support the generation of a "path forward" (e.g., draft a research plan)**
- **Broaden the effort to incorporate joint Service participation (particularly the USMC)**
- **Undertake a top-down directed research program, addressing**
  - **Human behavior, robotic representation**
  - **C3I representation**
  - **Data needs**

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We support AMSO's MOUT FACT effort. This should be a good forum for identifying the salient technical issues for modeling urban operations.

Furthermore, we acknowledge the substantial work of the USMC in MOUT. Initiatives such as Project Lincolnia and Metropolis that conducted experiments and examined MOUT issues have been very valuable to this study. In addition, we believe the agent-based modeling efforts of Project Albert show much promise in developing TTPs for MOUT. Consequently, we recommend the Army S&T community develop a closer relationship with USMC efforts and broaden this effort.

Finally, we recommend a top-down S&T effort in deficient M&S areas regarding OFW. The Army should investigate the development and uses of simulation for robotics, human behavior, and C3I. Moreover, the Army needs to conduct an intensive data collection effort to support analysis of OFW.

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M&S for Dismounted Operations: Recommendations (1 of 2)

- **Pursue OFW within SMART paradigm**
  - **Experimentation using "model-experiment-model"**
  - **Virtual prototyping of OFW integrated system design**
- **Establish an S&T Program for M&S as foundation for far term capability in:**
  - **Knowledge acquisition**
  - **Instrumentation, data collection and warehousing, algorithms**
  - **New computation techniques and computer science (e.g., quantum computing, generative analysis)**
  - **Scope: Individual soldier behavior to effectiveness of larger forces, including robotics, C4ISR, …**

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Next, the Army must pursue OFW within the context of SMART. In order to accomplish this, the Army needs to focus on developing virtual prototypes of OFW to examine OFW as a system of systems. Moreover, we need to exploit the "model-experiment-model" approach to rapidly develop concepts for OFW.

Moreover, the Army should establish a focused science and technology (S&T) program for M&S research. Current research is often done outside the S&T community without a long term focus. The Army needs to invest in fundamental science that exploits areas such as quantum computing, genetic algorithms, and agent-based modeling that show potential for dramatically advancing our simulation capabilities. Furthermore, the Army needs to develop a knowledge acquisition plan to establish a base of knowledge to support OFW analyses and SMART.

Areas for applied research include robotics and C4ISR. This research should support acquisition programs such as OneSAF, Land Warrior, and FCS.

The 1997 NRC study on Modeling and Simulation (http://www.nap.edu/html/simulation/) has an extensive discussion on simulation research needs.

M&S for Dismounted Operations: Recommendations (2 of 2)

- **Constructive M&S**
  - **Enhance usability of existing key M&S**
  - **Provide open access to source code**
  - **Foster partnerships which institutionalize standards, retain community knowledge,…**
- **Live M&S – Establish a laboratory for urban combat to:**
  - **Characterize a set of representative future urban battlespaces**
  - **Develop a strategy for implementing appropriate instrumented live M&S facilities**
  - **Conduct experimentation, support acquisition and T&E**
- **OFW Virtual Representation**
  - **Create virtual representations of OFW units, systems, and sub-systems**
  - **Include OFW representation in JVB scope**
    - ∗ **Resource adequately**
    - ∗ **Clarify customer base and align Management structure accordingly**
  - **Develop *in situ* Mission Training and Rehearsal Tools**

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Current constructive simulations are difficult to use and are inflexible to adapt to new scenarios. This problem is further compounded by closed models that do not provide access to source code despite the fact that most models are goverment developed and owned. We recommend that all government-owned simulations be made open-source to government users, academic researchers, and contractors.

Given the decline of in-house expertise in Army M&S organizations, it is critical to foster stronger relationships between goverment, academia, and industry to promote standards and retain community knowledge.

We propose that the Army develop a national laboratory for urban combat to experiment with OFW concepts, to collect relevant data for M&S, and to provide a venue to support test and evaluation. The Army also needs to create a set of representative urban environments (e.g., ranging from Pristina to Seoul) as the model for both constructive and live simulation. The USMC should be an integral element of this laboratory.

The Army lacks a virtual representation of OFW which is necessary for SMART. For example, the Close Combat Tactical Trainer (CCTT) does not have an adequate capability to represent dismounted soldiers (e.g., dismounts from a Bradley). This is also evident in JVB. This shortfall must be redressed. In addition, once the scope of JVB is adjusted to incorporte the dismounted soldier, the testbed should be resourced adequately, its customer base should be clarified, and its management structure should be aligned accordingly.

We also recommend that an *in situ* mission rehearsal and training capability be developed for OFW. *In situ* examples could include embedded training in OFW that take advantage of augmented reality technology or enroute mission rehearsal tools.

ASB 2001 Summer Study
Analysis Panel

Annex C: Analyses

25 July 2001

In last year's ASB Summer Study, extensive analyses were performed to assess the potential effectiveness of proposed technologies in the context of mounted operations in Smaller Scale Contingencies (SSCs). The assessments in this year's ASB Summer Study extend those results in two dimensions. First the emphasis is on dismounted operations in complex terrain. Second, assessments are performed for various Support and Sustainment Operations (SASO) in addition to SSCs.

This Assessment Section documents the Panel's efforts in two areas. First, it summarizes the major analyses that the Panel produced for five scenarios: attack of a dug-in, small squad in a treeline (SSC); protection of a convoy in an urban environment (SASO); use of Low Collateral Damage Weapons (LCDW) to disrupt the flow of traffic near a choke point (SSC); floor-clearing in a urban building (SSC); and the protection of a squad distributing food in a hostile environment (SASO).

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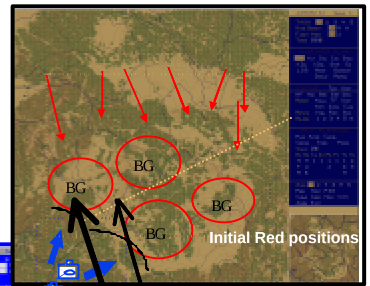
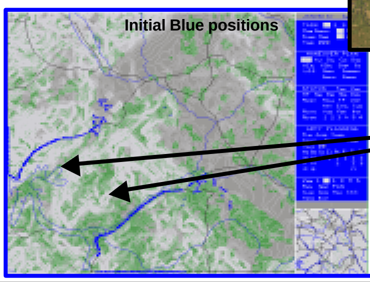
ASB Summer Study 2000 Highlighted Dismounted Operations Issues

	Blue	Red	
	MWF	Dug-in	On-the-Move
Tanks	58	32	56
APC	146	69	84
Artillery	33	48	21
Mortar	42	12	21
Helo	33	0	0
ADA	24	68	12
Trucks	115	64 (unload)	112 (load)
Dis. Infantry	N/A	~360	N/A





- Army Airborne BN & MEU hold pass until medium forces arrive
- Medium forces conduct forced entry operation vs. Red battle positions
- Mounted Recon Force takes significant losses in ambush

Excursion with Dismounted Attack

Resulted in 1.0 LER

2

The 2000 ASB Summer Study focused on the FCS platforms, and examined the effectiveness of a force in a stressing "Kosovo II" scenario. Here the Blue force is inserted through Albania, fights its way into Kosovo, and must evict Serb forces from locations in treelines and cover. Additional Serb battle groups are moving from the North to support the defense. Many different excursions were run with different technologies and tactics.

The focus of this work was on mounted Blue operations with FCS platforms, and showed the importance of armed UGVs, active protection systems, and enveloping maneuver. The work also showed the need for dismounted operations by the Blue force, because the 360 Red infantry in the treelines were not countered well by the mounted attack. Also, a special Blue dismount excursion with current generation equipment did not fare well in the scenario.

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Our Analyses Considered Five Vignettes

- **Complex Terrain**
  - **Reverse slope, treeline attack in Kosovo context (RAND analyses employing JANUS)**
- **Urban Operations**
  - **Convoy in an urban (Sarajevo) environment (RAND analyses employing JANUS and JCATS)**
  - **Low Collateral Damage Weapon technologies in complex terrain (JFCOM/SNL & LLNL analyses employing JCATS)**
  - **MOUT ACTD floor clearing operations (Dismounted Battlespace Battle Lab / IDA analyses employing JCATS)**
  - **Humanitarian assistance in a small village (Project Albert/Mitre analyses employing MANA)**

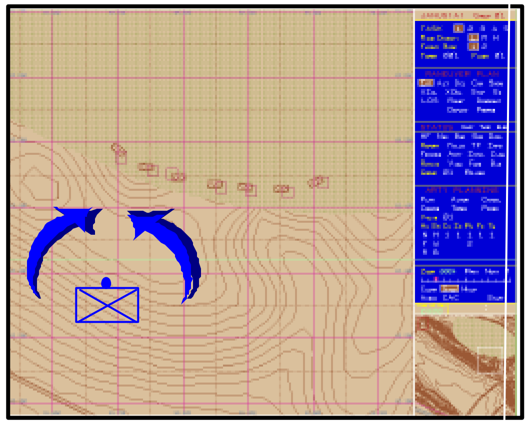
3

Five different analytic studies are described in our effort, conducted at three different sites using three different models. Most of these focus on urban operations, but one looks at complex terrain in the form of treelines and cover. Each will be described in turn, along with insights gleaned from the analyses.

Treeline Scenario

SUMMER STUDY 2001

Complex Terrain - JANUS



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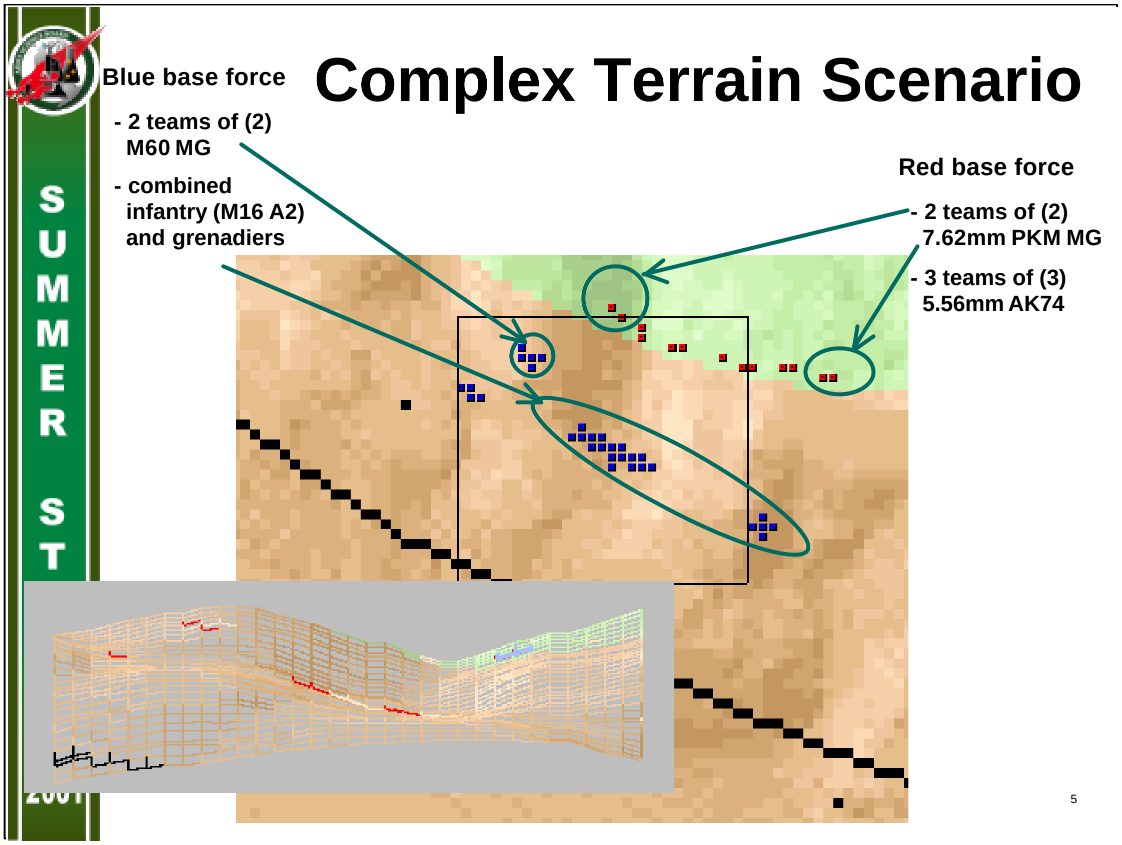
The first vignette of interest was an offshoot of the Kosovo scenario described above, and was specially developed for the 2001 ASB (under the sponsorship of ASA(ALT)). This scenario employs high resolution digital terrain from Hunter-Liggett (1-meter resolution sampled to 9 meters), overlaid with vegetation and trees to represent a rolling, forested area such as Kosovo. Three squads of Blue dismounted soldiers attack a squad of Red soldiers hidden in a woodline. The Red force is in defillade and has AK-74s (5.54 mm) and PKM machine guns (7.62mm). Blue must cross 300 meters of relatively open terrain, and does so in sprints with covering fire.



The situation faced by Blue is shown in more detail here. Red holds the treeline, and Blue has initial intelligence of their general location and strength. Blue probes the area, runs into resistance, and quickly returns fire. Movement is by echelon, with machine gun fire for cover. Depending on the equipment, tactics, weather, and responses, the outcome varies widely.

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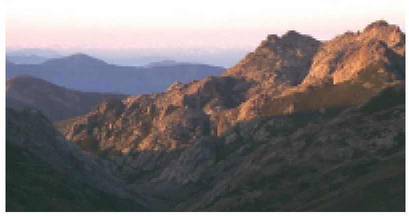
Complex Terrain Results – Base Case

- **Blue-Red force ratio -- 3:1**
  - **Red in very strong defensive position**
  - **Blue moves in overwatch/sprints**
- **Blue Force accomplishes immediate objective, but unable to proceed further -- *both sides lose roughly 50% of forces***



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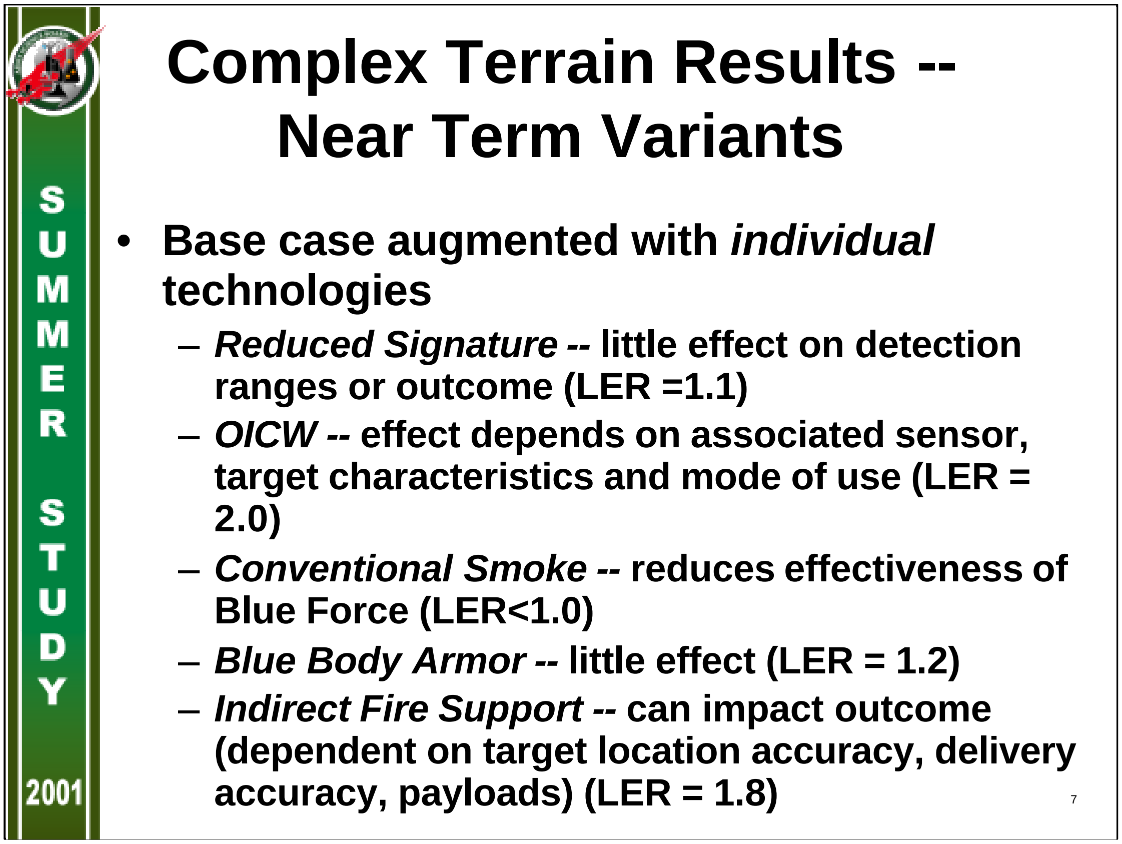
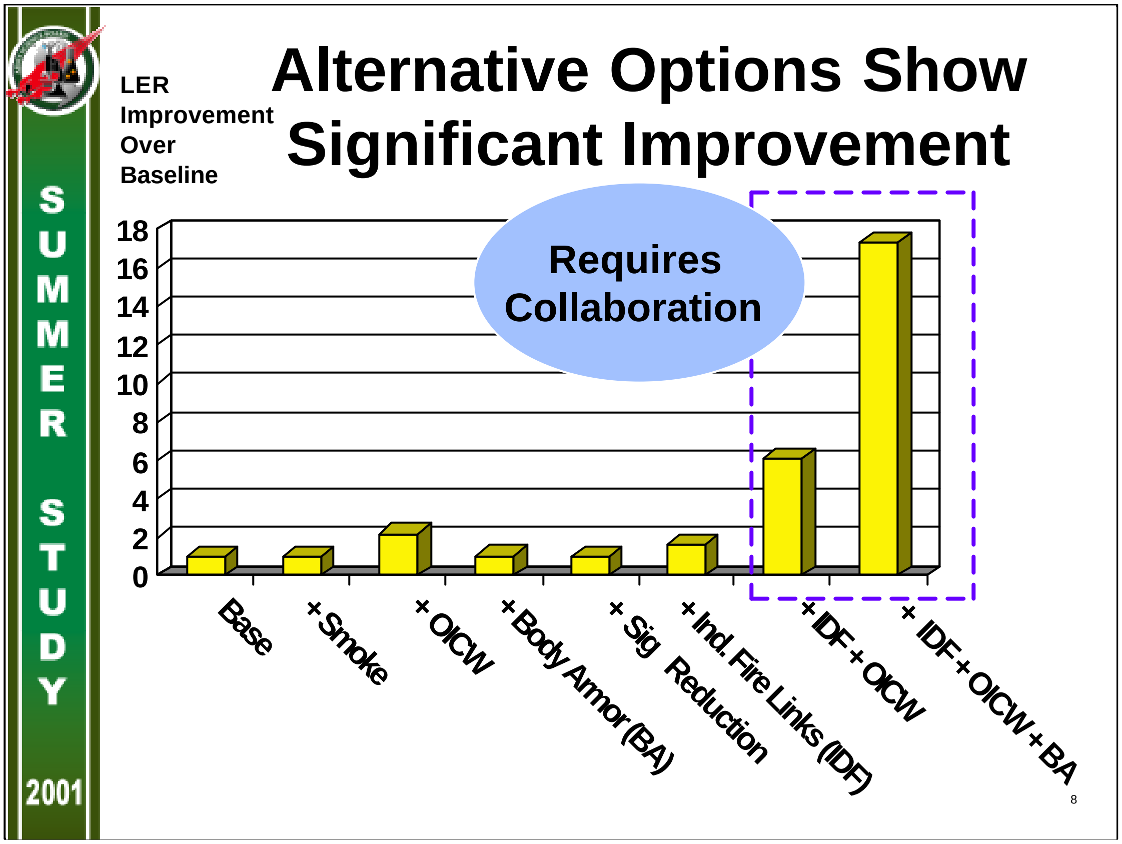
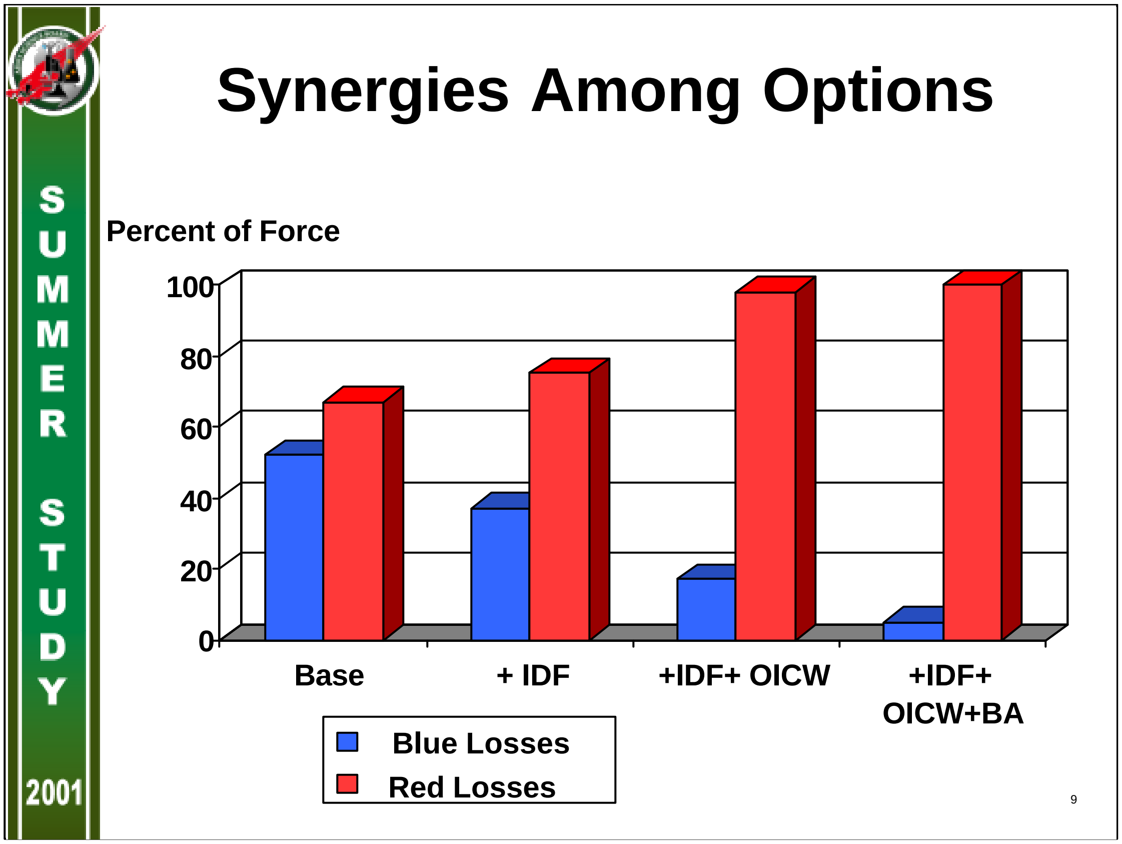
The treeline attack scenario is a very stressing one for the current generation Blue forces. While they have a three-to-one force ratio over Red, they have to attack against prepared positions with good cover and protection. Blue moves in 5-6 second sprints with covering fires, but most of the engagement takes place at short range (often under 100 meters), and heavy losses take place on both sides. Blue attrits Red but would be unable to continue fighting.



Individual technologies added to the dismount soldier produced marginal improvements. Reducing Blue dismount signatures by as much as 80 percent made little difference in this scenario because the engagement distances were so short. Adding the OICW to the force (in particular the 20mm round) doubled force effectiveness, but did not negate the ambush advantage. Conventional smoke actually reduced force effectiveness, because detection ranges were reduced for both sides, and the ambush took place at even shorter range. Body armor able to stop 5.54 mm and a portion of 7.62 mm rounds produced a minor effect. Indirect fire support, in the form of cannon and MLRS fires with high explosive and dual-purpose improved conventional munitions, was useful for attriting and suppressing a portion of the enemy force.



Another way to look at the cumulative effects of adding options to the force is shown above. The chart starts with the base LER as a calibration point, assigned a value of one, and all other cases as a ratio of that value. Minor improvements are seen with individual options, but very large outcome differences occur with combinations of systems.



We found that combinations of the improvements to the Blue dismounts have much greater performance than might be expected from the additive effects alone. By themselves, indirect fire resulted in a rough doubling of effectiveness of the force (in terms of kills and losses), use of the OICW weapon and FLIR improved effectiveness by about 60%, and body armor had a negligible effect. When used together, indirect fire and OICW increased effectiveness by over five times, while the same combination with body armor improved the outcome over 15 times.1 In the last case, only two Blue soldiers were lost and all the enemy were killed. The synergies seem to arise from the ability to start the direct fire battle with a better force ratio after attrition from long range fires, withstand a round without casualty, and return fire with first round lethality.

1 Not that we did not try stealth in the mix of technologies because in this scenario, the ranges appeared to be too short to have an effect

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Selected Excursions

- **Limited impact**
  - **More ambitious levels of individual movement**
  - **Enhanced stealth**
- **Appreciable Impact**
  - **Augmented body armor**
  - **Partial fielding of OICW**

A number of additional excursions were performed by RAND to identify promising technologies to pursue. Recent parametric excursions have shown that more ambitious levels of individual movement (e.g., through exoskeleton mobility) and stealth add little to system effectiveness in this scenario.

• Augmented body armor. Augmented body armor (up to 90% effectiveness against 7.62mm), increases force effectiveness by 50% compared to the baseline.

• Partial fielding of OICW. Much of the benefit from the OICW seems to be achievable by outfitting only a small portion of the force with the system. The baseline force equipped with M-16s would achieve a LER of 0.35, a force with 6 of the 40 Blue dismounts equipped with OICWs would achieve a LER of 0.55, while a force with 36 of the 40 Blue dismounts equipped with OICWs would achieve a LER of 0.75. In other words, the very limited fielding of OICWs manifested a 57% increase in LER over the base force, while the nearly fully equipped OICW force achieved a 114% increase in LER over the base force.

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"Junkyard Dog" Options

- UGV Features
  - Sensor: Javelin-quality sensor
  - Weapon: OICW weapon
  - Mobility: up to 10 mph over good terrain
- Alternative Configurations, TTPs
  - Case 1.
    - When run several minutes before attack, they moved too far ahead, and had little impact on outcome
    - The following manned reconnaissance vehicles were not able to respond to enemy muzzle flashes
  - Case 2. When equipped with sensor mounted on vehicle (no mast) and with a vehicle size of one meter, many losses of UGVs with few kills
  - Case 3. Small UGV, moving directly in front of force, with short mast, was most effective

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In the final set of excursions, we defined a robotic element to aid in the attack. Termed "Junkyard Dog", this is a small UGV with a Javelin-quality sensor, OICW weapon, and able to move at up to 10 mph on good terrain. It is assumed to send back images to the manned scout or C2 vehicles, and so it does not have to rely on ATR-level resolution (10 lines or so across the target) for acquisition. Vulnerability was assumed to be less than that of an infantryman. Only six were added to the force, as this was thought to tax the span of control possible for an attacking infantry unit.

We tried several variations of the system before finding one that would help the force. If the UGVs were pushed well out in front of the force, the associated manned reconnaissance vehicles could not interact well when the UGVs took fire. Large (one meter) UGVs with chassis-mounted sensors also suffered quick losses to the enemy.

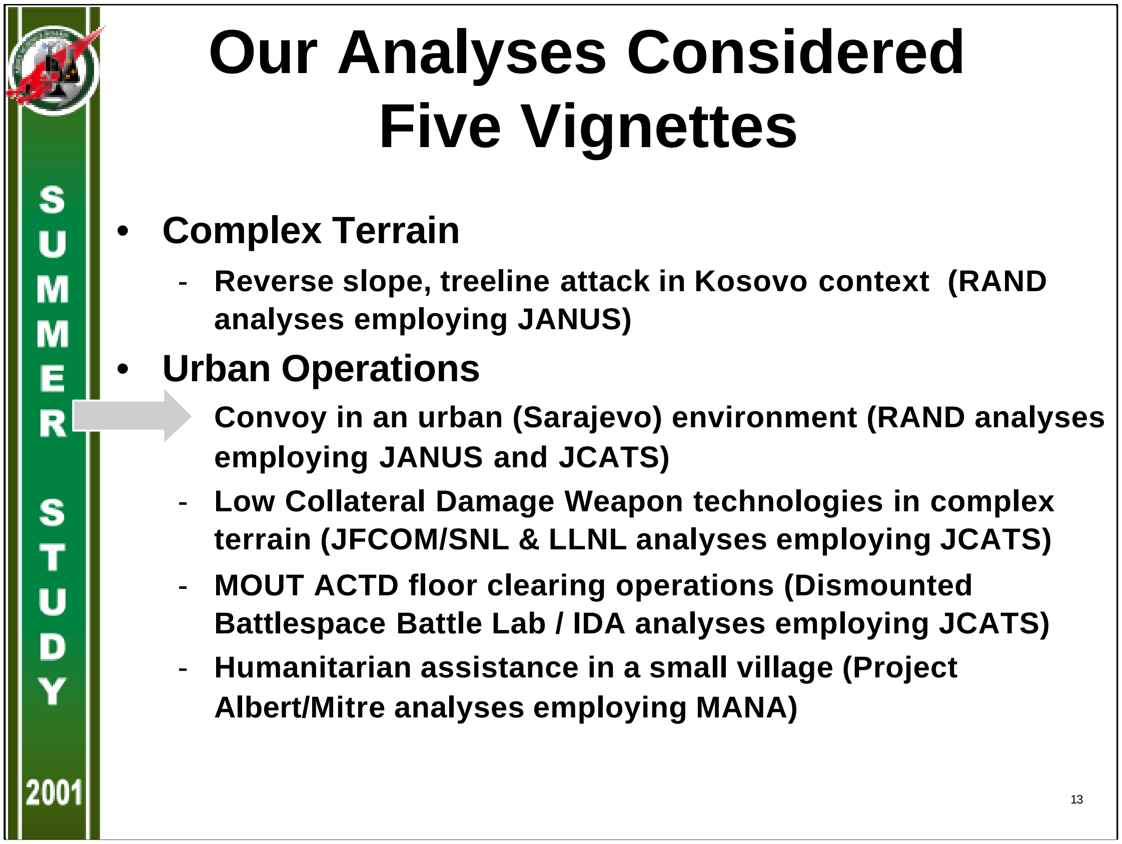
The best option was a small UGV with a mast-mounted sensor (2 meter high) that stayed "on-leash" with the force. This configuration was examined for two options: an addition of 6 "junkyard dogs" to the baseline and 6 to a force partially equipped with the OICW.

"Junkyard Dog" Results

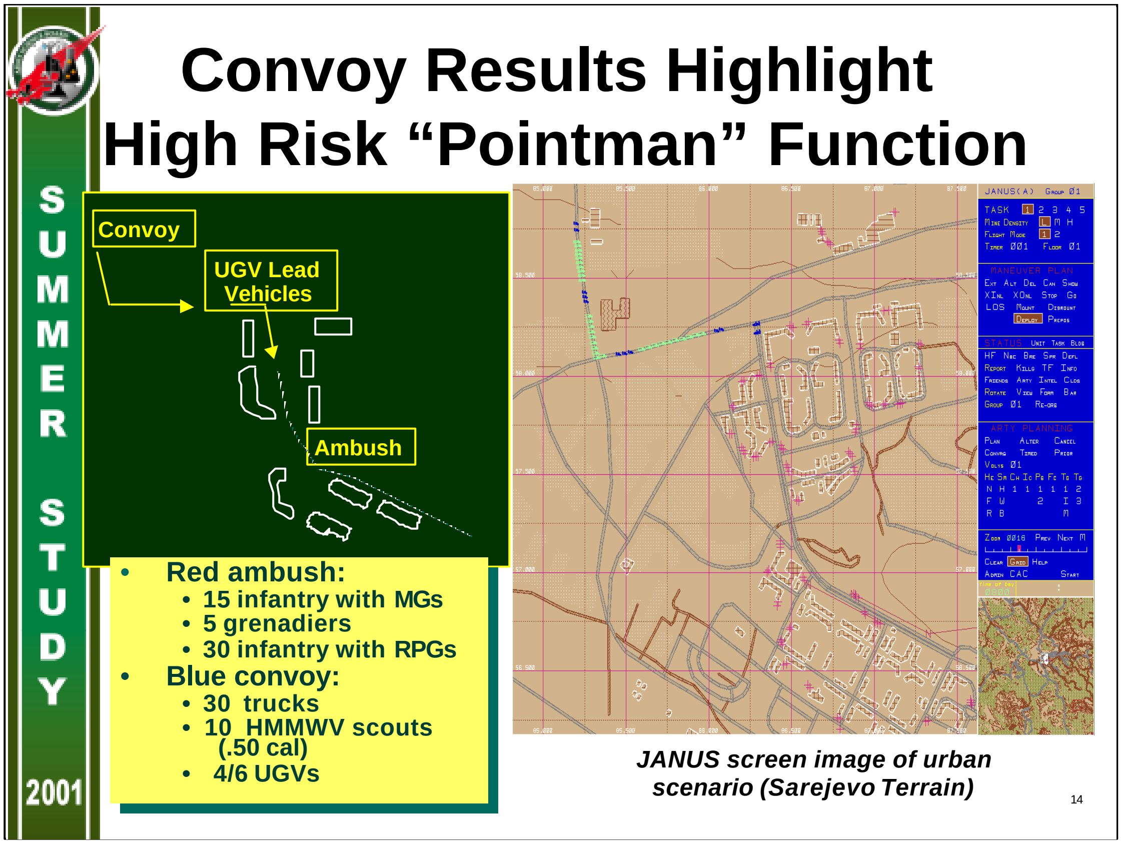
MoEs	w/ Baseline	w/ Partial OICW
• LER	+37%	+ 35% (over non-UGV) +102% (over baseline)
• Manned System Survivability	+20%	+20% (over non-UGV)
• System Exchange Ratio	+10%	+35%
• UGV Contribution to Kills	+23%	+24%

In one option, six "junkyard dogs" were added to the Baseline force. As can be seen in the chart, they increased the LER by 37%, increased the survivability of the manned systems by 20%, improved the efficiency of infantry (i.e., increased the system exchange ratio by 10%) and contributed 10% increase to the number of kills. In this engagement, the UGV contribution to Red kills was an increase of 23%. Note that five of the six UGVs were killed in the engagement.

In a second option, six "junkyard dogs" were added to the partial OICW force (i.e., a force where only six of the members of the forty man team were equipped with OICW). For this option, the overall LER increased by 35% over the non-UGV equipped force. Note that this corresponded to a 102% in LER over the baseline. This latter enhancement was roughly equivalent to equipping all of the force with OICW. The survivability of manned systems increased more than 20% compared to the non-UGV force. In addition, the system exchange ratio of OICW increased by 35%. Moreover, the UGV contribution to Red kills was an increase of 24%. As in the prior option, five of the six UGVs were killed in the engagement.



The second scenario focuses on urban terrain, and was originally developed for the Military Applications of Robotic Systems project under DARPA sponsorship.



A MOUT vignette was adapted from a scenario based on a Sarajevo mission. Blue is escorting a resupply or humanitarian convoy of trucks through the downtown area. Blue leads with HMMWV-scouts equipped with .50 cal machine guns, and changes routes if an enemy ambush is spotted in time. Red has prepared an ambush partway through the town, with cratering charges along the road and infantry in the nearby buildings. Red waits until most of the convoy is in the killing zone and opens fire. Often, the lead vehicles are hit and the convoy is halted. When Blue Unmanned Ground Vehicles (UGVs)are present, these lead the convoy and periodically stop to scan the buildings and find Red units.

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Urban Convoy Results

- **Contribution of *UGVs***
  - **Substantial improvement in all measuress, *particularly if UGVs are equipped with weapons* (e.g., Red losses increase by factor of 40)**
- **Contribution of *smoke***
  - **Truck losses reduced by approximately 54%**
  - **Blue scout losses reduced by 37.5%**

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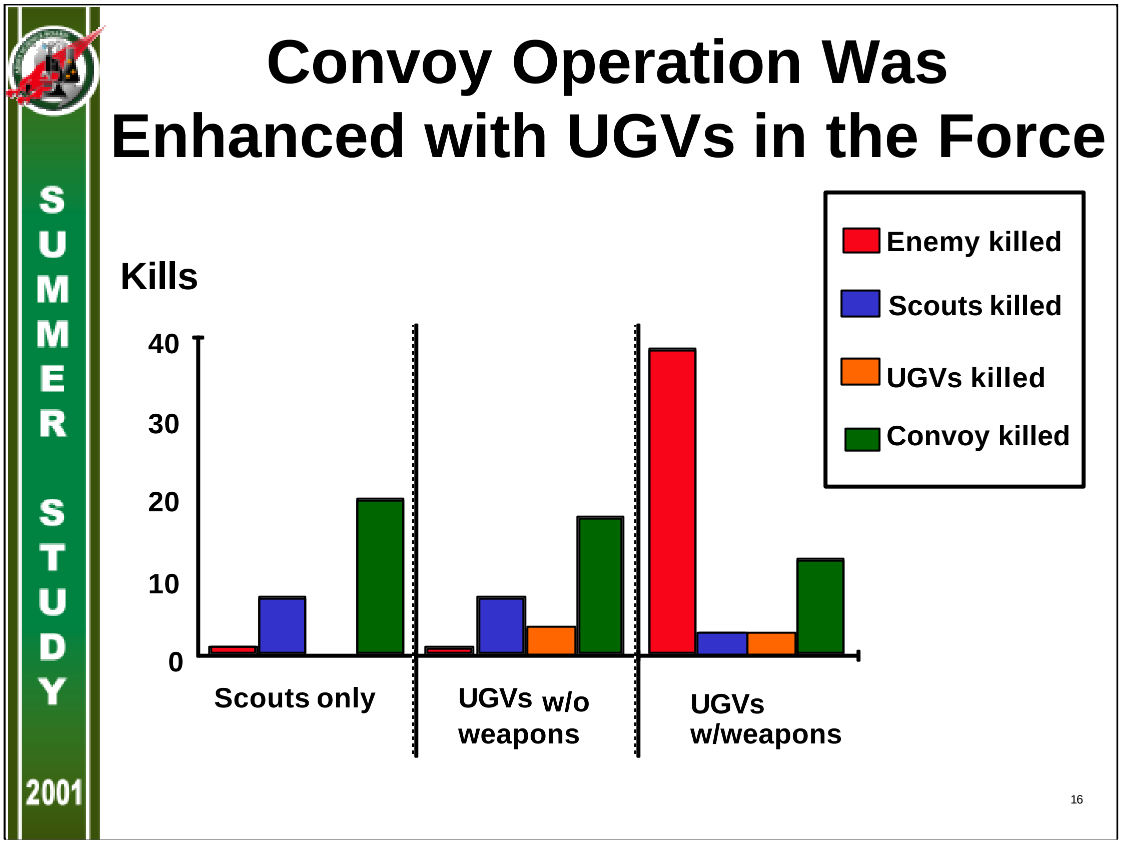
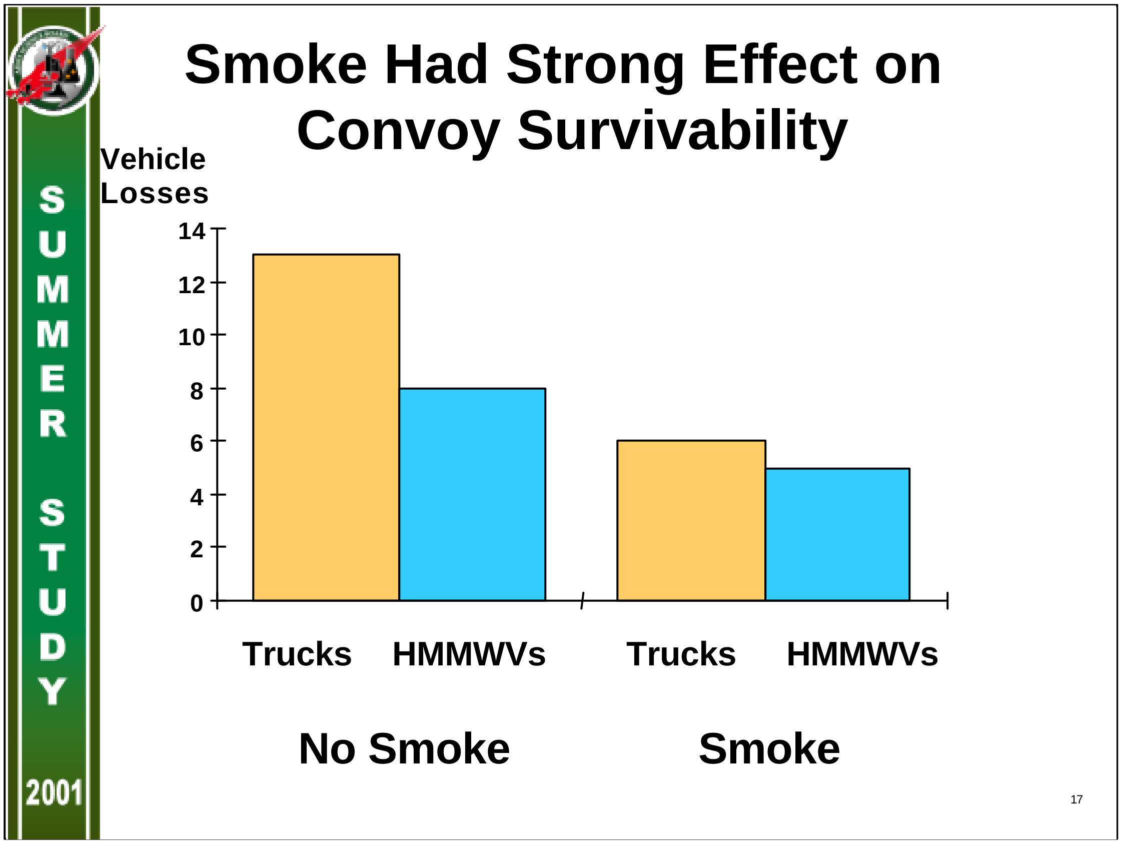
UGVs and smoke made a large difference to convoy survivability and lethality against the Red force. Unlike the treeline attack situation described earlier, smoke to degrade detection range helped in this case.

The use of unmanned vehicles for convoy recon was validated in 25 June 2000. U.S. soldiers from Camp Able Sentry, outside of Skopje, Macedonia, provided security for 21 Brown & Root contractors to transport 100 fully armed Macedonia Liberation Army fighters and 250 civilians from Aracinovo to Umin Dol, an Albanian enclave 11 miles away. The soldiers were from the 3rd Battalion, 502nd Infantry, 101st Airborne Division. Reconnaissance was provided by Hunter UAVs. The convoy avoided blocked roads and potential threats with information provided by the intelligence unit controlling the UAVs.



The convoy operation was highly exposed and Red could launch the attack at the moment of his choosing. In the baseline case with only scouts and trucks, the Blue force had little to protect itself and most of the convoy was destroyed. Adding UGVs in the force (indistinguishable from manned vehicles) diluted Red fires, and reduced some of the convoy losses. The real difference occurred when the UGVs were equipped with machine guns and could react to fire. This raised lethality strongly and had the linked effect of increasing survivability.



A preliminary excursion with the Sarajevo scenario showed the effect of simple smoke generators on survivability in an ambush situation. Without smoke, almost half of the trucks and most of the HMMWVs are killed. Many of the detections are at range (up to 1 km), and the Blue force is able to kill only one of the Red infantry. With smoke generators, detections by Red are decreased strongly in number and range, and losses fall to almost half of those experienced in the open. The Blue HMMWVs detect more Red soldiers when smoke is present (Blue has FLIRs which are less affected by the smoke), and they kill more infantry. We expect survivability and lethality would further increase with a "spectrally matched" smart smoke and more responsive maneuvers and reactive fires.

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Our Analyses Considered Five Vignettes

- **Complex Terrain**
  - **Reverse slope, treeline attack in Kosovo context (RAND analyses employing JANUS)**
- **Urban Operations**
  - **Convoy in an urban (Sarajevo) environment (RAND analyses employing JANUS and JCATS)**
  - **Low Collateral Damage Weapon technologies in complex terrain (JFCOM/SNL & LLNL analyses employing JCATS)**
  - **MOUT ACTD floor clearing operations (Dismounted Battlespace Battle Lab / IDA analyses employing JCATS)**
  - **Humanitarian assistance in a small village (Project Albert/Mitre analyses employing MANA)**

18

The third vignette assessed the use of Low Collateral Damage Weapon (LCDW) technology in complex, urban terrain.

SUMMER STUDY 2001

Collateral Damage

Railroad bridge over the Grdelica Klisura gorge, a Serbian re-supply route into Kosovo

"Marshal Tito" Petrovaradin (Varadinski) Bridge

19

Collateral damage and post conflict reparations was an issue in the Balkans conflicts and will remain an issue for similar smaller scale contingencies, peacekeeping, and other future military operations.

SUMMER STUDY 2001

Contributors

- **Joint Forces Command**
  - **LTC Kevin Woods**
  - **Mr. Don Davidson**
  - **Mr. John Fentor**
- **Sandia National Laboratory**
  - **Dr. Dan Rondeau**
  - **Mr. Mike Senglaub**
  - **Mr. Ron Woodfin**
- **Lawrence Livermore National Laboratory**
  - **Mr. Mike Tobin**
  - **Dr. Steve Peglow**
  - **Mr. Boyd Wheeler**
  - **Dr. Mike Bland**

20

The list of contributors included operational experimenters from JFCOM, Subject Matter Experts from Sandia National Laboratories (i.e., for robotics, foams, and other systems technologists), and analysts, experts in RF weapons and intelligence, and JCATS modelers from Lawrence Livermore National Laboratories.

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Definitions

<u>Non-Lethal weapons</u> (NLWs) are *<u>explicitly designed</u>* and *<u>primarily employed</u>* so as to incapacitate personnel or material, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment. - *DoD Directive 3000.3*

<u>LCDWs</u> are weapon systems that can precisely target an enemy function while generating desired, but only desired effects.

Our contribution is to examine the operational role of LCDWs, i.e., systems that have mass effects, as Joint Task Force assets in the 2008-2012 time frame

21

A new category of tools for the JTF commander was created and investigated. This category defines weapons beyond non-lethal warfare that minimize their impact on combatants. This new category seeks to focus on creating the desired effects on enemy operations/functions while mitigating collateral damage.

Concept for Operational LCDW

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Use Limited Collateral Damage Weapon technologies to complement kinetic engagements in order to build a complete and comprehensive capacity to generate specific effects against any target set within a wide range of operational, political, and ethical constraints.

J9 efforts focused on innovative concepts applied to specific missions. Only high-level technical analysis was performed and no countermeasures were played in the exercises.

22

The J9 experiment sought to develop and investigate the utility of innovative concepts for specific contingency operations without fully assessing all related aspects of the specific tactics, doctrine, or technologies or enemy response.

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LCDW 'Smart' Matrix

	TARGET	WEAPON	DEFEAT MECHANISM	DELIVERY SYSTEM	EFFECT DURATION
LCDW-1	**Bridges**	**Bridge denial package**	**Defended barriers**	**C-130 –GPADS**	**Goal ~ 72 hrs (OPFOR CM)**
LCDW-2	Roads	Robots	Vehicle disablement	A/C –JSOW(2)	24 hours
LCDW-3	Airfield	Robots	A/C disablement	A/C-JSOW(2)	24 hours
LCDW-4	**Hydro Power plant**	**SMART FISH**	**Turbine damage**	**A/C – JSOW(2)**	**Power outage For 14 days**
LCDW-5	Thermal/ Diesel Power plant	MINNOW	Cooling system shutdown	A/C – JSOW(1)	Power outage For 14 days
LCDW-6	Locomotive	Carbon Bomb	Immobilize Rolling stock	A/C – JSOW(4)	72 hours
LCDW-7	**C4I**	**E Bomb**	**Computer/ Comm. Damage**	**A/C – JDAM(4)**	**12 hours**
LCDW-8	Ship	E Bomb-H	Navigation/control failure	UCAV	18 hours
LCDW-9	**SAM site**	**Nighthawk**	Radar/ **Computer damage**	**UCAV – UAV (8)**	**24 hours**
LCDW-10	**Air Defense Artillery**	**Wasp**	**Vehicle Shrapnel kill**	**A/C – JSOW (1)- UAV(24)**	**24 hours**
LCDW-11	Assembly Area/Convoy	Advanced Tactical Laser	Engine Fire	V-22	Permanent
LCDW-12	Convoy	Anti-Traction Material	Loss of traction	A/C – MK 84(2)	5 hours
LCDW-13	Assembly Area/Convoy	Aerosols	Personnel dispersal	A/C – MK 7 (4)	1 hour

UE 01-3

LOE 001

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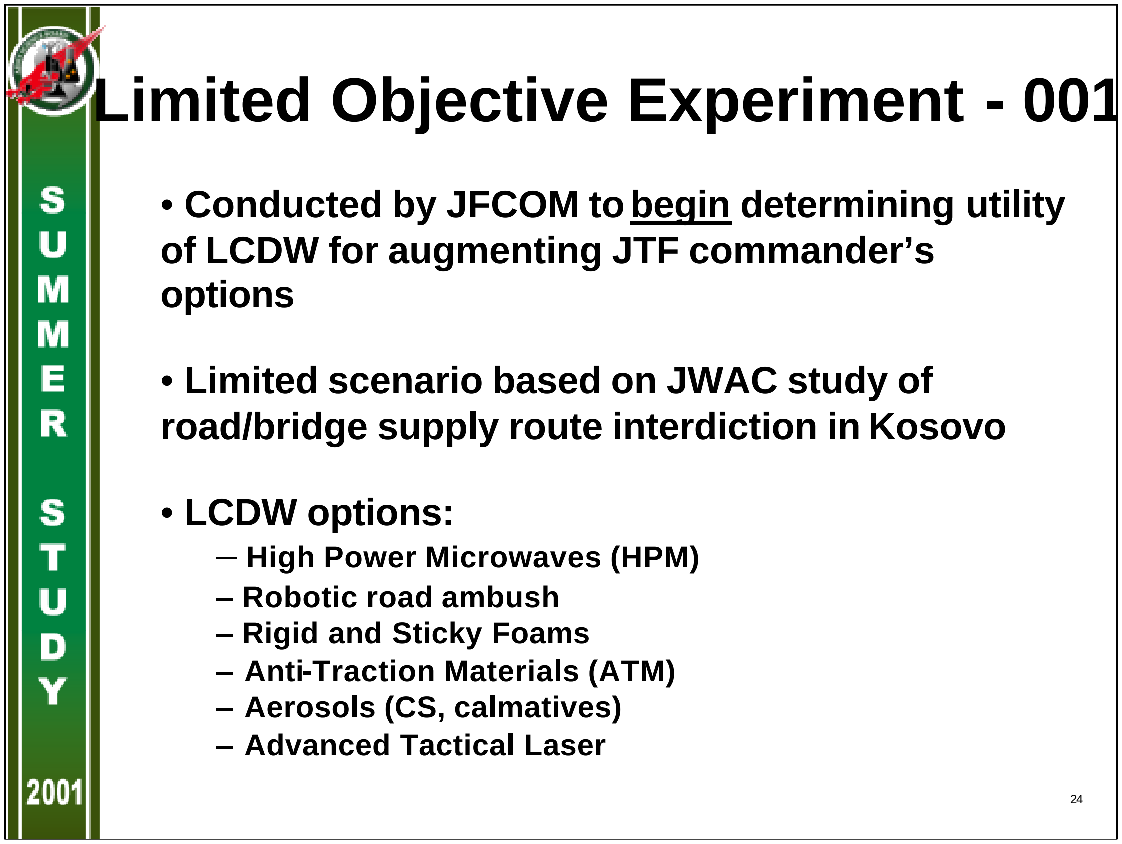
The experiments included a broad set of target or vignettes and related conceptual responses. These experiments are summarized in the slide.



In Oct 1998, the J9 JFCOM Battle Lab Director scheduled LOE-001 for Jan 2000. The experiment was conducted by JFCOM to begin determining the utility of LCDW for augmenting JTF commander's options.

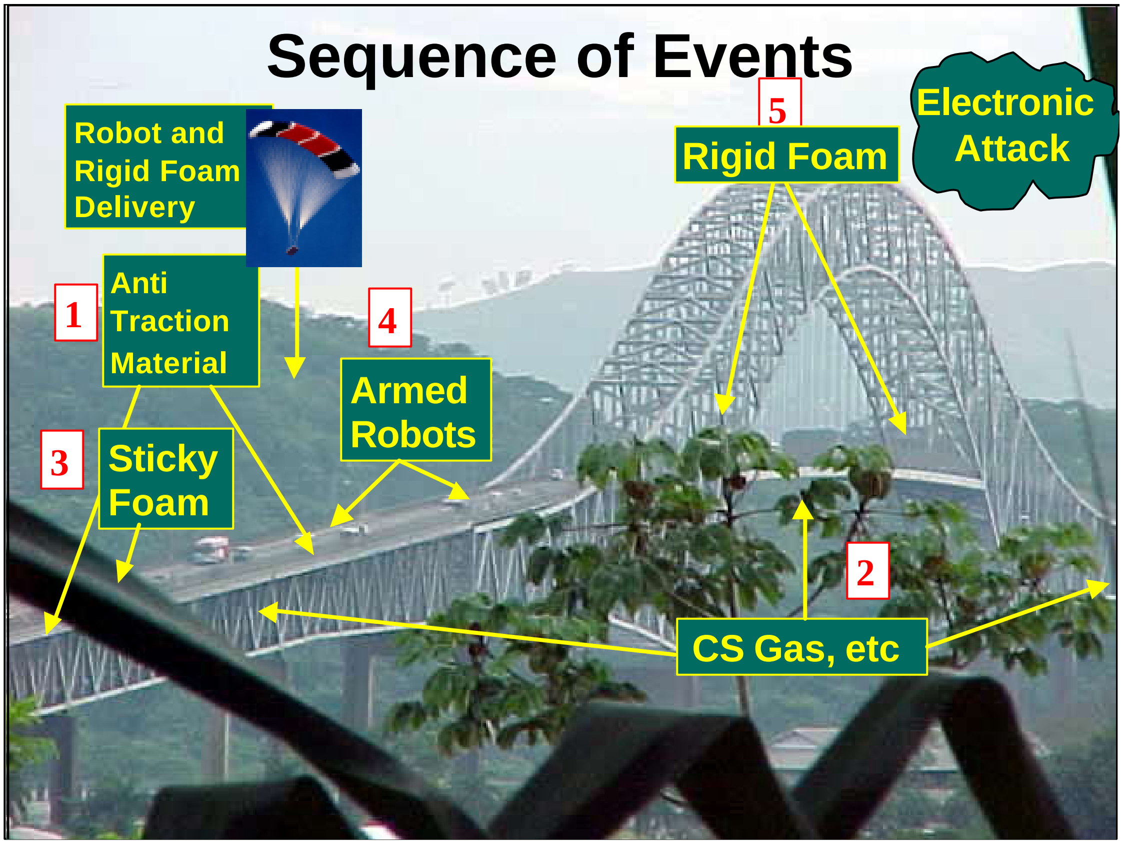
The limited scenario was based on the JWAC study of road/bridge supply route interdiction in Kosovo. The LCDW options considered included: High Power Microwaves (HPM), robotic road ambush, rigid and sticky foams, Anti-Traction Materials (ATM), aerosols (CS, calmatives) and advanced tactical laser.

The LCDW bridge Denial Rules of Engagement (ROE) included:

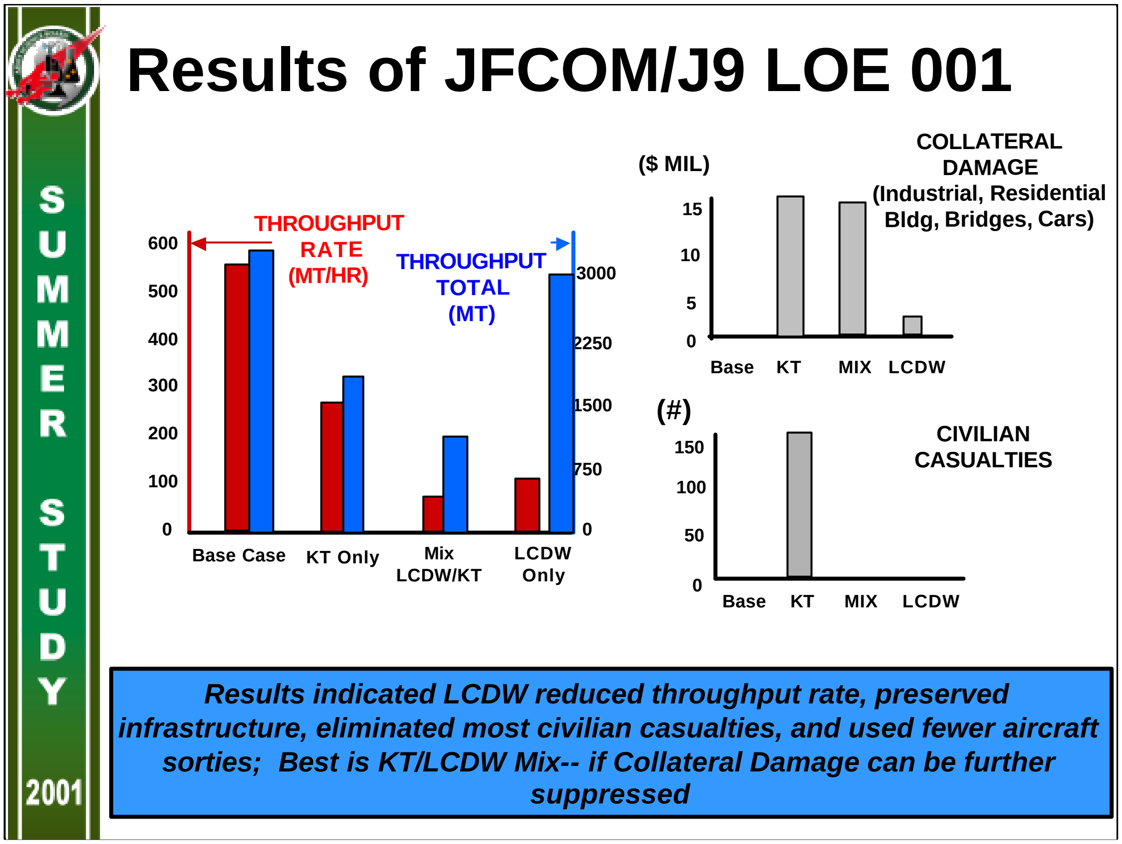
Totally non-lethal delay will deny access for the time it takes to bring up heavy clearing equipment, and get into the MOPP gear.

The mix of non-lethal and lethal weapons adds credibility to barrier defense.

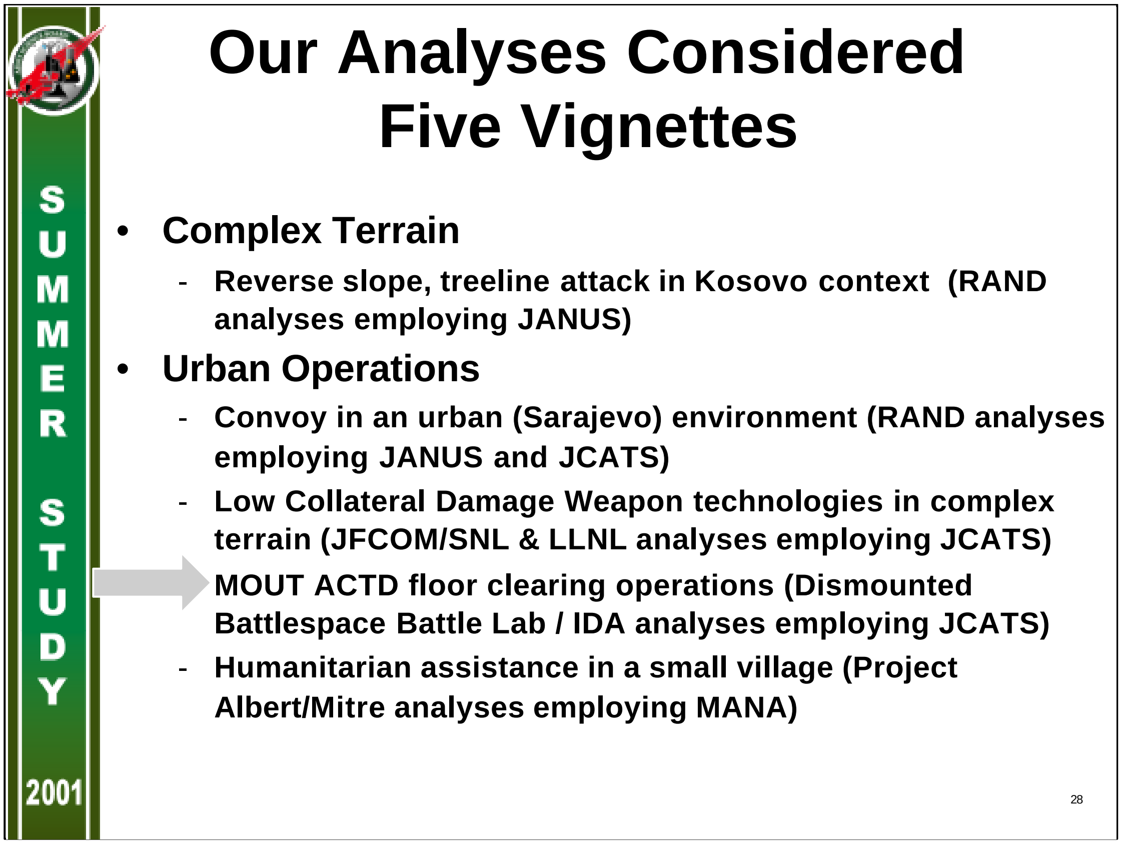
• Selective targeting will mitigate collateral damage and non-combatant injuries.



This slide depicts the sequence in which the LCDW were employed in the assessment. The technologies support three actions: clearing the bridge of civilians, creating a barrier to enemy mobility, and defending the barrier against enemy attempts to overcome. The bridge clearing was accomplished through unattended ground sensors to continuously monitor activity, non lethal technologies such as a calmative spray (CS), pepper spray, psyops, and TASERS on munitions or robotic platforms. Further disruption to civilian traffic would be achieved through electronic attack via HPM devices. The second action involves barrier options of sticky foams, antitraction materials, and semi-rigid foam embedded with mines, caltrops, and entanglements. The barrier defense involves armed robots with guns or explosively formed projectiles or WAM submunitions supported by the unattended ground sensors or UAV surveillance systems. Electronic attack technologies such as HPM also support barrier defense.



Key results of the analysis indicate LCDW was able to reduce throughput rate while preserving infrastructure and eliminating civilian casualties. However, because the mission was countermobility, not target destruction, the convoy eventually found other paths to the distribution point, so total throughput did not diminish significantly. With target defeat through traditional munitions (aka Kinetic Technology or KT) coupled with countermobility LCDW at choke points (KT/LCDW mix), civilian casualties can be significantly mitigated while reducing total convoy throughput. This can be achieved by selecting more advantageous places for attacking convoys (especially when convoys are delayed due to countermobility actions) where traditional munitions can be used with lower civilian casualties than perhaps at major bridges. However, buildings and other infrastructure are still at risk whenever traditional munitions are used in urban environments as well as civilian personnel. Therefore more work is needed to improve traditional weapon precision and target location parameters and to reduce blast effects (e.g., 500 vs 2000 pound bombs). Another outcome of the study was that the countermobility effect was achieved with fewer sorties than would have otherwise been needed to destroy a large bridge.



This section briefly summarizes recent analyses that have been performed to explore the impact of alternative communications options on the effectiveness of floor-clearing operations in an urban environment.

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Background

- **What**
  - Work performed in support of the MOUT ACTD
- **Who**
  - Lead: Simulation Center of the Dismounted Battlespace Battle Lab (DBBL)
  - Support: Institute for Defense Analyses (IDA)
- **Where**
  - Fort Benning, GA
- **When**
  - 1999 - 2000

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The work summarized in this section was originally performed in support of the MOUT ACTD. The Simulation Center (SimCenter) of the Dismounted Battlespace Battle Lab (DBBL) performed this work at Fort Benning in the 1999 - 2000 timeframe. The Institute for Defense Analyses (IDA) supported the effort by providing oversight, and analyzing and integrating the results.

Purpose

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- Determine impact of proliferating squad-level radios throughout a division operating in a dense urban environment
- Determine the impact of such communications on combat effectiveness at the platoon level

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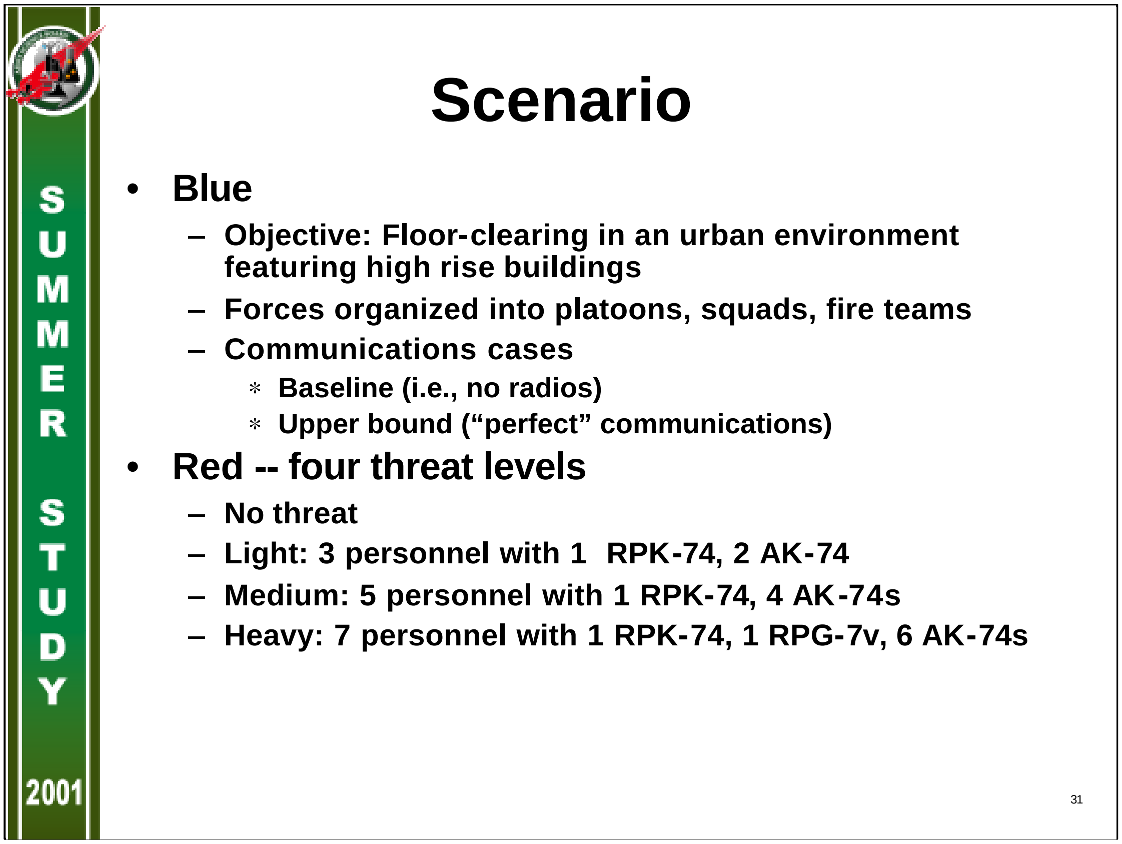
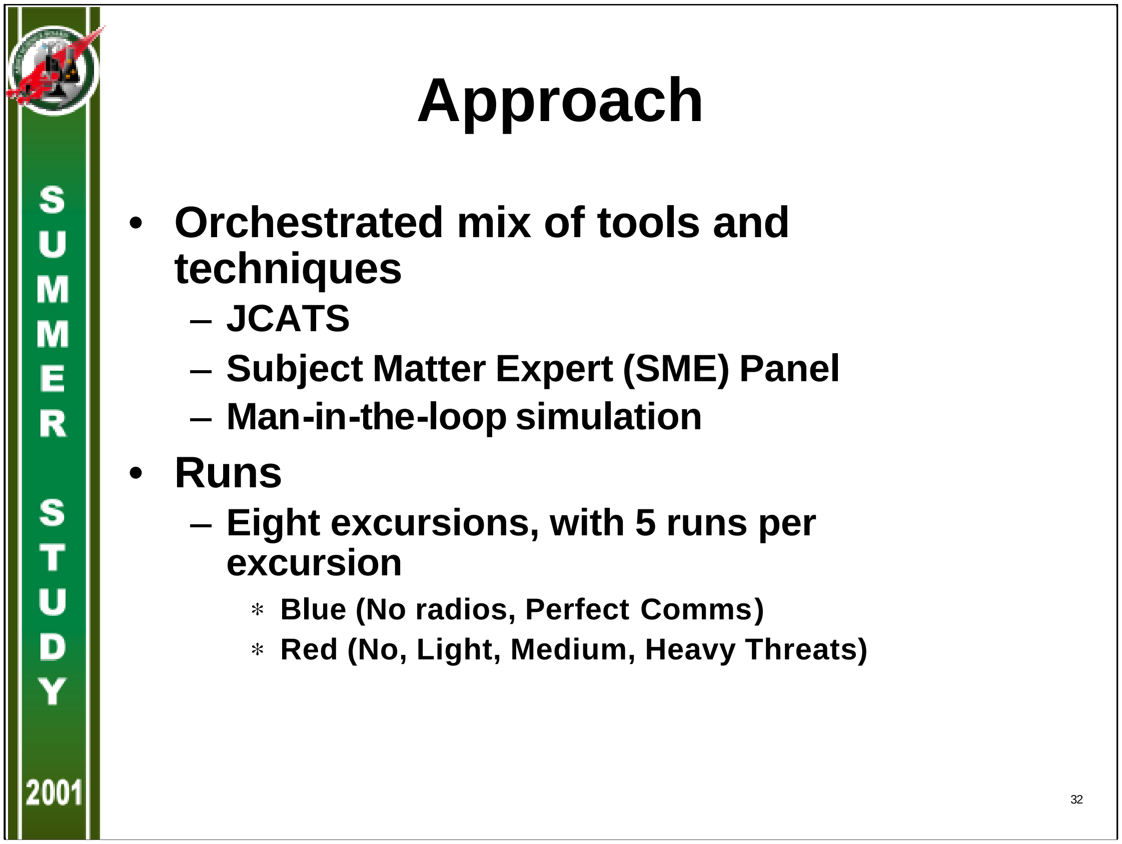
The broad purpose of the assessment was to determine the impact of proliferating squad-level radios throughout a division operating in a dense urban environment. More specifically, the objective was to determine the impact of such communications on combat effectiveness at the platoon level. This constituted one manifestation of the "Holy Grail" for the assessment community -- evaluating the impact of selected elements of C3I on mission effectiveness. By performing such analyses, it informs the decision maker about the operational payoff associated with investing in selected C3I systems.



To address this issue, this analysis focused on floor-clearing in an urban environment featuring high rise buildings. The Blue forces were organized into canonical platoons, squads, and fire teams. Two basic Blue conditions were assessed. In the first condition, Blue fire teams and squads were not provided with radios. They performed their communication either verbally or using hand signals. In the second condition, it was assumed that the participants were provided with intra- and inter-squad communications that were "perfect" (e.g., perfect connectivity; immunity from adverse effects such electromagnetic interference, enemy jamming, or multipath).

Four levels of threats were considered in the floor-clearing operation. These subsumed no threat (e.g., the Blue encountered no adversaries in conducting floor clearing), and light, medium, and heavy levels of threats. The personnel and material levels associated with those threat levels are summarized in the vugraph.



The complexity of this problem is such that there is no single tool that can readily be employed to support this analysis. To compensate for this shortfall, several tools and techniques were employed and orchestrated. These included the following.

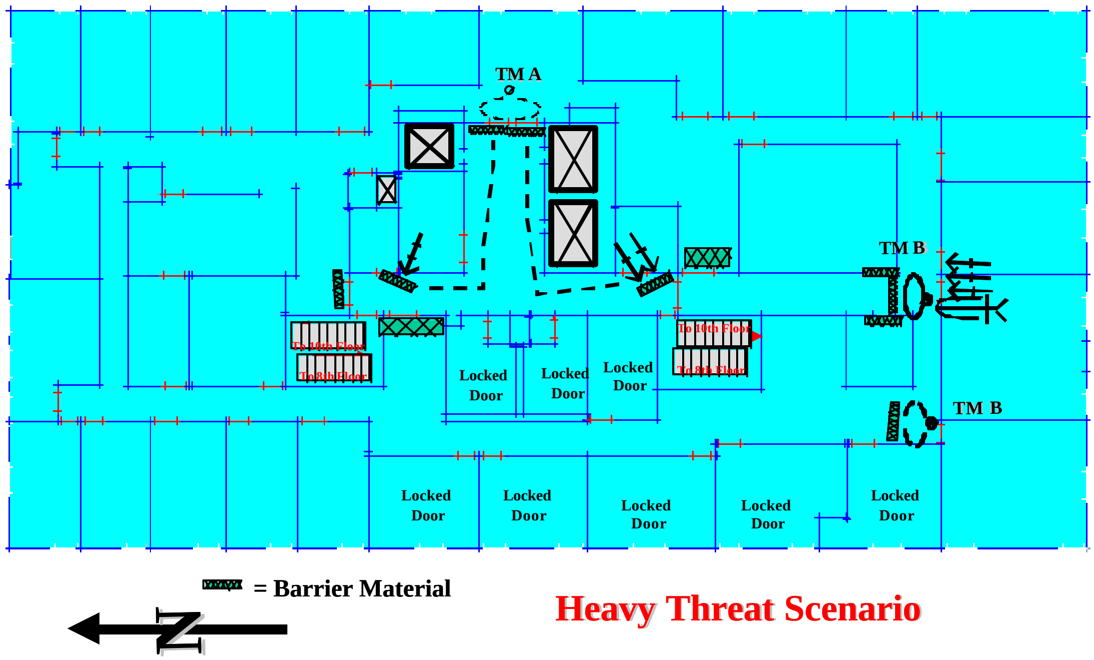
• JCATS. JCATS was employed to satisfy several needs. It was used as an input to a set of communications models. In addition, it was employed to analyze Red and Blue losses.

• Subject Matter Experts (SMEs). To obtain a first cut at the problem, a SME Panel was used. They ensured that the most pressing issues were addressed in the assessment. Their collective response was incorporated into the the simulation scenario.

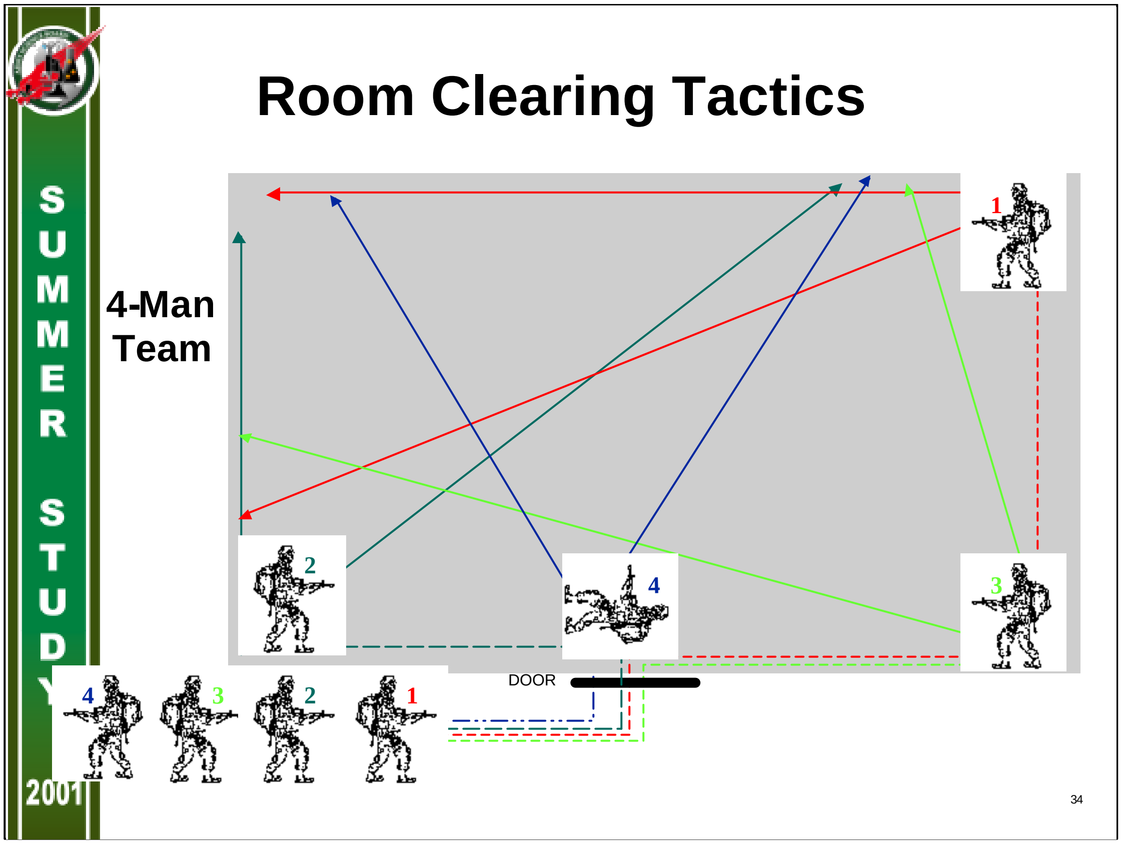
• Man-in-the-loop simulation. Operators, acting as platoon, squad, and fire team leaders, were video-taped as they performed the actual radio transmissions. The video tapes were subsequently reviewed to obtain communications data for other models. These data included the location of the sender/receiver, the type of message sent (e.g., SITREP, Frago), the duration of each messaged, and when the communication occurred. When a unit cleared a room or a floor, those data were also recorded.

Eight excursions were run with five runs per excursion. These cases corresponded to all possible combinations of Blue radio equipment and Red threat levels

Floor with Forces Deployed
(JCATS Terrain/Scenario Files)



This vugraph depicts the engineer floor plan of the 12th floor of an actual building in Rosslyn, Virginia. It was put into JCATS by the DBBL SimCenter personnel to be used in the floor-clearing scenario. Also shown is the diagrammed Operations Order for the Red forces in the Heavy Threat Level case. As in the case of the Blue forces, the Red forces were played interactively.



This animated vugraph illustrates the room clearing tactics, techniques, and procedures (TTPs) used by the Blue fire teams as they cleared the floor. The operation begins with the explosive breaching of the door, followed by the entry of the fire team in the order shown. The dashed lines represented the movement of each team member, while the solid lines/arrows illustrated their fields of fire. The tactics are based on standard U.S. infantry TTPs and demonstrate the level of detail and tactical realism possible in JCATS.

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Observed Red, Blue Average Losses

Red Force Level	Light		Medium		Heavy	
Losses	**Red**	**Blue**	**Red**	**Blue**	**Red**	**Blue**
No Commo	2.8	11.2	4.2	21.8	7.0	18.8
Perfect Commo	3.0	7.2	5.0	7.0	7.0	17.8

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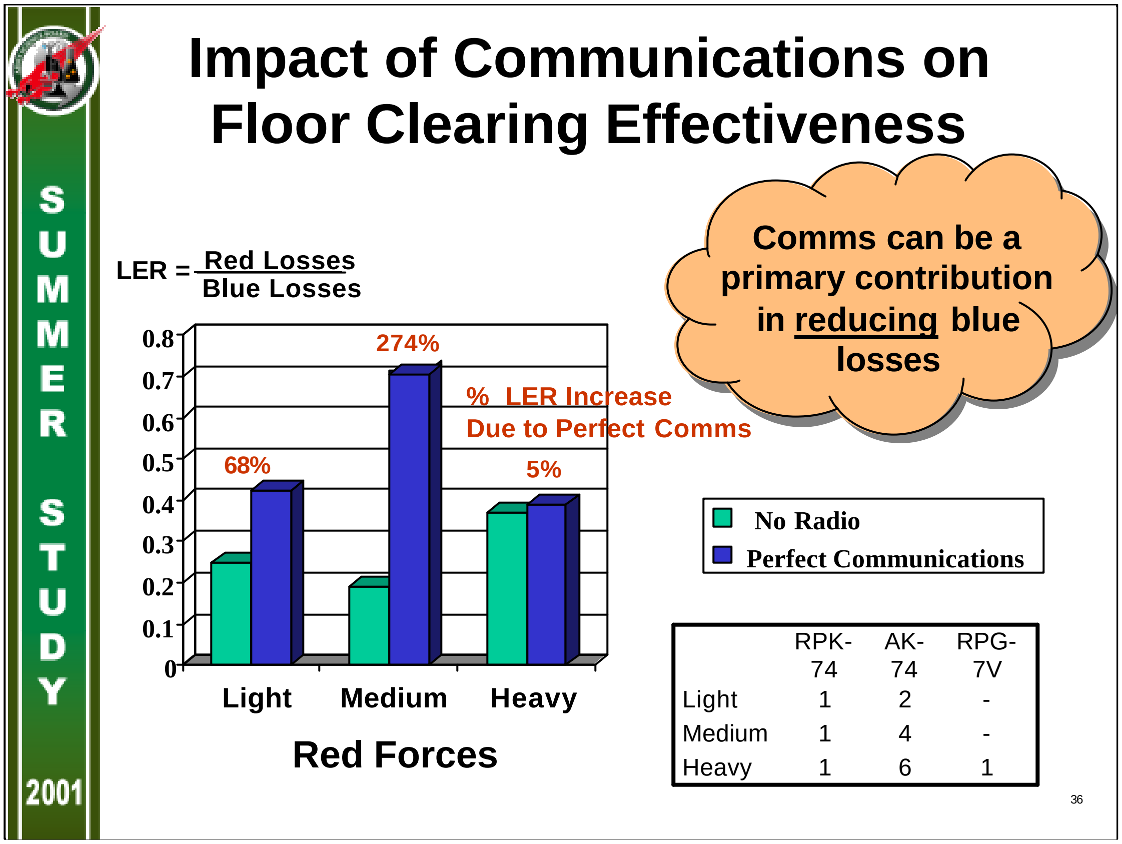
Using the tools and the approach described above, distribution functions describing the losses for Blue and Red forces for each threat level were developed. The losses summarized above represent the average loss values observed over the five runs that were conducted for each cell of the experimental design matrix.

Several trends are evident in these results. First, the greatest impact of enhanced communications on operational effectiveness is evident for the medium threat case. For this situation, the addition of perfect communications results in a dramatic reduction in average Blue losses (i.e., 21.8 to 7.0, or a reduction of 68%) with a relatively modest increase in average Red losses (i.e., 4.2 to 5.0, or an increase of 16%). Lower benefits in operational effectiveness for perfect communications were observed for the light threat condition (i.e., a reduction of 45% in average Blue losses and an increase of 7% in average Red losses). Negligible enhancements in operational effectiveness were observed for heavy threat conditions. In the latter case, it was concluded that the large number of losses and high conflict intensity for all communications conditions made the results insensitive to communications performance.



As a complementary way of viewing the results, the above vugraph summarizes the difference in loss exchange ratios (LERs) that were observed for the three different Red Force levels. This perspective highlights two additional facts. First, the estimated LERs are always less then one. This underscores the level of risk that the attacker incurs in performing this extremely hazardous mission. Second, it dramatizes the potential contribution that perfect communications could have for operations against the Red Medium Forces (i.e., increasing the LER by 274%). Although it is unlikely that imperfect communications will result in such dramatic enhancements in operational effectiveness, it does suggest that for selected scenarios, the benefits associated with enhanced communications can be significant.

The “bottom line” is that the contribution of communications to operational effectiveness is strongly scenario dependent. When benefits are significant, they are largely associated with reduced Blue losses. It would be valuable to perform additional assessments to extend these results to a broader set of urban scenario conditions.

Our Analyses Considered Five Vignettes

- **Complex Terrain**
  - Reverse slope, treeline attack in Kosovo context (RAND analyses employing JANUS)
- **Urban Operations**
  - Convoy in an urban (Sarajevo) environment (RAND analyses employing JANUS and JCATS)
  - Low Collateral Damage Weapon technologies in complex terrain (JFCOM/SNL & LLNL analyses employing JCATS)
  - MOUT ACTD floor clearing operations (Dismounted Battlespace Battle Lab / IDA analyses employing JCATS)
  - Humanitarian assistance in a small village (Project Albert/Mitre analyses employing MANA)

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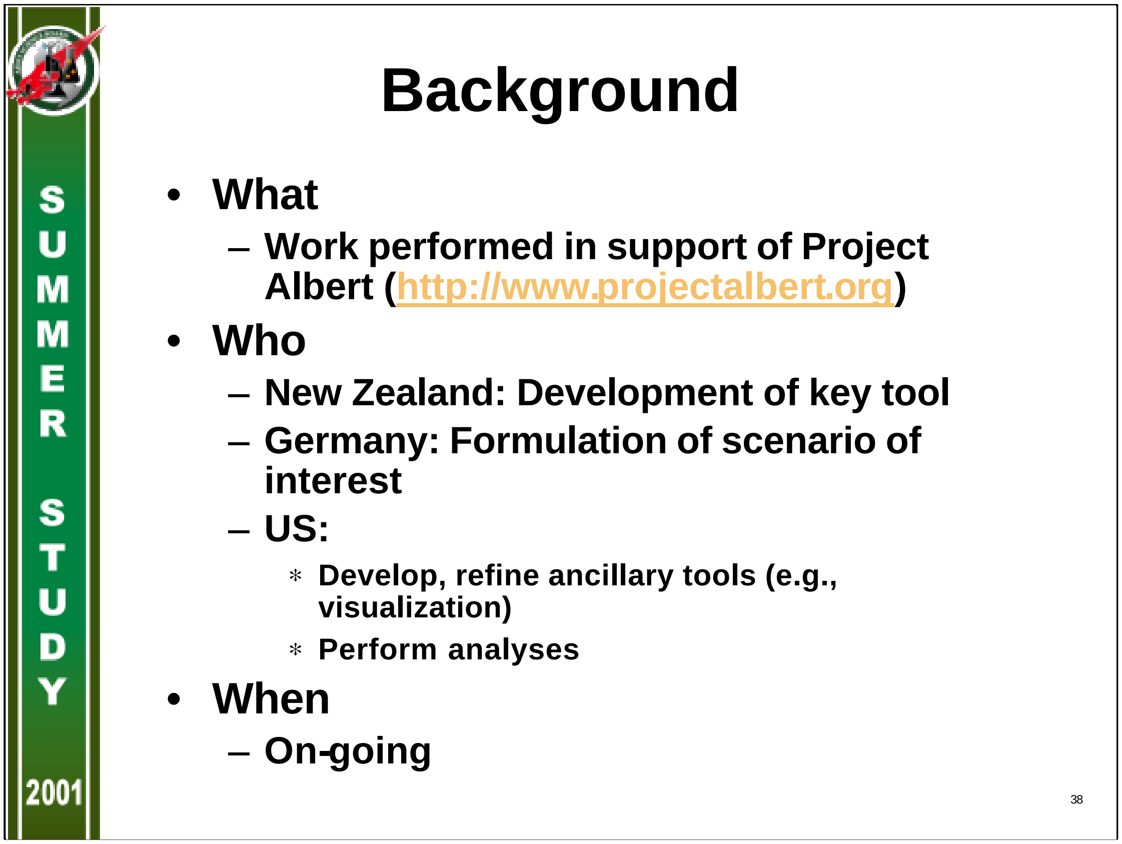
This section briefly summarizes on-going analyses that are being performed to formulate and assess Courses of Action for Humanitarian Assistance in an urbanized environment.



In 1995, The USMC began an initiative, based on the so-called "New Sciences", to provide quantitative answers where feasible, to significant issues confronting military decisionmakers. This initiative, which is continuing under Project Albert, is seeking to harness key advances in supercomputing, data farming, and visualization; capture the impact of intangibles and coevolution on warfare; prototype new models and techniques; and apply these products and insights to significant military issues.

The material in this section summarizes on-going work in the application of selected Project Albert products to key issues associated with Humanitarian Assistance in urbanized terrain. The primary tool in question, MANA, an agent based simulation, is being developed by the Defence Operational Technology Support Establishment (DOTSE), New Zealand. They have evolved the tool in concert with operational forces in New Zealand assigned to support UN activities in East Timor. Representatives from Germany are interested in applying MANA to a variety of Humanitarian Assistance issues. In support of that interest, The MITRE Corporation has been exercising MANA to illuminate those issues. The material that follows draws upon a subset of those MITRE analyses

Scenario

- **Blue Force**
  - **Assigned mission:**
    - **Distribute food to hungry, local people**
    - **Pursue a defined patrol route from the city into the countryside**
  - **Size of Blue Force: Variable (5, 10, 15)**
  - **Equipment:**
    - **Sensor/Weapon Ranges (Fixed at 5)**
    - **Option: Take a LAV [Yes (Y), No (N)]**
  - **TTP:**
    - **Number of food distribution points: 1 or 3**
- **Locals:**
  - **Aggression: Pre-fed (friendly); post-fed (aggressive)**
  - **Disposition:**
    - **If one food distribution point: 1 squad of 60**
    - **If three food distribution points: 3 squads of 20**

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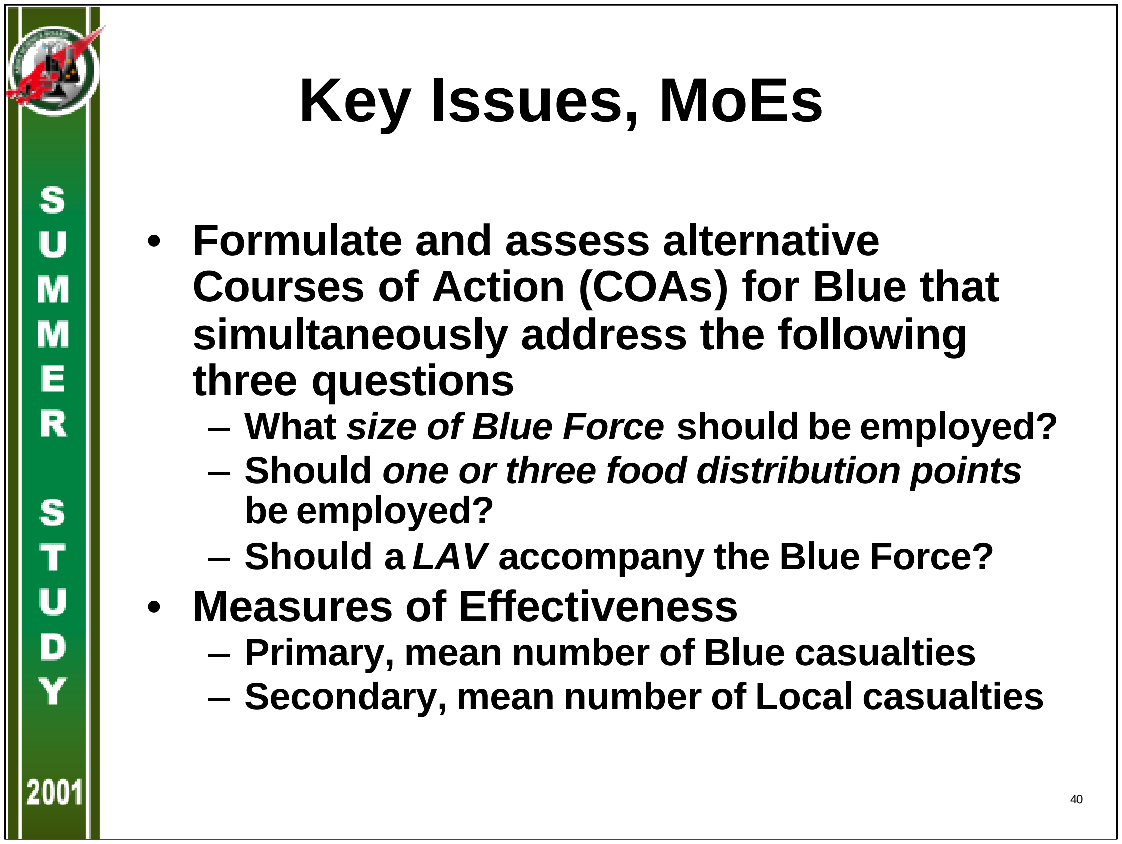
The German participants in Project Albert have identified the following scenario as the context for their deliberations. A Blue Force is assigned the mission to distribute food to hungry, local people. The Blue Force has a defined patrol route which leads them to the local people and out of the immediate city/village area. The size of the Blue Force is variable (ranging from 5 to 15) and has the option of bringing a Light Armored Vehicle along on the patrol. In the full study, the characteristics of the Blue Force equipment are variable (e.g., variable range in sensors and weapons). However, for the purposes of this analysis, it was assumed that the ranges of the Blue Force sensors and weapons are fixed at 5. Finally, the Blue Force is given the option of delivering the food to either one or three distribution points.

Locals are friendly to the Blue Force while hungry (Blue is a food source), but once they receive food, the locals become aggressive/hostile towards Blue. If Blue Forces distribute the food to a single distribution point, the locals are arrayed into a squad of 60. Conversely, if the food is delivered to three distribution points, the locals are arrayed into three squads of 20.



From an operational commander's perspective, this issue can be perceived as a question of formulating and evaluating alternative courses of action (COAs). These courses of action can be decomposed into three subordinate decisions:

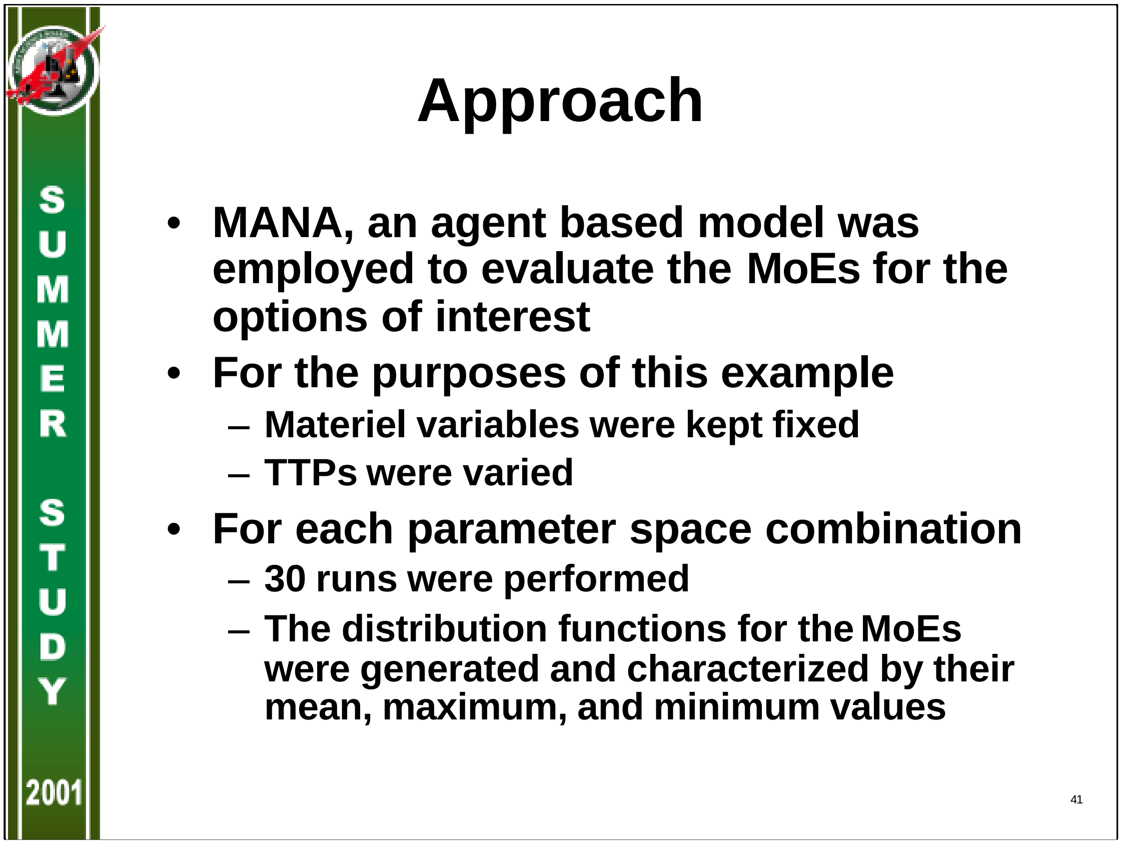
• What size of Blue Force should be employed (i.e., 5, 10, or 15)?

• How many food distribution points should be employed (i.e., 1 or 3)?

• Should a LAV accompany the Blue Force (i.e., yes or no)?

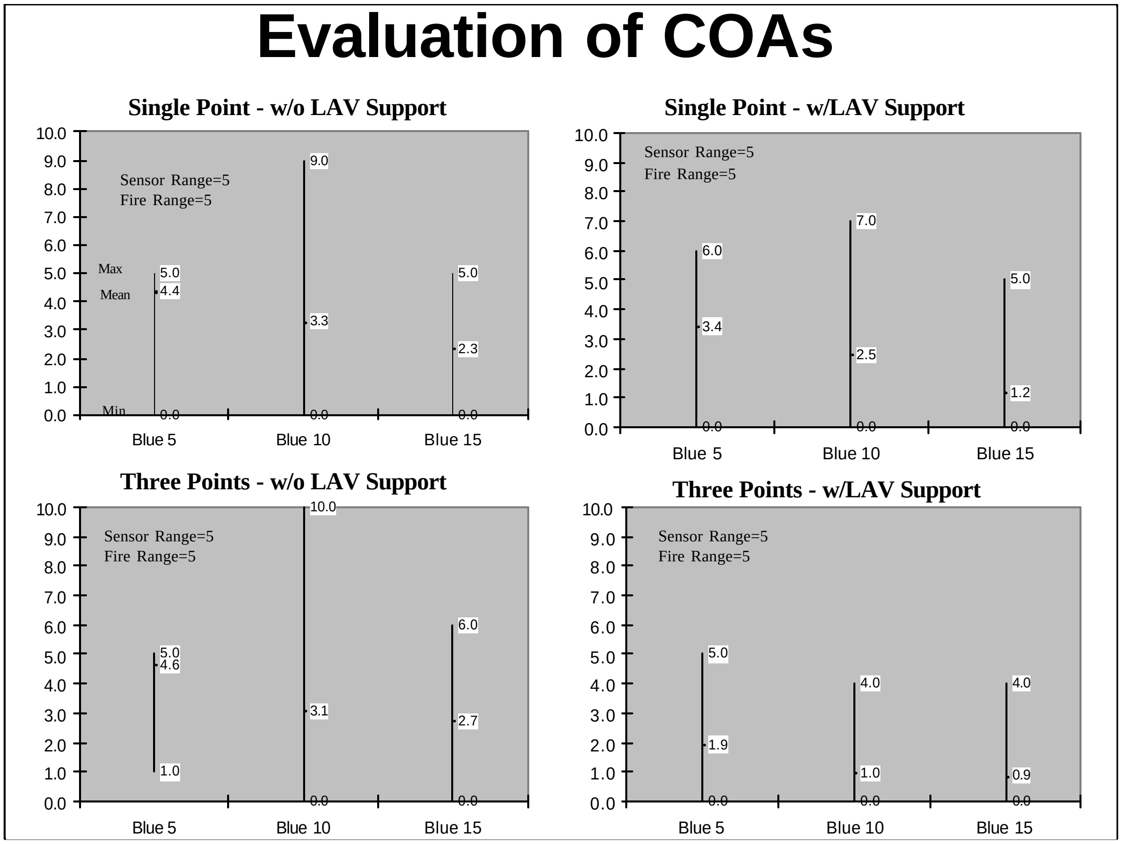
Cumulatively, these questions give rise to 12 candidate COAs.

In order to evaluate these COAs, it is necessary to identify the MoEs of interest. From the operational commanders perspective, the most important of these MoEs is the mean number of casualties that the Blue Force is likely to suffer when performing the mission. There are a number of subordinate MoEs that might be considered in selecting a preferred COA (e.g., the mean number of Local casualties; the average length of time required to accomplish the mission). However, for the purposes of this illustrative assessment, attention will be limited to a consideration of the mean number of expected Blue casualties.

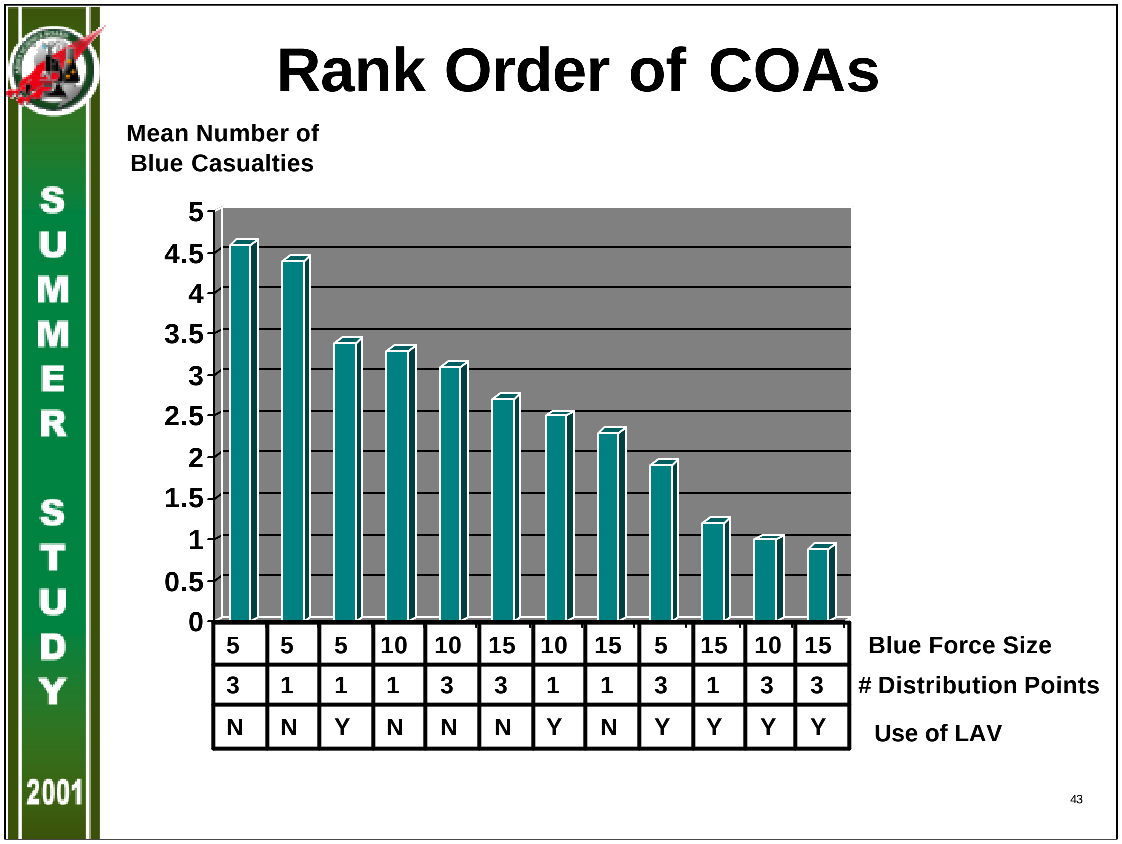


In order to accomplish this assessment, MANA was selected as the preferred tool. MANA has a number of properties that suggests that it should be useful in shedding light on the problem. First, it does not use a high level of detail (e.g., terrain features are modeled simply at block obstacles; weapons are modeled in terms of a range and a kill probability within that range). Thus, it would be feasible to set up and execute the simulation in a tactical environment. Second, we seek to characterize and explore "emergent behavior" that arises form the specification of the low level interactions among the agents in the simulation. The agents are characterized by "personalities" that represent the behaviors of the participants (e.g., their degree of aggressiveness; fear of adversaries; unit discipline) and their low level tactics, techniques, and procedures. Thus, the individual COA attributes identified on the prior page can easily be represented in the simulation. Finally, MANA is being used to support the generation and evaluation of TTPs by New Zealand forces in the context of East Timor operations. This experience affords some confidence that the tool has utility in simulating peace support operations.

For the purposes of this study, the materiel variables were kept fixed (e.g., it was assumed that the Blue Forces' sensor and weapon were fixed at 5). However, the TTPs were varied to represent the COAs of interest. For each of these parameter space combinations, 30 runs were performed. Based on the results of these runs, distribution functions of Blue Force casualties were generated. As a simplifying step these distribution functions were characterized by their mean, maximum, and minimum values.



This slide depicts the mean, maximum, and minimum values of Blue Force casualties for the 12 strawman COAs as derived from MANA. In general, the behavior of these values is a relatively complex function of the squad size, the number of food distribution points, and the presence of a LAV. A cursory examination of the figure reveals that all other factors being equal, employing a LAV always reduces the number of Blue Force casualties. To clarify the potential tradeoffs among the alternative COAs, it is useful to array the options in order of decreasing mean value of expected Blue Force casualties (see the following page).



This chart rank orders the 12 COAs with respect to the mean expected value of Blue Force casualties. As can be seen, the preferred COA is to select the largest squad (i.e., 15), the largest number of food distribution points (i.e., 3), and to include a LAV. Although this result is intuitively reasonable, it is interesting to note that the rank ordering of many of the sub-optimal COAs is not so obvious (e.g., using a very large force with only one distribution point is better than having a small force with three distribution points). This is important because resource constraints and operational demands may compel the operational commander to revert to a sub-optimal COA.

These results suggest that agent based models may have an important role to play in the area of COA formulation and selection. They are relatively flexible and not particularly resource intensive. Thus we may have the option of running a fairly broad number of cases in a timely fashion, with the potential to discover interesting, synergistic emergent behaviors. In addition, they may prove useful in helping to evaluate and refine TTPs that take advantage of advances in technology. In order to enhance the quality of these tools, and our confidence in their utility, it is critical that they continue to be used with operational forces and refined to reflect lessons learned.

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Back-up Slides

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“View from the Top” - Admiral Ellis

“Excessive collateral damage concerns created sanctuaries … and opportunities…for the adversary -- which were successfully exploited.”

“Public Info & Public Affairs - Not a shining moment for the U.S. or NATO -- The enemy deliberately and criminally killed innocents by the thousands…but no one saw it -- We accidentally killed innocents sometimes by the dozens …and the world watched on the evening news.”

“Self-Inflicted Wounds in Asymmetric Warfare - The enemy *benefited* from:

The NCA / NAC target approval processes Our self-suspension on cluster munitions Our standards for limiting Collateral Damage”

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Our adversaries are becoming increasingly adept at exploiting our concern for indigenous civilian personnel and property and world opinion in creating sanctuaries, concealing militants, and furthering their objectives.

ASB 2001 Summer Study
Analysis Panel

Appendix D: References

25 July 2001

1

References

- 1. Project Metropolis Interim Report, "Squad and Platoon Combined Arms Team in MOUT", X-File 3-35.37, Marine Corps Warfighting Laboratory, USMC, 23 August 2000.
- 2. "MOUT Battalion Level Experiments -- Experiment After Action Report", Project Metropolis, Marine Corps Warfighting Laboratory, February 2001.
- 3. Inside the Navy, August 20, 2001.
- 4. "NATO Soldier Modernization Measurements of Analysis -- A Framework for Modelling and Trials", AC/225(LG/3)D/25, NATO/PfP Unclassified, 4 October 1999.

Recommended Web Sites

- Handbook for Joint Urban Operations
  - www.dtic.mil/doctrine/jel/other_pubs/juoh.htm
- Center for Army Lessons Learned (CALL) Homepage
  - http://call.army.mil
- The MOUT Homepage
  - http://www.geocities.com/Pentagon/6453
- CSS Support of MOUT Homepage
  - http://www.cascom.army.mil/multi/mout
- OneSAF Homepage
  - http://www.onesaf.org
- Project Albert
  - http://www.projectalbert.org
- Blackhawk Down Homepage
  - http://www.philly.com/packages/somalia/sitemap.asp

3

Manpower and Personnel for Soldier Systems in the Objective Force

SUMMER STUDY 2001

Mission Statement

To focus, prioritize and recommend research and development on soldier knowledge, skills and attributes to meet Army requirements for the Objective Force

Co-Chairs: Dr. Harry O'Neil and BG(R) Jim Ralph

Sponsor: The DCSPER, LTG Timothy Maude

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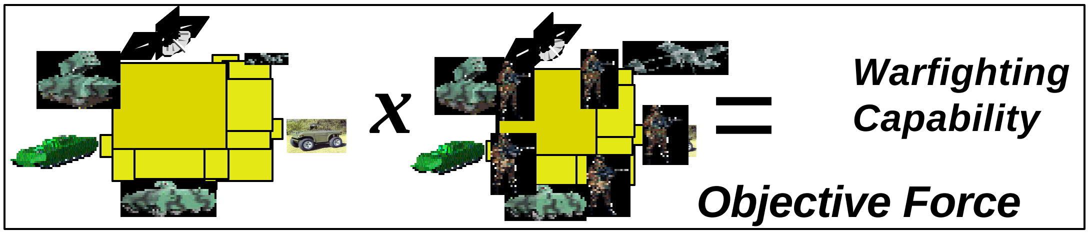
The Army Science Board (ASB) 2001 Summer Study was titled "Objective Force Soldier / Soldier Team." The Manpower and Personnel Study was one of several Special Studies conducted in FY01 in support of the Summer Study and the only one selected for incorporation into the main Summer Study.

The Manpower and Personnel study was also a follow-on for the 2000 Summer Study called "Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era." The 2000 Study Report is available on the ASB Web site (www.saalt.army.mil/sard-asb/).

Editor's note: The Manpower and Personnel study will be published in its entirety in a separate publication. This is the Manpower and Personnel briefing incorporated into the Objective Force Soldier study with annotations from the full length Manpower and Personnel study report.

WHAT IS THE OPERATIONAL VALUE OF GOOD SOLDIERS?



ASB M&P 3 May 01 v3 Slide 40

The nature of this equation is that Weapons Systems capability times People capability equals War Fighting capability. Thus, if People capability is little or zero, then War Fighting capability is also zero, as Weapon Systems capability x 0 People capability = 0 War Fighting capability.

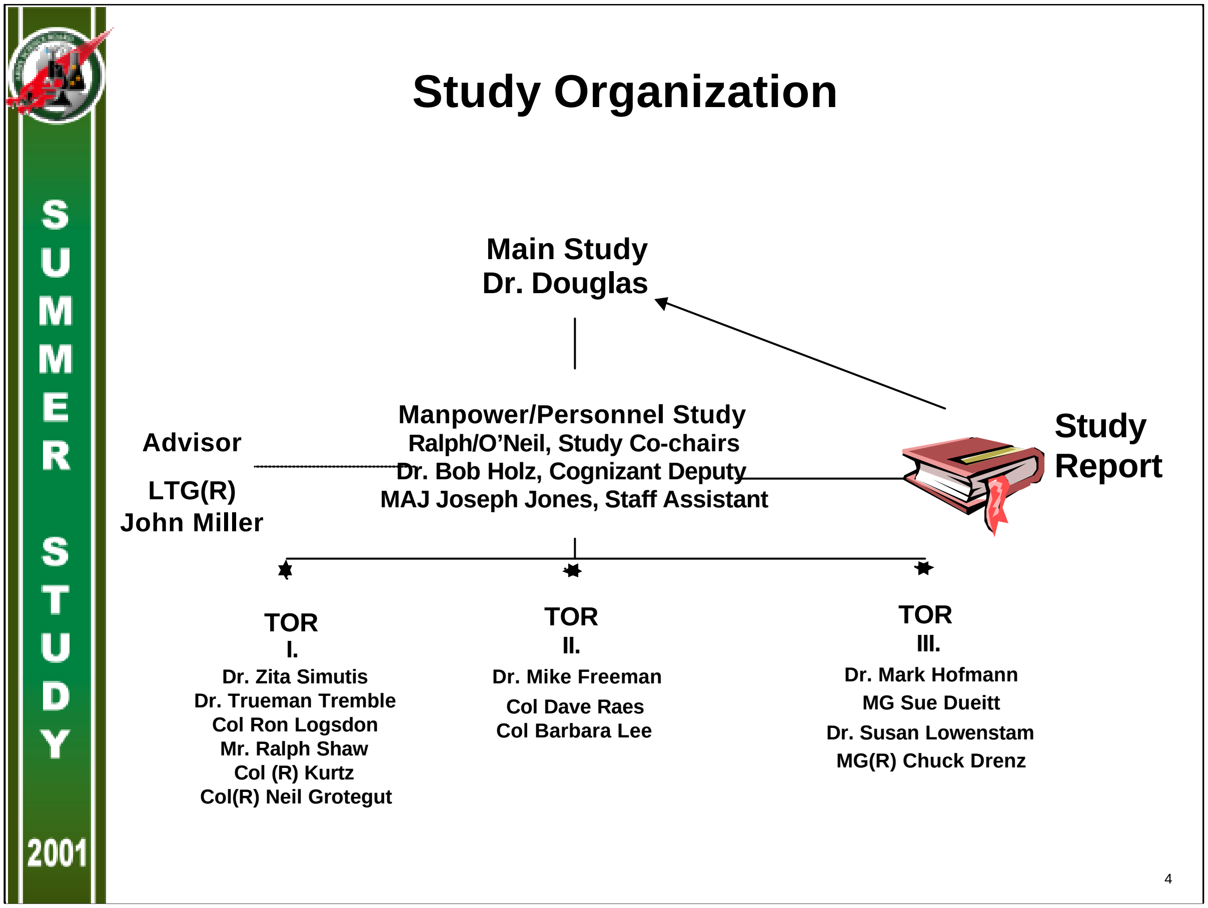
"The Army is quality soldiers, veterans, civilians, and our families...Our physical, moral, and mental competence will give us the strength, the confidence, and the will to fight and win anywhere, anytime." (The Army Vision (2001), www.army.mil/armyvision).

The Army Vision

SUMMER STUDY 2001

Agenda

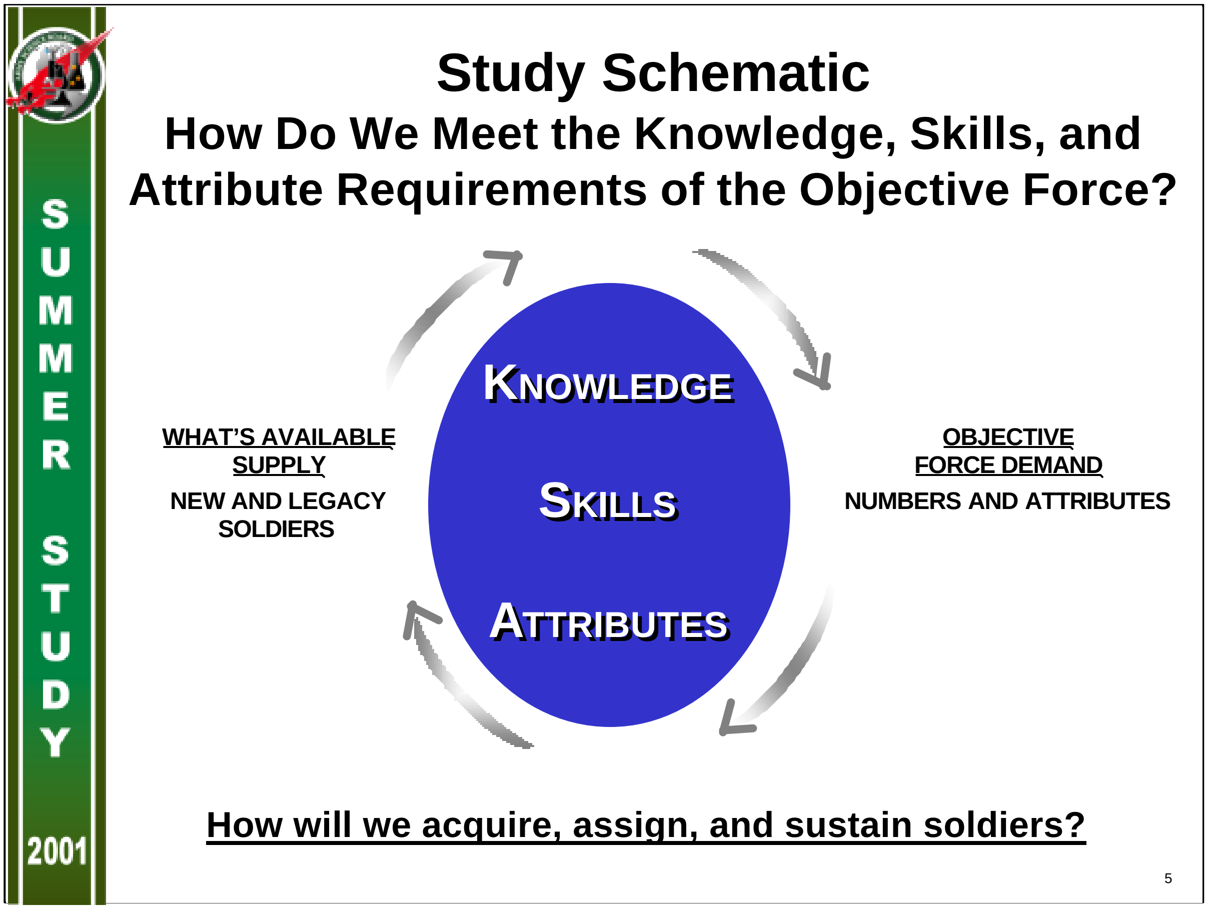
- Background of study
- Terms of reference (TOR)
- Results of study (TOR 1, TOR 2, TOR 3)
- Recommendations
- What we want you to remember



The study organization involved a standard approach to managing a Special Study. The purpose of the Special Study was to inform the Main Study, headed by Dr. Bob Douglas, of relevant manpower and personnel issues impacting the Objective Force. The Special Study deliverable was a brief with notes (Ralph, J.R. et al. June 2001. Manpower and Personnel for Soldier Systems in the Objective Force, Army Science Board 2001 – Special Study. Arlington, VA: Assistant Secretary of the Army for Acquisition, Logistics and Technology.)

We organized ourselves into three groups with responsibilities for each of the TORs, headed by Drs. Simutis, Freeman, and Hofmann respectively. We were also informed by a Special Advisor, LTG(R) Miller, to the Manpower/Personnel Study Leadership (BG(R) Jim Ralph, Dr. Harry O'Neil, and Dr. Bob Holz).

There was a good mix of active and retired military, industry and academic, and U.S. Army civilians on this Special Study. The members are listed alphabetically. Further, there was representation from both the National Guard (COL(P) Dave Raes), the Army Reserves (MG Sue Dueitt), OCAR (Col. Ron Logsdon).



The conceptual framework for the study starts on the right with the demand side of the equation. Demand, in terms of numbers, is strength requirement driven. On the other hand, demand is driven not only by the number of jobs but also by the types of jobs. Thus, at the top, "How many are needed with what KSAs?" represents the desired parameters for "Knowing what we would like to have". This serves as the basis for recruitment and incentive activities. Still moving counter-clockwise we reach "What will be available?" This question embraces a KSA's perspective as well as a demographic perspective, i.e., our Objective Soldier Supply. In this supply mix, we must consider legacy soldiers or those which are already on board, as well as those provided by recruitment efforts. The final step is "How to best access or acquire from the supply pool to achieve best job match or assignment?" Also, to identify those factors that will motivate and provide a sense of well being. The ability to achieve the "best job match" will reduce attrition and training costs. It will increase job performance and job satisfaction Combining good job match with well-being factors will also reduce attrition, enhance performance, improve retention and increase morale. Having said this: "Is there adequate Tech Base resources to produce valid tools, techniques and knowledge to answer the questions posed in the schematic?"

In summary, this is a model for acquiring, assigning and sustaining soldiers for the Objective Force. The model highlights the need to:

- Estimate the number of soldiers and the attributes they must have to meet Objective Force requirements.
- Assess the availability of civilians and the Legacy Force soldiers having these attributes.
- Evaluate Army capability to meet Objective Force requirements with appropriately qualified soldiers.

Terms of Reference
Simply Stated

Manpower and Personnel

- **Demographic Characteristics:**
  - **Who Will Be Available**
  - **What Attributes Will They Have**
- **Attribute Requirements:**
  - **What Knowledge, Skills, Attributes Will Be Needed**
- **Research and Development Requirements**
  - **Is R&D Effort Adequate To Permit the Army to Acquire**
  - **Assign, and Sustain Personnel for the Objective Force**

SUMMER STUDY 2001

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The chart above provides an outline of the study TORs.

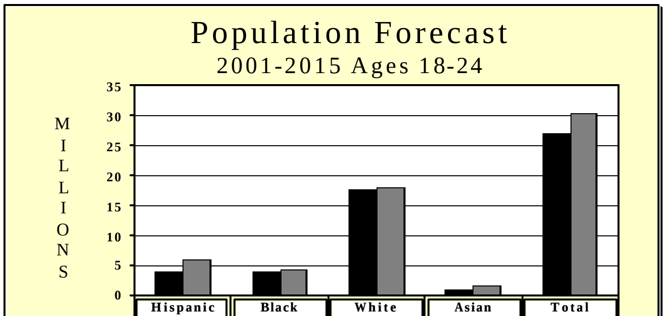
The Army DCSPER fully supported this Special Study to investigate these issues and whether there is adequate funding for 6.1, 6.2, and 6.3A programs in this area. Such funding should provide for appropriate research in soldier qualifications, skills, knowledge, attitudes etc., to meet quality, quantity, and ethnic and gender diversity to fill Army requirements for FCS in 2010-2025.

This Special Study supports the 2001 Summer Study, “[The] Objective Force Soldier / Soldier Team,” chaired by Dr. Bob Douglas.

Demographic Characteristics (TOR1)

SUMMER STUDY 2001

- **TOR1: Demographic Projections**
  - **Minority youth population will increase, especially Hispanics**



	Hispanic	Black	White	Asian	Total
2001	4.114	3.892	17.839	1.093	27.187
2015	5.978	4.307	18.031	1.674	30.254
% Increase	+45 %	+11%	+1%	+53%	+11%

- **By the 12th grade in 2010, he or she will be**
  - ∗**Showing equivalent academic achievement earlier generation U.S. 12th graders**
  - ***National Assessment of Educational Progress trends**
- **As in past, comparing very unfavorably academically to children from other nations**
  - ∗**Third International Science and Mathematics Study**

While future population demographics are not explicitly requested in TOR1, projecting soldier demographics requires comparable civilian information. This information was based on Census Bureau and National Center for Education Statistics reports.

The TOR was interpreted as a task:

(1) to compare civilians and Army populations across demographic variables with an emphasis on quality-related demographics, over time using historical data and future projections, and

(2) to identify emerging policy and research needs.

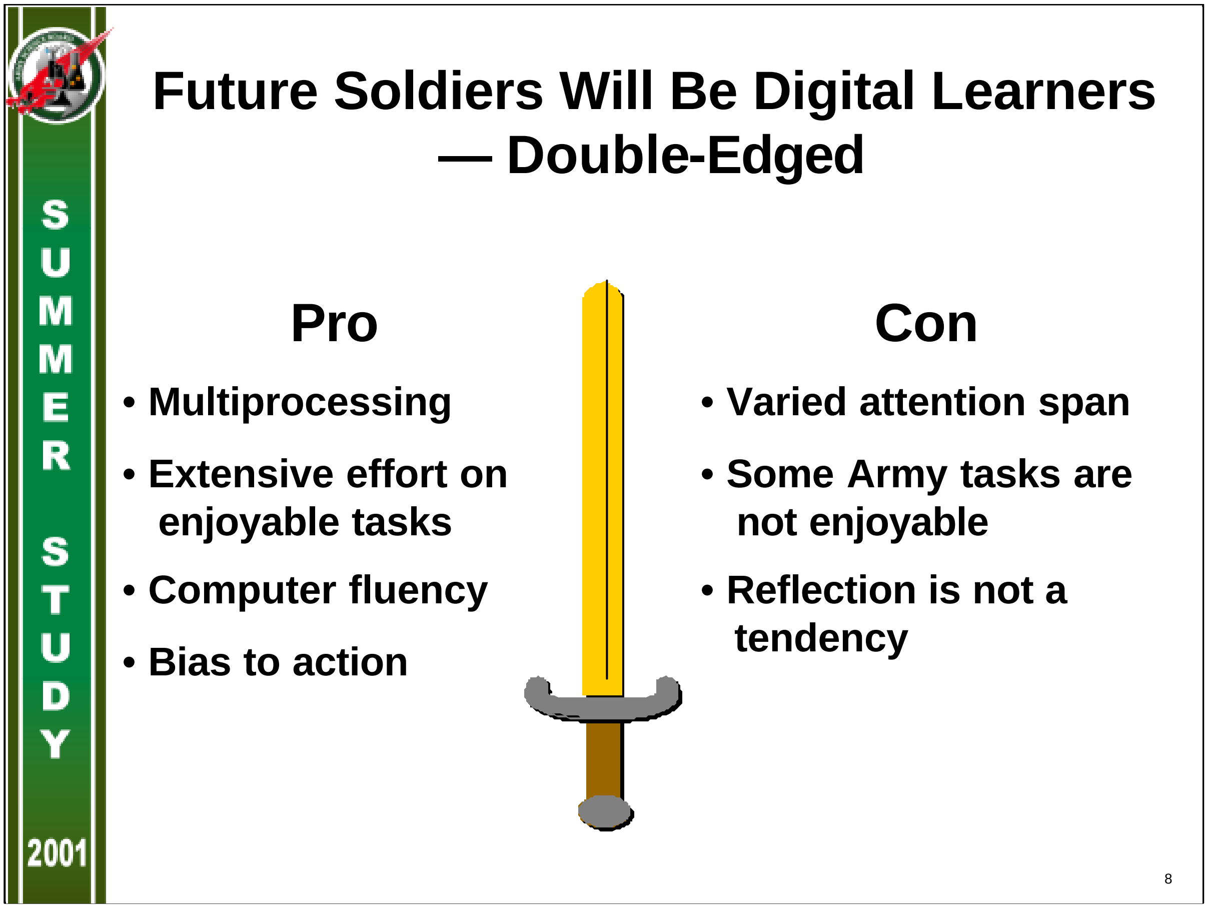
Population Forecast bar chart is based on data from the U.S. Census Bureau Population Projections Program and available at http://www.census.gov/population/www/projections/natsum-T3.html The projection estimates take into account assumptions associated with fertility, mortality and migration. They are based on the 1990 census data.

There is consistent agreement among demographers that minority populations will increase in the United States, especially Hispanics (U.S. Department of Commerce, Bureau of the Census, Current Population Reports, Population Projections of the United States by Age, Sex, Race, and Hispanic Origin: 1995 to 2050 (P25-1130)).

For the time period 2015, there are no Army or RAND or Army Research Institute projections. There is a RAND report that had information on 2025 (Orvis, Nichipourk, MacDonald, Quigley & Sastry (August 1998) Future Personnel Resource Management: Initial Report, Rand Corporation Report Number AB-210-1-A)).

Academic Achievement: U.S. Department of Education. Office of Educational Research and Improvement. National Center for Education Statistics. NAEP 1999 Trends in Academic Progress: Three Decades of Student Performance, NCES 2000-469, By J. R. Campbell, C.M. Hombo, & J. Mazzeo. Washington DC: 2000.

International Comparisons: Mullis, I. V. S., Martin, M. O., Beaton, A. E., Gonzalez, E. J., Kelly, D. L., & Smith, T. A. (1998, February). Mathematics and Science Achievement in the Final Year of Secondary School: IEA's Third International Mathematics and Science Study (TIMSS). International Association for the Evaluation of Educational Achievement, TIMSS International Study Center, Chestnut Hill, MA.



Future soldiers will come to the Army with long experience using computers and playing complex computer games. This also is a dual-edged sword. These young people will be quite adept at playing games that require high skill levels in multi-processing and eye-hand coordination. They spend long hours honing their skills, very much enjoying the experience. The games bias them to act, to keep up with the game's rapid pace. On the negative side, future soldiers are likely to have attention spans that will vary depending on the ease with which they achieve high levels of skill and on how much they enjoy the experience.

Brown, J. S. (2000). Growing up digital. How the Web changes work, education , and the ways people learn. Change, 32(2), 11-20.

Skill Summary

- **Skill Level Projections**
  - **Academic achievement will change very little from 2001 to 2010**
    - **NAEP scores have increased less that .20 standard deviation units across all testing domains since 1980**
  - **Technology familiarity will increase due to home and school computer use**
  - **AFQT scores will remain stable from 2001 to 2010**
    - **Since 1985, Mean AFQT has ranged from 57.79 to 59.32, only 1.53 points**
  - **High school graduation and college continuation rates will remain high in 2010**
    - **Current high school graduation rates are 93.0% (white) and 88.7% (black). A lower Hispanic rate, 61.6%, may reflect recent immigration**
  - **Bottom Line: Potential recruits will be similar in skills to today's recruits**

SUMMER STUDY 2001

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This chart summarizes changes in the cognitive characteristics and skills that civilian youth are likely to have as they enter the Army through 2010. On the basis of NAEP test performance data and AFQT recruit trend data, it is expected that the youth population and new recruit cohorts will change very little in terms of either general academic achievement or general cognitive aptitude. Educational enrollment data are consistent with this expectation and indicate that a high proportion of the youth population will continue to graduate from high school. However, youth are likely to be much more technologically savvy because the presence of computers in home and educational settings has dramatically increased.

Citations linked to topics:

Academic Achievement: U.S. Department of Education. Office of Educational Research and Improvement. National Center for Education Statistics. NAEP 1999 Trends in Academic Progress: Three Decades of Student Performance (NCES 2000-469). By J. R. Campbell, C.M. Hombo, & J. Mazzeo. Washington DC: 2000.

Technology Familiarity: U.S. Department of Education, Office of Educational Research and Improvement, Digest of Educational Statistics (NCES 2001-034).

AFQT: Analyses based on enlisted accession datafiles maintained at ARI since 1973

High school and college continuation rates: U.S. Department of Education, Office of Educational Research and Improvement, Digest of Education Statistics 2000 (NCES 2001-34).

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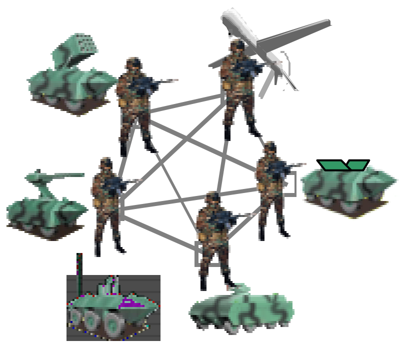
Terms of Reference (2)

Projected Skills and Match/Mismatch

Objective Force:

Distributed, internetted, collaborative team of teams engaging in very complex tasks



<u>Tenets</u>

- **See First**
- **Understand First**
- **Act First**
- **Finish Decisively**

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Initial projections indicate that a single command and control station with multiple robotic weapons platforms and a crew of four could cover a 10-kilometer front, an area that now requires a 100-man tank company (Gourley, S. R.[2000]. Future combat systems: A revolutionary approach to combat victory. Army, 50 [7], 23-26).

In the dynamic battlefield environment of the future, C4ISR functions will be critical to the FCS success. The blinding speed and sheer volume of information will overwhelm and inundate the FCS operators and decision-makers. The information must be integrated and filtered (fused) appropriately.

Sensor-to-shooter operations will become increasingly complex and will pose formidable training challenges. Extensive knowledge and substantial inferential capability are required to interpret sensor data, generate hypotheses about their meaning, and propose courses of action, particularly when multiple sensors, weapons, and tactical situations are involved. All of these tasks require deep understanding of the functional properties being sensed, the operation and limitations of sensors, and the environmental or real-world interactions that affect data observation and interpretation. Further complexity is encountered in most warfare applications as intelligent opponents seek to avoid detection, confuse identification, and gain tactical advantage by employing intelligent countermeasures or unconventional maneuvers to make sensor employment even more difficult. (ASB 2000)

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Examples of Very Complex Tasks

- **Manage C2 of direct and indirect fire robotic systems**
- **Conduct teleoperated robotic navigation**
- **Control anti-jamming networks**
- **Ensure network security for C2 of distributed robotic systems**
- **Control robotic sensors**

~15% of tasks can be described as very complex

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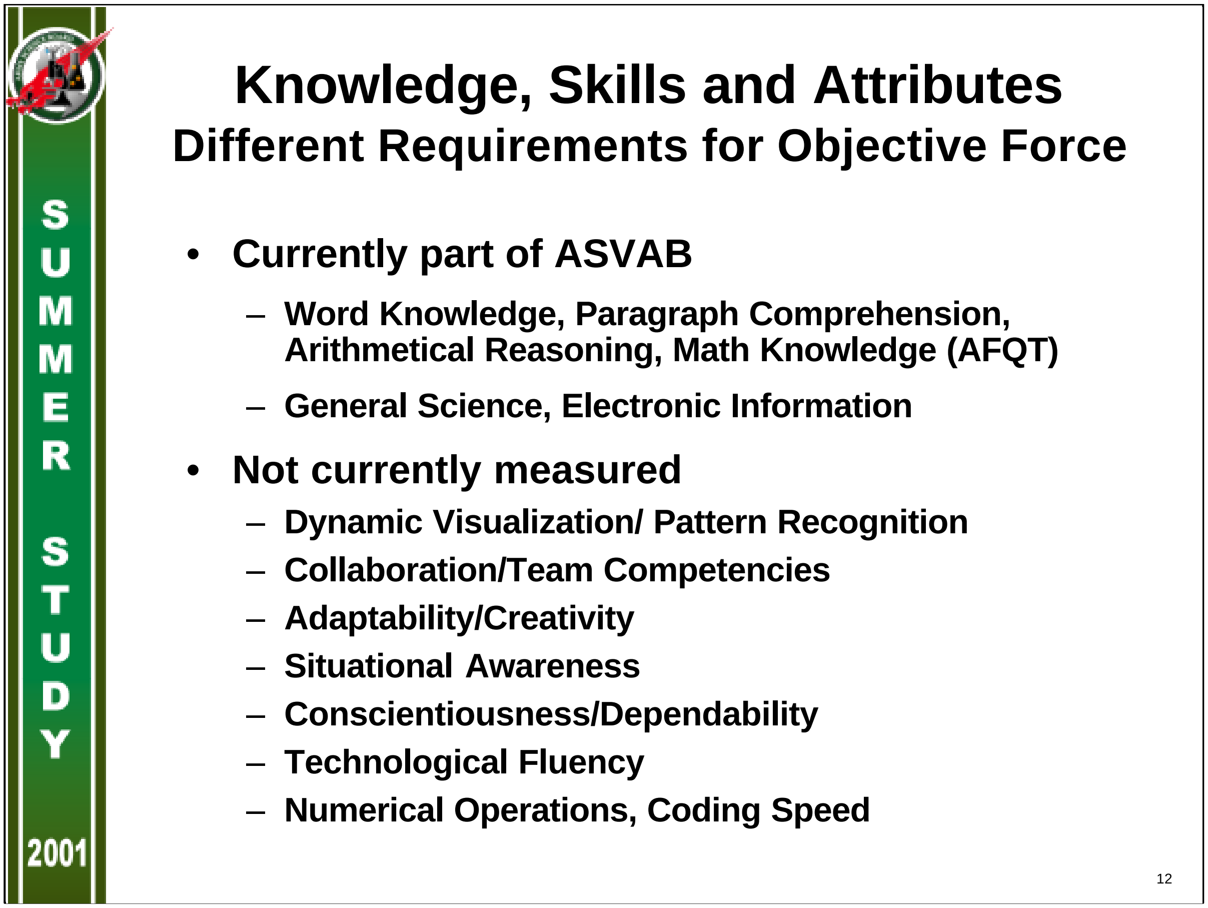
This information is from the Training Panel of the Army Science Board report O'Neil, H. F., Jr., Drenz, C., Lewis, F., et al. (2000), Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 era. Army Science Board-1999-2000 Summer Study.

Shown on this chart are examples of very complex tasks. For a verbal transition the briefer could allude to naval sonar tasks. The tasks are modified from a draft concept paper by Terry D. Faber, Army Training Support Center, Enhanced Embedded Training, 7/14/00. In this scenario, an operator determines where high-speed robots must navigate and chooses anti-jamming frequencies and networks based on recent intelligence information. While controlling the robotic system, the operator must assess information from other sensors supporting the operation as to reliability and counter measures effects. The operator must also select responses with other operators while also performing Battlefield Defense/Damage Assessments (BDA) and responding appropriately. (ASB 2000)



Not Currently Measured

Dynamic Visualization

This ability implies that people are capable of forming mental images of dynamic objects that are analogous to the objects being presented and that these mental images can be "viewed" to make decisions and answer questions about a hypothetical referent. Such ability is useful for careers in engineering, physical science, or art, or assessment in C4ISR. (Duesbury, & O'Neil. (1996). Effect of type of practice in a computer-aided design environment in visualizing three-dimensional objects from two-dimensional orthographic projections. Journal of Applied Psychology, 81, 249-260.)

Collaboration/Team Competencies:

This is the ability to interact dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission,

within a distinguishable set of two or more people who have each been assigned specific roles or functions to perform. Adaptability (situational awareness)

(Salas, E., Dickinson, T. L., Converse, S. A. & Tannenbaum, S. I. (1992). Toward an understanding of team performance and training (pp. 3-29). In R. W. Swezey & E. Salas (eds.), Teams: Their training and performance. Norwood, NJ: Ablex Publishing Corporation.

Canon-Bowers and her colleagues indicate that team competencies can be thought of as the requisite knowledge (e.g. principles and concepts underlying a team's task performance), skills (e.g. psychomotor and cognitive behavior necessary to perform the team task correctly), and attitudes (e.g. collective orientation) that result in effective team performance, while competencies can be generic or specific to a team or a task (Cannon-Bowers et al. 1995; Cannon-Bowers & Salas, 1997, 1998). To accomplish this, team members must share a common sense of the task and similar mental models to coordinate activities effectively. Using this reasoning, team members require knowledge of the task, the environment, and their team members to be effective.

Adaptability/Creativity

"Adaptability may not be a single attribute, but rather a combination of attributes. Pulakos, Plamondon, and Kiechel (1997) described a project being conducted for the Army Research Institute which is examining cognitive abilities and such non-cognitive characteristics as openness, flexibility, and tolerance of ambiguity as predictors of adaptive performance." (Rumsey (1999). Officer selection in the 21st century (pp. 9-1 to 9-10). In Officer Selection. RTO Meeting Proceedings 55, North Atlantic Treaty Organization. Creativity refers to the potential to produce novel ideas that are task-appropriate and high in quality (p. 360; Sternberg, 2001, Amer Psychol, 56, 360-362).

Situational Awareness

"the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." (Endsley, M. (1988). Situation awareness global assessment technique (SAGAT) (pp. 789-795). In Proceedings of the Aerospace and Electronics Conference. New York: IEEE.

Conscientiousness/Dependability

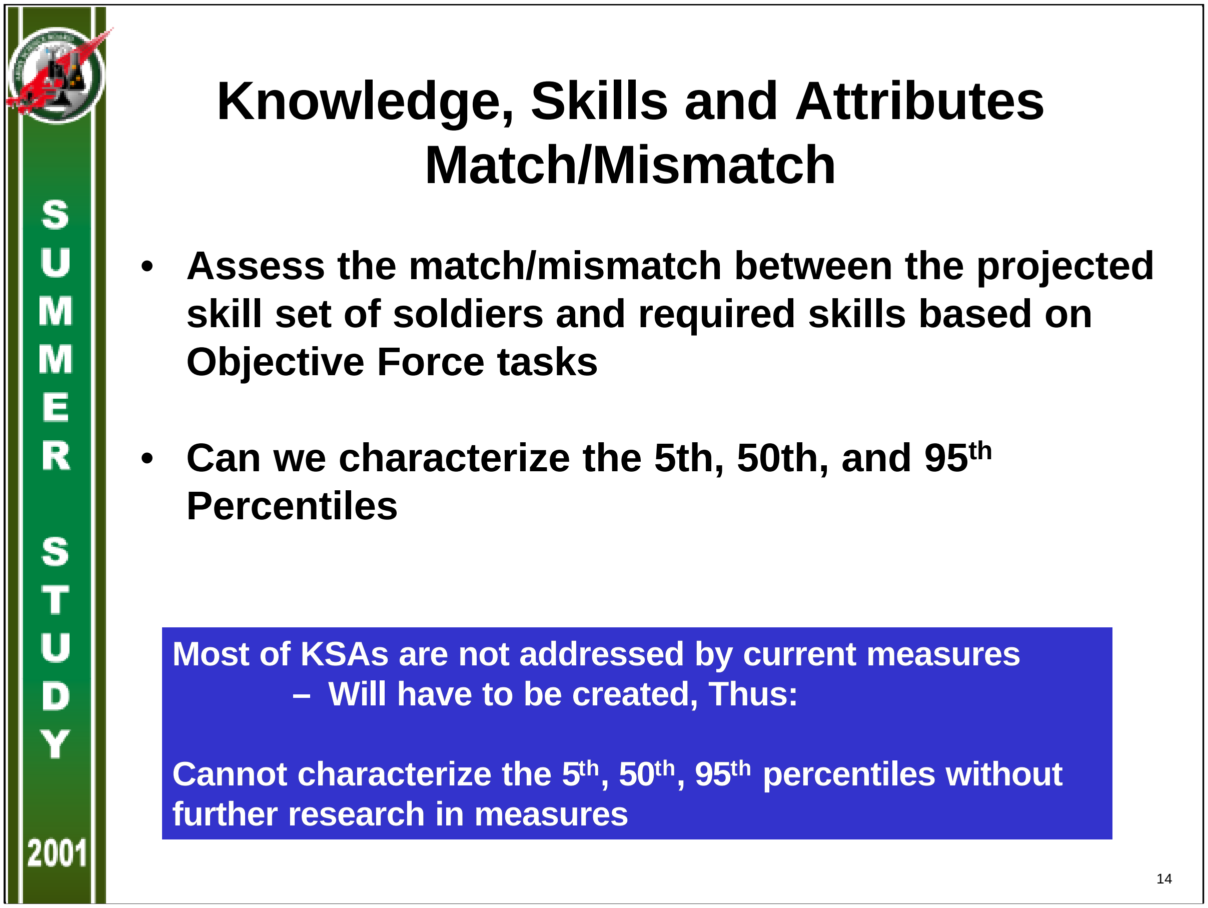
"Characteristic amount of behavioral self-control. The highly conscientious person is dependable, planful, well organized, and disciplined. This person prefers order and thinks before acting." Peterson, N. G. (ed.) (1987). Development and field test of the Trial Battery for Project A. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Pattern Recognition

"The ability to recognize and match visual patterns. (Auditory pattern recognition is the ability to recognize spoken words." The author goes on, using computer processes to explain this concept: "Pattern recognition basically works by having the computer seek out particular aspects of the character (assuming it's pattern recognition for reading words) and then having the computer compare what it finds to what's in its database of patterns." (Newton, H. (1996). Newton's Telecom Dictionary. New York: CMP Books, p. 517.)

Technological Fluency

The term "technological fluency". . . was generally described earlier by Papert (1996). . . . [O}ur definition [is] that technological fluency denotes an individual's well-developed skills, propensities, and knowledge that are required to use, design and develop electronic and bionic hardware and software to enhance various aspects of life. (Baker & O'Neil. (in press). Technological fluency: Needed skills for the future. In O'Neil & Perez (Eds.), Technology applications in education: A learning view. Mahwah, NJ: Erlbaum.)



The main utility of determining the knowledge, skills and attributes (KSAs) available in the projected recruit population and comparing them to KSAs required for FCS tasks/objective force soldiers was to highlight match/mismatch between the two. However, we found that most of the KSAs we projected are not addressed by current measurements. Further, we expect that KSAs for the National Guard and Army Reserves may be different, considering the limited time for training and the impact of a forgetting curve between training sessions.

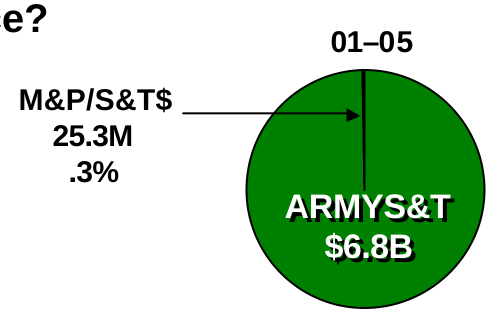
Therefore, we couldn't reliably determine match/mismatch, nor characterize the distribution of soldiers, with the required KSAs. This means appropriate measurements will have to be created, validated and implemented before characterization of the population or decisions on appropriate policies and treatments.

SUMMER STUDY 2001

Manpower & Personnel/ Science & Technology (TOR 3)

The question:

Is Manpower and Personnel S&T funding adequate to provide research-based tools, techniques, procedures and information needed to meet the soldier acquisition, assignment and sustainment requirements of the objective force?



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The current (FY2001) S&T Budget is approximately $1.3 Billion. Of this about $45M (or .03%) is allocated to personnel performance and human factors engineering research. If the “soldier is the centerpiece for Army Transformation” then the study team’s results question the adequacy of this allocation.

SUMMER STUDY 2001

Good News

- Manpower and Personnel R&D efforts (ongoing and planned) are solid but will not meet the needs of the Objective Force
- Time is available to conduct Manpower and Personnel R&D to meet the needs of the objective force — <u>must start now</u>
- There is sufficient basic research (6.1) to have confidence to conduct the applied R&D (6.2/6.3) — <u>no new breakthroughs required</u>
- Significant savings from timely investment can offset Manpower and Personnel R&D costs for the Objective Force

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The Special Study reviewed Manpower & Personnel research conducted at the Army Research Institute. The following Program Elements (PE) were reviewed: Manpower, Personnel and Training (62785) and Manpower Personnel and Training Advanced Technology (63007). Our judgment was that the ongoing and planned R&D efforts are solid and on-track.

The vast majority of the R&D efforts that we suggest require no new breakthroughs in basic behavioral social science research and technology. There is sufficient basic research (6.1) to have the confidence to conduct the applied R&D (6.2/6.3). The cycle time for such research is within the needed requirements if started ASAP.

Significant Cost Savings

- **Small changes lead to big savings due to size of manpower pool**
  - **Back of envelope calculation indicates potential 5 year savings of $180M if 5% cut in attrition rates**
    - * **Annual cost of attrition = $719,640,000**
      - **Number of accessions (71,749) X**
      - **attrition rate (.368) X**
      - **cost of each attrit ($27,255)**
    - * **5% reduction in attrition over POM = $180M**
      - **720M X 5% X 5yrs = $180M**
- **Additional advantages in improved readiness and combat effectiveness**

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The above data were provided by ARI. GAO testimony (2/24/2000) on the issue is consistent with these data.

Their summary indicated while many of their initiatives appear promising, the latest 4-year attrition data available, for those who entered the services in fiscal year 1994 and left by the end of fiscal year 1998, indicate that this rate continued to rise and currently is at an all-time DOD high of 36.9 percent.

Military Personnel: First Term Recruiting and Attrition Continue to Require Focused Attention. Statement for the Record of Norman J. Rabkin, Director, National Security Preparedness Issues, National Security and International Affairs Division (GAO/T-NSIAD-00-102). Released February 2000.

1The average cost of recruiting and training a soldier is approximately $27K. Does not include replacement costs. Costs are not net present value. A reduction of 5% in the attrition rate, using the FY98 accessions figures, would result in 1325 fewer attritees. Approach:

Step One: Calculate the number of soldiers who access each year, e.g., FY98 Accessions: 71, 749 (includes 66,442 non prior service accessions and 5,307 prior service accessions.

Step Two: Calculate the rate of attrition over a full term of service, e.g., Projected 36 month attrition rate for FY98 cohort: 36.8% (data from First Term Enlisted Attrition Council of Colonels Steering Committee, 28 April 1999, based on Feb 99 data).

Step Three: Calculate the cost of each attrit, e.g., recruiting cost: $16,644, Training costs:$10,611 (13,264 reduced by half the cost of attrition occurring during training) Total costs:$27,255 (includes average costs; does not account for additional marginal costs. Costs based on AMCOS data accessed in Dec 1998.

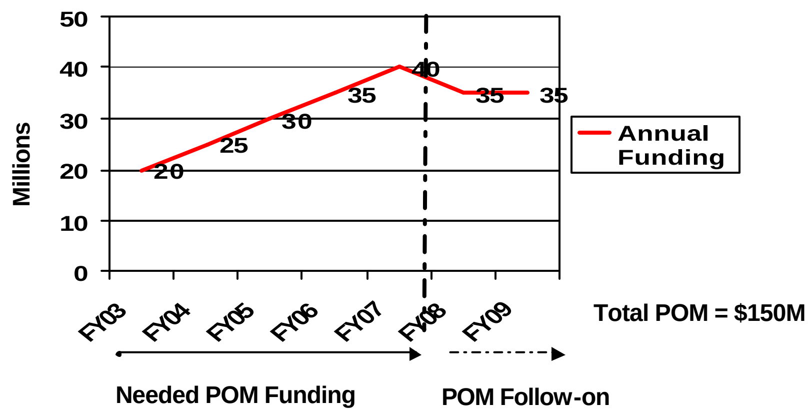
Step Four: Multiply number of accessions X attrition rate X cost of each attrit to get estimated annual costs associated with attrition, e.g., 71,749 X .368 X 27,255=$719,639,935.

Step Five: Estimate potential impact of 5% reduction, e.g., 718m X 5% X 5yrs.=175 m

SUMMER STUDY 2001

Bad News

- Little relevant 6.2/6.3 industry or academic research exists
- Lots of opinion but little hard data on what skills will be needed, how to best assign those recruited, and what factors will sustain
- Need to fund R&D — add an additional $150M in POM cycle



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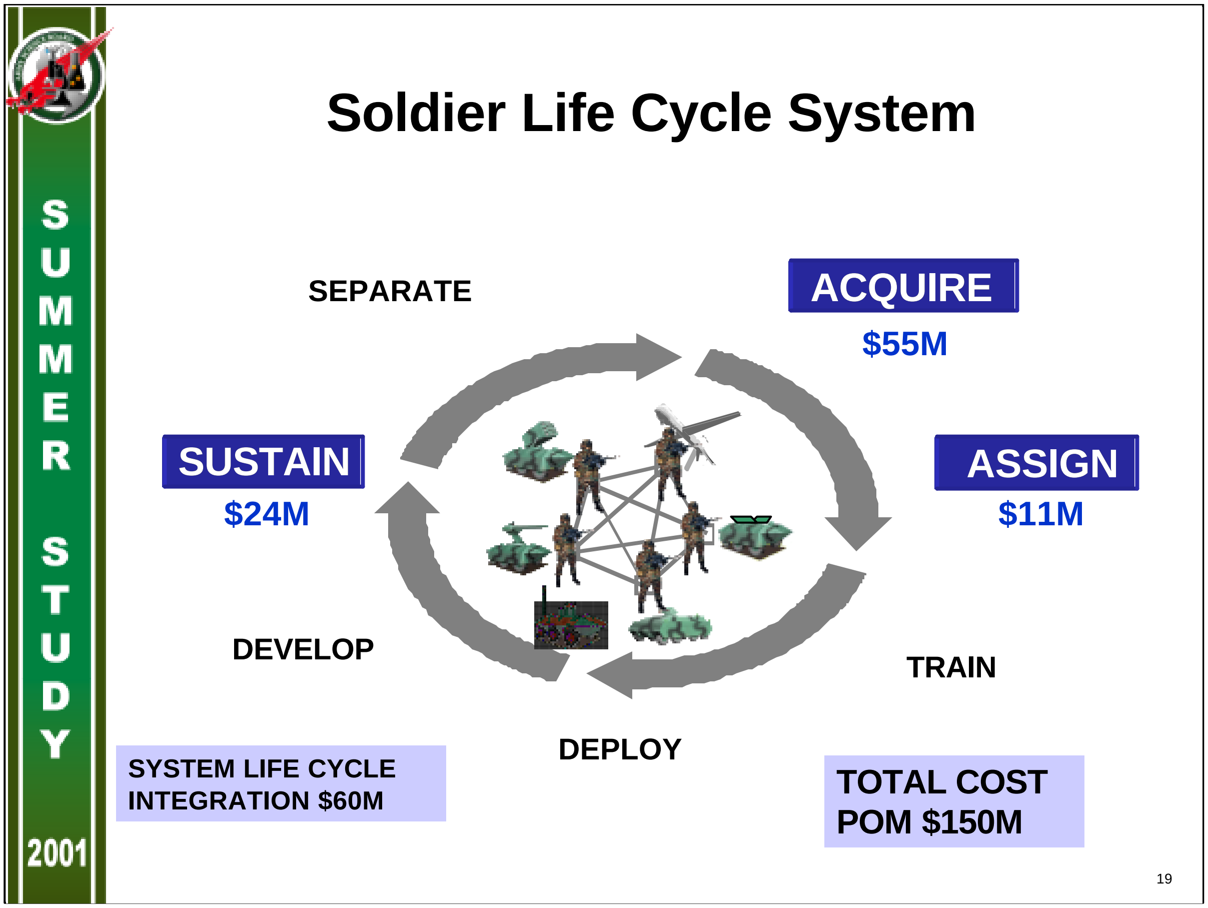
ARI has comprehensively reviewed over 400 available industry and academic research documents on future requirements. Almost no work was found that scientifically addressed the issues of future skills, future assignment or future sustainment. Neither the Air Force or the Navy is systematically addressing these questions. There is much speculation within the Army on future skill requirements. Research conducted by ARI is developing methods to quantify future skill requirements and has attempted to quantify the future skill requirements of NCOs. This work was restricted to NCOs, and then only generic NCO skills because of funding limitations. These methods will be refined in 02 to 05 to predict generic skills required for first tour Objective Force soldiers. Research beyond the current POM will focus on addressing future requirements for NCO's, Warrant Officers, and Officers across the Total Force.



Regarding the personnel life cycle functions, AR 600-3 (2.16) specifies the three functions our panel was concerned with (www.usapa.army.mil). Consistent with what the AR says, we know that acquire primarily relates to recruiting; assign matches faces to the spaces in the force structure; and sustainment relates to retentions efforts like quality of life and well being. We have adopted the Army ODCSPER's Soldier Life Cycle model for focusing R&D issues (ARI 2001 Work Program). This model, although slightly different in terminology and function, is consistent with the Army Regulation. In our graphic, ACQUIRE is consistent with Acquisition in the regulation, ASSIGN is consistent with Distribution in the regulation, and SUSTAIN is consistent with Sustainment in the regulation.

SUMMER STUDY 2001

To Improve Objective Force Life-Cycle Processes

- **Improve Acquisition, Recruitment & Assignment Process - $55M**
  - Revise ASVAB
  - Test youth population on very complex tasks
  - Determine Cultural Characteristics of Hispanics to Improve Process
- **Improve Assignment Process - $11M**
- **Improve Sustainment & Retention Process - $24M**
  - Cost Effectiveness of Well-Being Factors
  - Trust in Robots

POM Increase = $90M

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•To Improve the Objective Force Acquisition/Recruitment Process

Create and validate new selection measure ($50M)

Validate skills required by Objective Force

Leader tasks vs. soldier tasks

Test youth population on very complex tasks

Revise and validate ASVAB

Develop performance assessment measures (e.g., SQT/ARTEP)

Determine the cultural characteristics of Latinos that would improve ACQUIRE/ASSIGN process ($5M)

Possible action agency ARI

POM increase = $55M for ACQUIRE R&D

•To Improve the Assignment Process

Match Knowledge, Skills and Attributes of available Objective Force soldiers to available Objective Force jobs

Use new assignment process with existing ASVAB ($10M)

Use new assignment process with revised ASVAB, e.g., simulation ($1M)

Possible action agency ARI

POM increase = $11M for ASSIGN R&D

•To Improve the Sustainment/
Retention Process

Validate cost-effectiveness for alternative well-being factors ($15M)

Determine how educational opportunities provided by the Army impact the skill level, commitment, and attrition of the force

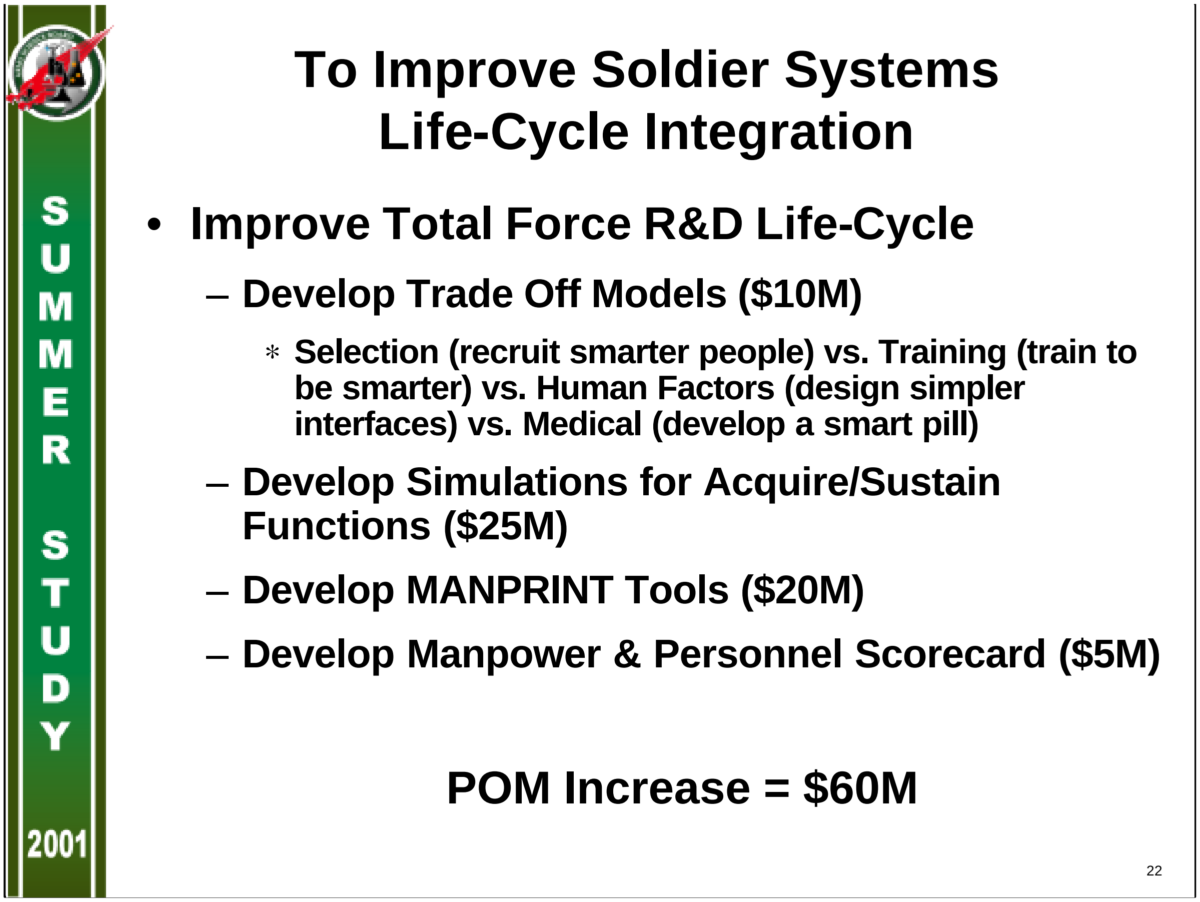
Validate motivation measures for distance learning ($5M)

Establish factors needed to trust in robots/ automation ($3M)

Examine how the changing ethnic and gender composition impacts outcomes important to the Army (e.g., cohesion, cultural tolerance, attrition) (1M)

Possible action agency ARI

POM increase = $24M for SUSTAIN R&D



To Improve Total Soldier
Life-Cycle for Objective Force

Develop trade-off models: Selection (recruit smarter people) vs. Training (train to be smarter) vs. Human Factors (design simpler interfaces) vs. Medical (develop a smart pill) ($10M)

Possible action agency ARI

Develop virtual, distributed, man-in-loop simulations for ACQUIRE, ASSIGN, and SUSTAIN functions ($25M)

Possible action agency STRICOM

Develop/refine “system of systems” MANPRINT tools ($20M)

Possible action agency Human Research and Engineering Directorate, AMC

Develop manpower and personnel scorecard ($5M)

Possible action agency ARI

POM increase = $60M for TOTAL LIFE CYCLE R&D

SUMMER STUDY 2001

Immediate Actions

- Continue to recruit persons who attend college but who will not graduate
- Make MANPRINT factors mandatory for evaluation in Objective Force acquisition
  - Rand Study
- Continue to foster cooperative agreements between AMC and ODCSPER
- Impact is immediate.

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1 Personal communication, Martin Orland, email. 3/30/01

2 Currently, MANPRINT is an optional program. It should be made mandatory with resources added to accomplish policy and oversight. RAND briefing 3 April 01.

3 AMC and DCSPER or HR/Personnel Mission Area do not have cooperative agreements to support the personnel info technology R&D, modernization, or recapitalization. This is a void in AMCs Army support structure. The Personnel community (Guard, Reserve, and Active) gets minimal benefit from AMC wide software management efforts. AMC has programs to support the Commander, S2-G2, S3-G3, S4-G4, Fire Support (FA and Air Defense), all maneuver, and most classes of supply (repair parts, ammo, fuel, etc). There is no AMC program to benefit the S1-G1. Given transformation, it is time to fix this condition.

SUMMER STUDY 2001

What We Want You To Remember

- **Objective Force will require soldiers with different Knowledge, Skills and Attributes due to very complex tasks at lower echelons**
- **Present R&D does not provide the foundation for Manpower & Personnel**
- ***Adequately funding and focusing Manpower and Personnel R&D investment will enable the Objective Force***

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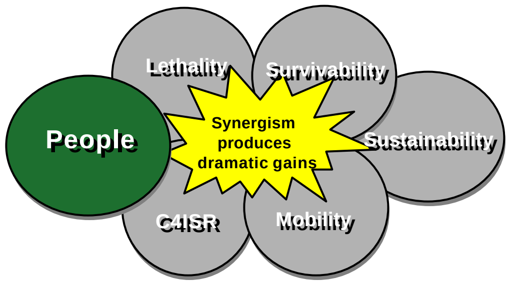
Given the nature of the FCS, it is expected that different personnel knowledge, skills and attributes (KSAs) will be needed. Given the very low levels of R&D funding in Manpower & Personnel, there is no foundation for such a force. Without an infusion of R&D funds now, the Army will not be ready for the FCS. The funding estimates represent our expert judgment of what the type of research we suggest will cost. They are probably accurate within 10-20%.

This R&D investment will enable accomplishment of FCS, improve readiness and combat effectiveness. We must invest in people.

Bottom Line

- **Adequately fund Manpower & Personnel research ($150M short over POM cycle)**



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Army Science Board
2001 Summer Study

Objective Force
Soldier / Marine Team

GEN Wayne Downing, USA Retired

SUMMER STUDY 2001

Observations

- What is the Vision for the Dismounted Soldier/Marine?
- ASB Postulates:
  - 10X effectiveness improvements through preliminary goals for:
    - ∗Lethality
    - ∗Survivability
    - ∗C4ISR
    - ∗Mobility
    - ∗Sustainability
    - ∗Affordability

Observations

- **The dismounted Warrior is grossly overloaded—and, the Army appears to accept those loads. Needed:**
  - **A logistics system to Unit of Action that works**
  - **Command discipline and control**
  - **Lighter weapons, ammunition, equipment, and body armor**
  - **Exoskeletal assist**
  - **Water purification systems**
  - ***Centralized Management of Soldier Systems***

Observations

- **Urban Combat**
  - Cannot pick your battlefield
  - Be prepared to fight there
  - Situational Awareness particularly challenging
- **Training -- the "glue" that holds the unit together in peace and war**
  - Embedded training devices affordable and offer great gains but are usually the first thing cut in systems fielding
  - Simulations promising
  - Full-up, full mission profile training on instrumented areas against a realistic opponent will always be required

SUMMER STUDY 2001

Observations

- These technologies are affordable
  - Identify and manage the cost drivers
  - Share FCS technology development
  - Appoint a single manager for Soldier Systems
  - Look for economies in the total Army structure
  - Continue to work Congressional and industry sponsors

Observations

- **People—Always the Key; and equip them with the best technology available**
  - **Consider SOF tools for identification, assessment & selection, training, retaining**
  - **Technological advances warrant a fresh look at:**
    - ∗**Leader/Led ratios**
    - ∗**Hierarchy of tactical formations**
  - **Don't underestimate the ability of a military organization to absorb diverse people**
    - ∗**Discipline**
    - ∗**Standards**
    - ∗**Cohesion**
    - ∗**Morale**
    - ∗**Performance**

Observations

- **The Dismounted Warrior has an enduring role in future military operations**
  - **D-T-L-O-M-S will mandate changes**
  - **The Army will take and hold 'dirt'; control people and critical resources**
  - **Close combat will always be a possibility**
  - **S&T cannot create a risk free environment**

APPENDIX A

TERMS OF REFERENCE

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY
ACQUISITION LOGISTICS AND TECHNOLOGY
103 ARMY PENTAGON
WASHINGTON DC 20310-0103

REPLY TO
ATTENTION OF

December 28, 2000

Mr. Michael Bayer
Chairman, Army Science Board
2511 Jefferson Davis Highway, Suite 11500
Arlington, Virginia 22202

Dear Mr. Bayer:

I request that the Army Science Board (ASB) conduct a study on "Objective Force Soldier/Soldier Teams" in line with recent ASB studies that support Army transformation toward the Objective Force. The study should address, but is not limited to, the Terms of Reference (TOR) Described below. Appointed ASB members to this study are to consider the TOR as guide lines and may expand the study to issues considered important to the study. Modifications to the TOR must be addressed with the Chairman of the ASB.

Background:

a. Deployment of forces to Southwest Asia, Bosnia, Kosovo and Somalia demonstrated the growing need for a strategically deployable, medium-weight force that is mobile and as survivable and lethal as current Heavy Forces.. Future adversaries are expected to use urban and complex terrain, state-of-the-art commercial technology, human shields and asymmetric means to mitigate U.S. military strengths. The medium weight Objective Force must be capable of deploying and fighting in situations where it is outnumbered and facing a technologically laden threat. Moreover, soldiers will more likely fight dismounted from their platforms in the streets and alleyways of urban complexes. Strict rules of engagement will dictate that targets are clearly identified and that collateral damage is minimized. Soldiers of the Army's Objective Force, enabled by a network-centric suite of manned and unmanned ground and air platforms, robust C4ISR and non-lethal means, must be able to fight, survive and win in those environments.

b. I envisage that this study will provide practical insights into current and future science and technology opportunities that will assist Army Leadership prioritize research, development and acquisition in order to yield dramatic improvements in Objective Force Soldier lethality, survivability, supportability and situational awareness. The study will examine those technologies that will enable the mounted and dismounted Soldier to fight within a network-centric, system-of-systems across the full spectrum of operations. Military operations in urban and complex terrain will be addressed as part of the study

TOR: The study should be guided by, but not limited to the following TOR.

(1) Characterize the level and nature of lethality, survivability, logistical and information systems for command, control, communications and computer improvements that must be achieved to yield a more effective Objective Force Soldier across the operational spectrum. Evaluate connectivity/interface between Future Combat System variants and the Objective Force Soldier.

(2) Map the technology from present to future that would obtain the improvements as described above.

(3) Include in the technology roadmap an assessment of current and projected Research Development and Acquisition efforts. Highlight those areas where modest investments now may yield significant capabilities in soldier effectiveness, weight reduction, power efficiency and affordability of soldier systems.

(4) Recommend alternative science and technology strategies that can provide the level of improvements outlined above. Stratify the level of cost, technical and schedule risk associated with each alternative. Address emerging technologies from academia, industry and other government agencies.

Study Sponsorship: Co-Sponsors for this study will be Vice Chief of Staff; Army; Assistant Secretary of the Army, Acquisition, Logistics and Technology; Deputy Chief of Staff for Operations and Plans; Deputy Chief of Staff for Programs; Deputy Chief of Staff for Logistics; Deputy Chief of Staff for Intelligence; Director, Information Systems for Command, Control, Communications and Computers; Commander, United States Army Training and Doctrine Command; and United States Army Materiel Command.

Study Duration: The study shall be completed by July 31, 2001.

Sincerely,

Paul J. Hoeper
Paul J. Hoeper
Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

APPENDIX B

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PARTICIPANTS LIST

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2001 SUMMER STUDY

THE OBJECTIVE FORCE SOLDIER / SOLDIER TEAM

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The Analysis Panel
Mr. Ed Brady
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The Weight Panel

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The Conceptual Framework Panel
LTG Charles Otstott (USA, Ret.)
Global Infotek , Inc.

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Mr. Srinivasan (Raj) Rajagopal
United Defense L.P.

The Power System Technologies Panel
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Sandia National Laboratories

Dr. James Sarjeant
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The S&T Investment Strategy Panel

Mr. Herb Gallagher
Computer Sciences Corporation

Senior Officer Observations
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* The Manpower and Personnel Study was conducted as an independent Special Study and then integrated into this study.

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2001 SPECIAL STUDY

MANPOWER AND PERSONNEL FOR SOLDIER SYSTEMS IN THE OBJECTIVE FORCE

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APPENDIX C

ACRONYMS

AAA	Anti-Aircraft Artillery
ACTD	Advanced Concept Technology Demonstration
AFQT	Armed Forces Qualification Test
AMC	Army Materiel Command
APM	Acquisition Program Manager
ARL	Army Research Laboratory
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics and Technology
ASVAB	Armed Services Vocational Aptitude Battery
ATCOM	Army Aviation and Troop Command
ATD	Advanced Technology Demonstration
BBN	BBN Technologies (sniper detection system; Bolt, Beranek, Newman)
BDA	Battle Damage Assessment
BLOS	Beyond Line of Sight
BN	Battalion
C2	Command and Control
C3D2	Cover, Concealment, Camouflage, Denial and Deception
C4ISR	Command, Control, Communications, Computers, Information, Surveillance and Reconnaissance
CAIV	Cost as an Independent Variable
CENTCOM	Central Command
CIDDS	Combat Identification Dismounted Soldiers
CL-20	An explosive/propellant material
COA	Course of Action
COP	Common Operational Picture
COTS	Commercial-off-the-Shelf
CSA	Chief of Staff, Army
DA	Department of the Army
DARPA	Defense Advanced Research Projects Agency
DISC4	Director of Information Systems for Command, Control, Communications, and Computers
DISIM	Dismounted Infantry Simulator
DTLOMS	Doctrine, Training, Leader Development, Organization, Materiel, and Soldiers
EPA	Extended Planning Annex
ESM	Electronic Support Measures
EW	Electronic Warfare
FCS	Future Combat System
FUE	First Unit Equipped
GFE	Government Furnished Equipment
GPS	Global Positioning System
GSR	Ground Surveillance Radar
HW/SW	Hardware/Software
IBCTs	Interim Brigade Combat Teams

ICBM	InterContinental Ballistic Missile
IDA	Institute for Defense Analyses
IDF	Indirect Fire Links
IFFN	Identification Friend, Foe, Neutral
IPB	Intelligence Preparation of the Battlefield
IR	Infrared
IRT	Independent Review Team
ITEMS	Imaging Technologies and Evolving Management Systems; Interactive Tactical Environment Management System
IW	Information Warfare
JANUS	an interactive, event-driven wargaming simulation
JCATS	Joint Conflict and Tactical Simulation
JFCOM	Joint Forces Command
JP8	Jet Propellant 8
JRTC	Joint Readiness Training Center
JSAF	Joint Semi-Automated Forces
JSOC	Joint Special Operations Command
LAM	Loitering Attack Munition
LAV	Light Armored Vehicle
LCDW	Low Collateral Damage Weapon
LLNL	Lawrence Livermore National Laboratories
LLL TV	Low-light level tv
LOS	Line of Sight
LRF	Laser Range Finder
LRRP	Long-Range Reconnaissance Patrol
LRU	Line Replaceable Unit
LW	Land Warrior
M&S	Modeling and Simulation
MANA	
MANPRINT	Manpower and Personnel Integration
MEU	Marine Expeditionary Unit
MILES 2000	Multiple Integrated Laser Engagement
MM&T	manufacturing methods and technology
MOUT	Military Operations in Urban Terrain
MTBF	Mean Time Between Failure
MTBR	Mean Time Between Repair
NAEP	National Assessment of Educational Progress
NAVSPECWARCOM	Naval Special Warfare Command
NSC	National Security Council
NVL-11	A computerized fire control night sight for Anti-Tank weapons
NWARS	National Wargaming System
O&O	operational and organizational
ODCSPER	Office of the Deputy Chief of Staff for Personnel
OF	Objective Force
OFW	Objective Force Warrior

OICW	Objective Individual Combat Weapon
ORD	Operational Requirements Document
OTB	Onesaf Testbed Baseline
PGM	Precision Guided Munition
PM	Program Manager
POM	Program Objective Memorandum
PTN	Paint the Night
R&D	Research and Development
RAND	
RDA	Research, Development and Acquisition
RPG	Rocket Propelled Grenade
RPK	squad machine gun
RPO-A	A Thermobaric Munition, Russian
S&T	Science and Technology
SASO	Stability and Support Operations
SBCCOM	US Army Soldier and Biological Chemical Command
SDD	
SMART	Susceptibility Model Assessment and Range Test
SNL	Sandia National Laboratories
SOCOM	Special Operations Command
T&E	Test and Evaluation
TOR	Terms of Reference
TRADOC	Training and Doctrine Command
TRL	Technology Readiness Level
TSM	TRADOC system manager
TTP	Tactics, Techniques and Procedures
TWS	Thermal Weapons Sight
UAV	Unmanned Aerial Vehicle
UGS	unattended ground sensors
UGV	Unmanned Ground Vehicle
USA	United States Army
USASOC	United States Army Special Operations Command
USMA	Unites States Military Academy
USMC	United States Marine Corps
WMD	weapons of mass destruction

APPENDIX D

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