Assessing C3I in Support of Dismounted Operations In Complex Terrain

Track C2 Assessment Tools and Metrics

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Abstract

The assessment of dismounted operations in complex terrain remains one of the most challenging problems for the military analysis community. Recently, a study was performed by the US Army Science Board to identify the operational capabilities that were needed to enhance the effectiveness of these operations, with emphasis on C3I.

To establish a context for the study, an extensive data mining activity was undertaken to identify the key issues and to formulate preliminary insights. This activity focused on "lessons learned" reports from actual operations and after action reports from recent experiments. In the former category, C3I lessons recorded (if not learned) were identified in the Handbook for Joint Urban Operations (reference 1). As an illustration, based on an assessment of the Russian experience in Chechnya, it was concluded that "The command and control structure needs to be able to adapt to the urban environment where communication may be difficult." Similarly, in the area of experimentation, the USMC's experiences in Project Metropolis (reference 2) revealed shortfalls in communications at the lowest tactical levels (e.g., platoon commander and squad leader). Based on the results of this data mining, several vignettes were selected that spanned an interesting set of levels of conflict and environmental conditions. Three of these vignettes were selected to illuminate selected C3I issues: a reverse slope, treeline attack against a well-protected squad in rugged terrain; floor clearing operations in a building; and humanitarian assistance in a small village.

• Treeline Attack Scenario. JANUS was used to assess the effectiveness of C3I-weapons system mixes in the treeline attack mission. Loss Exchange Ratios (LERs) were employed as the primary measure of merit. The assessment revealed that *individual* improvements in weapons systems (e.g., introduction of the Objective Individual Combat Weapon (OICW), enhanced indirect fire support), soldier technologies (e.g., reduced signature, body armor), C3I (e.g., enhanced collaboration, improved situational awareness) or tactics, techniques and procedures (e.g., use of smoke), had relatively minor impact on the effectiveness of Blue forces. However, when *mixes* of these enhancements were employed (e.g., improved situational awareness, introduction of the OICW, coordinated use of precise indirect fire, and introduction of body armor), very substantial enhancements in LERs were achievable.

• Clearing Operations in a Building. The Joint Conflict and Tactical Simulation (JCATS) was employed to assess the impact of squad-level radios on combat effectiveness at the platoon level. The analysis focused on floor-clearing in high rise buildings against a spectrum of adversary threats. Two communications cases were considered: baseline (i.e., no radios) and upper bound ("perfect" communications). It was concluded that "perfect" communications would afford the greatest enhancement in operational effectiveness against the medium Red force level (i.e., a 274% improvement in LER over the base case). This improvement was attributable largely to reductions in Blue loses.

• Humanitarian Operations in a Small Village. MANA, an agent based model, was employed to assess tactics, techniques, and procedures (TTPs) for distributing humanitarian aid while minimizing the risk of casualties to Blue forces. The assessment considered alternative Blue force sizes, differing numbers of humanitarian distribution points, and the use of a light armored vehicle (LAV). For the cases considered the mean number of Blue casualties ranged from 0.8 (for a Blue force size of 15, three distribution points, and the use of a LAV) to 4.6 (for a Blue force size of 5, three distribution points, and no LAV). The tool can be viewed as a potential decision aid that would enable the on-scene commander to assess the risks associated with alternative TTPs.

The paper concludes by recommending several initiatives to enhance assessment tools and capabilities to perform future assessments of dismounted operations in complex terrain.

A. Introduction

The assessment of dismounted operations in complex terrain remains one of the most challenging problems for the military analysis community. Recently, a study was performed by the US Army Science Board to identify the operational capabilities that were needed to enhance the effectiveness of these operations, with emphasis on C3I. The paper focuses on a sub-set of the findings and recommendations of that study. First, it summarizes the results of the study's data mining activities. Second, it discusses the results from three analyses: small unit treeline attack in complex terrain, floor clearing operations in a building, and humanitarian assistance in a small village. Third, it identifies and discusses key capabilities that have the potential for transforming dismounted warfare in the next ten years. Finally it summarizes the major results of the study and discusses the need for future tools to explore these issues further.

B. Data Mining Results

To establish a context for the study, an extensive data mining activity was undertaken to identify the key issues and to formulate preliminary insights. This activity focused on "lessons learned" reports from actual operations and after action reports from recent experiments. In the former category, C3I lessons recorded (if not learned) were identified in the Handbook for Joint Urban Operations (Reference 1). In that Handbook, 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 crosscutting 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." Clearly, that lesson has been revalidated by recent operations in Afghanistan.

In addition, interesting lessons were derived from USMC Project Metropolis, a multi year effort focused on military operations in urban terrain (MOUT). They found that training was one of the most important aspects of MOUT. They concluded (Reference 2) 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. <u>This can be overcome with better, more focused training.</u>" [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 2). 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. Moreover, they concluded that communications at the lowest tactical level (i.e., platoon commander and squad leader) is deficient and that this shortfall impedes operational effectiveness. 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).

C. Analyses

Based on the results of this data mining, several vignettes were selected that spanned an interesting set of levels of conflict and environmental conditions. Three of these vignettes were selected to illuminate selected C3I issues: a reverse slope, treeline attack against a well-protected squad in rugged terrain; floor clearing operations in a building; and humanitarian assistance in a small village.

C.1 Treeline Attack in Complex Terrain

Figure 1 depicts a JANUS screen for a Kosovo scenario in which a treeline attack is conducted in complex terrain. 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 data to understand properly the interactions at the individual soldier level. Since Digital Terrain Elevation Data (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.

Tool -- JANUS

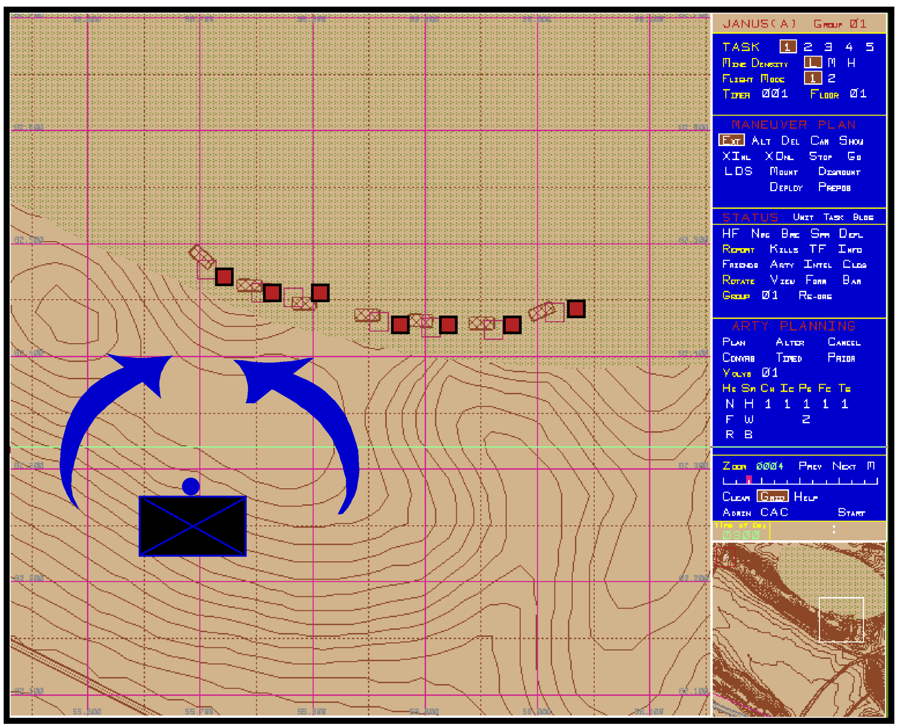

Figure 1. Kosovo Treeline Attack Scenario

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 defillade, with good lines of fire. It was assumed that Red does not have mines or unmanned airborne vehicles (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 (LER) 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.

Subsequently, several additional options were assessed, *one at a time:* smoke, Objective Individual Combat Weapon (OICW), body armor, signature reduction, and indirect fire support (IDF). As can be seen in Figure 2, several of these options provided modest improvement (notably the OICW). Note, in particular, that the addition of smoke actually reduced effectiveness because it resulted in shorter range, more lethal engagements for Red.

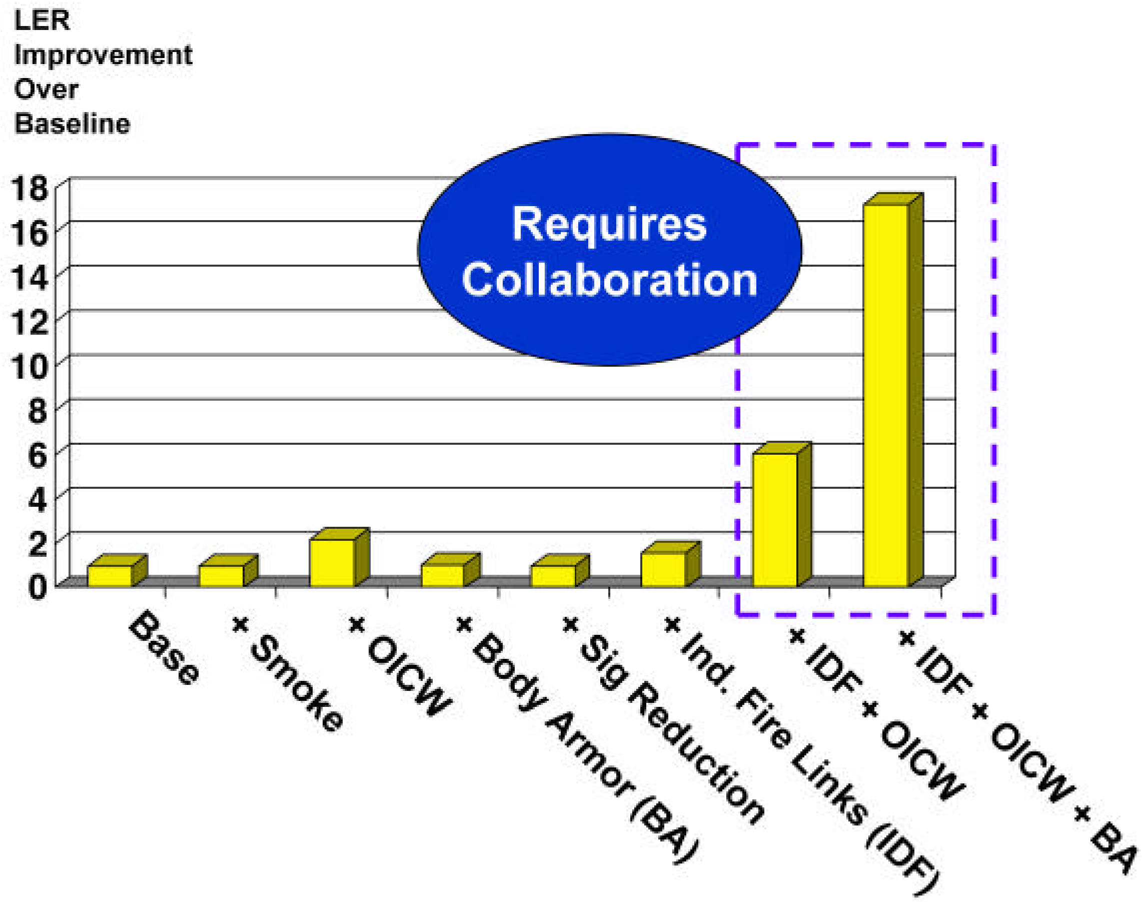

Figure 2. Treeline Attack Effectiveness for Alternative Configurations

The next phase of the analysis 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 body armor was added to the mix there was 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. In order to conduct this type of activity you need the ability to communicate and collaborate effectively amongst the Blue forces.

These analyses suggest that there is a substantial potential for synergy among materiel and tactical options if they are implemented in a synchronized fashion. However, it must be anticipated that Red will attempt to modify its concepts of operations to counter these actions. Thus, additional analyses are required to explore the potential interactions among Red and Blue countermeasures.

Based on these analyses, several conclusions are emerging. First, it is concluded that the Objective Force Warrior 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 Force Warrior 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, side excursions revealed that robotic "junkyard dogs" (i.e., small unattended ground vehicles equipped with an effective sensor and weapon) can provide a substantial enhancement in LER and Blue survivability. As an excursion, analyses were performed with a Baseline force augmented with six “junkyard dogs”. 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. However, five of the six "junkyard dogs" were killed in the engagement.

In summary, 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.

C.2 Floor Clearing Operations in a Building

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.

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 materiel levels associated with those threat levels are summarized in Figure 3.

	RPK-74	AK-74	RPG-7V
Light	1	2	-
Medium	1	4	-
Heavy	1	6	1

Figure 3. Alternative Red Threat Levels in Floor-Clearing Analysis

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, the Joint Conflict and Tactical Simulation (JCATS), subject matter experts, and man-in-the-loop simulation techniques were employed and orchestrated.

Figure 4 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.

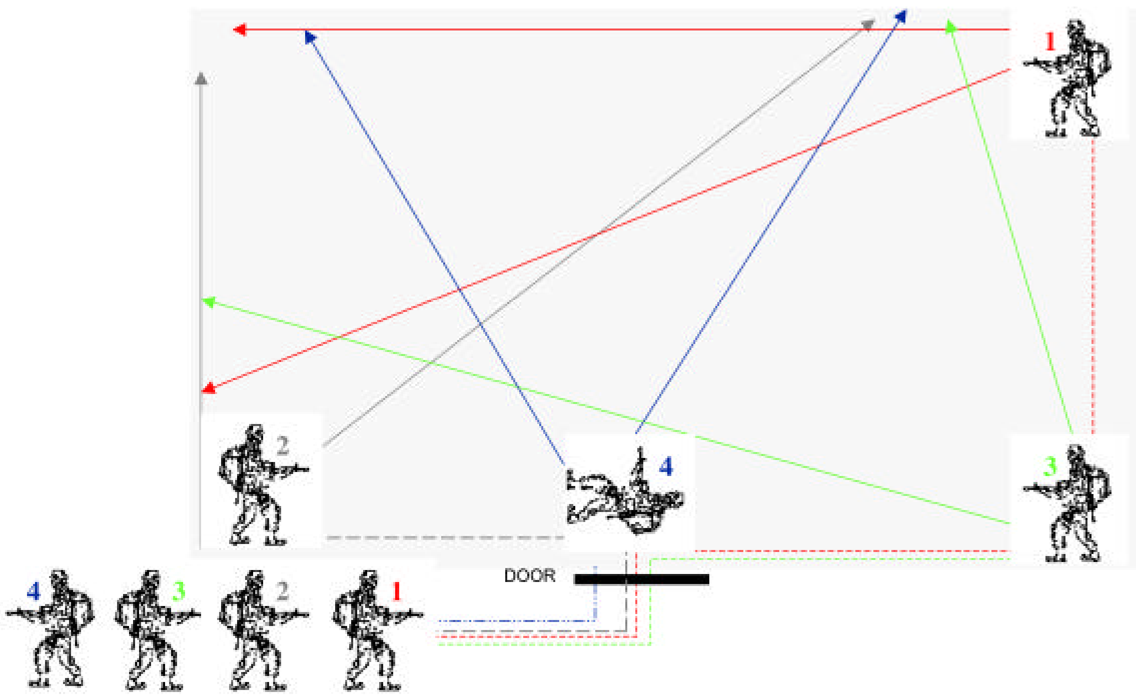

Figure 4. Room Clearing Tactics, Techniques and Procedures (TTPs)

Figure 5 summarizes the difference in LERs that were observed for the three different Red Force levels. This perspective highlights two key observations. First, the estimated

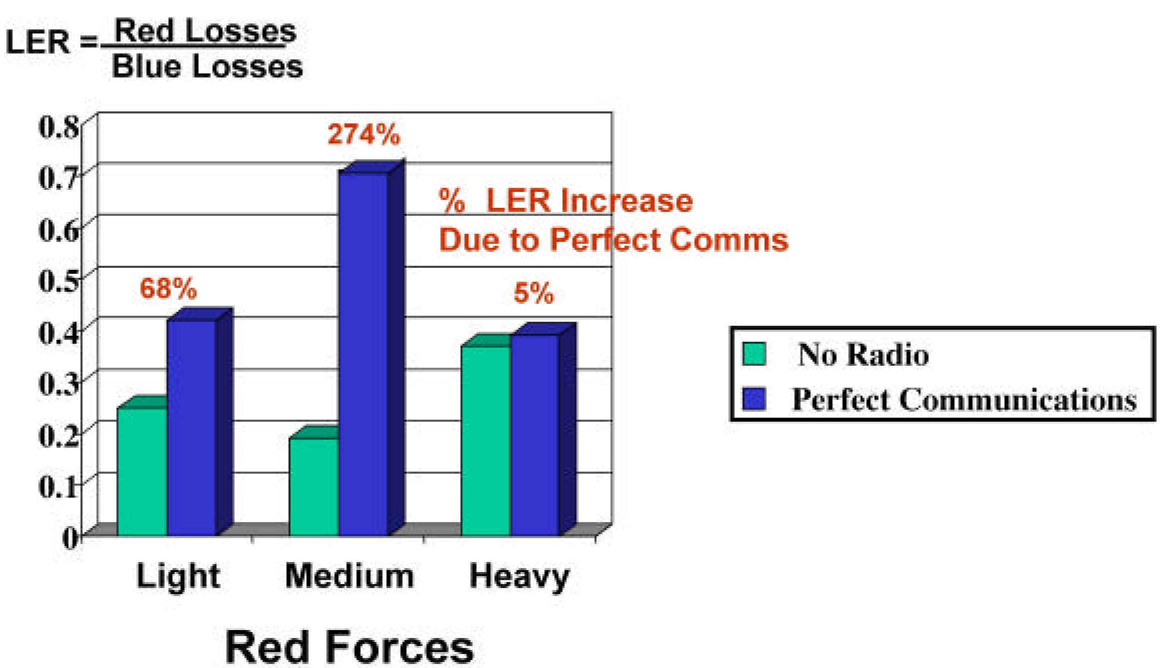

Figure 5. Impact of Communications on Floor Clearing Effectiveness

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 operationally feasible 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.

C. 3 Humanitarian Assistance in a Small Village

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 Defense 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.

Figure 6 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

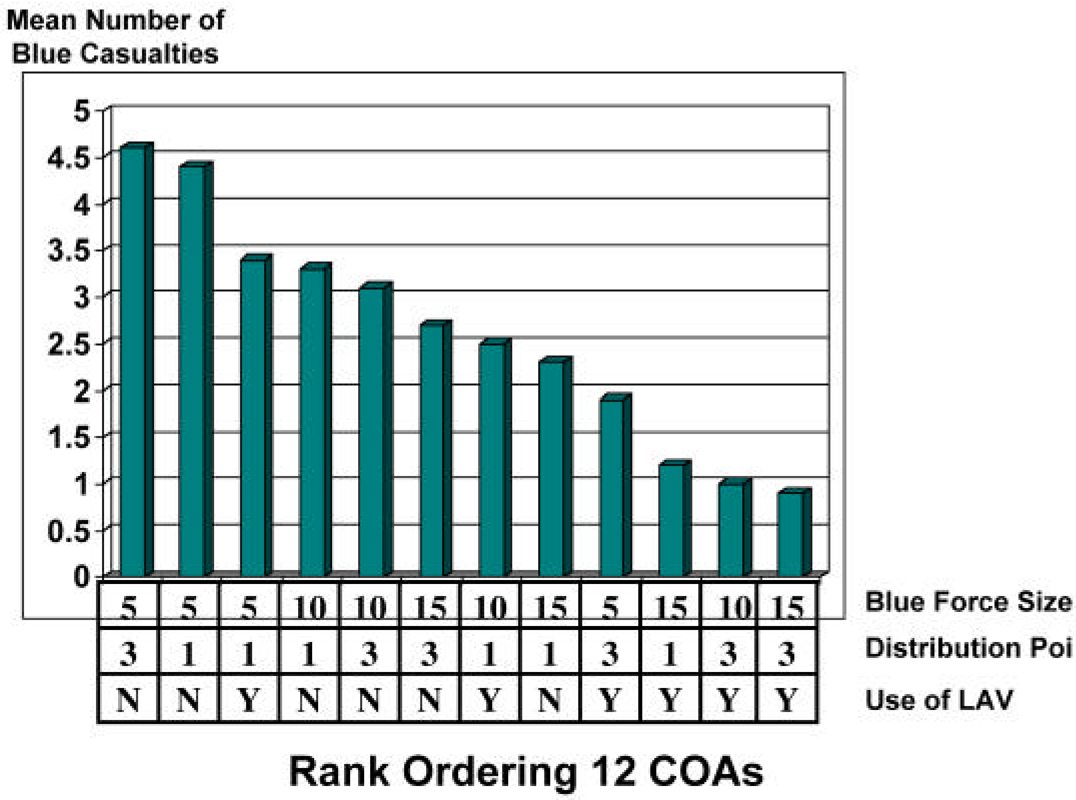

Figure 6.Course of Action Analysis Using MANA

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.

C.4 Key Capabilities Identified Through Analyses

The analyses suggest that there are several capabilities that have the potential for transforming dismounted warfare in the next ten years (Figure 7). However, these capabilities show major gains primarily through synergistic application. Therefore, it is concluded 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.

• **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

Figure 7. Key Capabilities for the Objective Force Warrior (Transformative)

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 Objective Force Warrior (e.g., data on time critical targets). Mechanisms must be established to ensure that the Objective Force Warrior 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.

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 (Reference 3).

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 Objective Force Warrior, 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 (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 Objective Force Warrior to support tactical psychological operations.
• 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.
• 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 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 Objective Force Warrior 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.

D. Summary

The 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 suffice. The 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. The 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, supported by a robust situation awareness capability, while the contributions of individual improvements in isolation were modest.

In addition, the assessments demonstrated that the effectiveness of many candidate options is a strong function of the assumed scenario. As an 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.

In performing the assessments summarized in this report, existing assessment tools (e.g., JCATS, JANUS) were found to be very cumbersome and inflexible. Since these tools are the basis for assessing dismounted operations in complex terrain 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.

E. References

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F. Acknowledgements

The analyses of the treeline attack in complex terrain were performed by Randy Steeb and John Matsamura of the RAND Corporation. The analysis of floor clearing in a building was originally performed in support of the MOUT ACTD by the Simulation Center of the Dismounted Battlespace Battle Lab (DBBL). IDA supported the effort by providing oversight, and analyzing and integrating the results. The analyses of humanitarian operations in a small village were performed by Sarah Johnson, MITRE, in support of a combined US-German-New Zealand assessment.