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Re-Assessing Dismounted Operations in Complex Terrain using the NATO CoBP for C2 Assessment

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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 U.S. Army Science Board to identify the operational capabilities that were needed to enhance the effectiveness of these operations, with emphasis on C4ISR. This paper uses the NATO Code of Best Practice (CoBP) for C2 Assessment to characterize the key attributes of that study and to highlight its findings.

To establish a context for the study, an extensive data mining activity was undertaken to clarify the key issues and to identify preliminary insights. This activity focused on "lessons learned" reports from actual operations and after action reports from recent experiments. Based on the results of this data mining, a set of five vignettes was selected that spanned an interesting set of levels of conflict and environmental conditions (e.g., a reverse slope, treeline attack in rugged terrain; defense of a convoy against an ambush in an urban environment; use of low collateral damage weapon technologies in complex terrain; floor clearing operations in a building; humanitarian assistance in a small village). In several of these scenarios, consideration was given to human performance and behavior (e.g., speed at which individuals could move over rugged terrain when wearing loads of specified weight). In many of these scenarios, loss exchange ratios provided the greatest insight into the impact of proposed changes in systems, tactics, techniques, and procedures on force effectiveness.

One of the key study challenges involved the acquisition of data of sufficient resolution (e.g., on the order of 1 meter, consistent with Digital Terrain Elevation Data (DTED) level V). These data were employed using a variety of assessment tools. These included several constructive simulations (e.g., JANUS, Joint Conflict and Tactical Simulation (JCATS)) and an agent based model (MANA). These tools proved adequate to provide preliminary assessments of the measures of merit (MoM) of interest. In all cases, variations around the baseline were assessed to determine the sensitivity of the results. In addition, by exercising MANA, the agent based model, it proved feasible to compute cumulative probability distribution functions of the key MoM (Blue losses) to facilitate the sensitivity assessment.

The major product of the assessment was the identification of key technological and operational capabilities that have the potential for transforming dismounted operations in complex terrain. It is notable that the majority of these transformative capabilities involve C4ISR (e.g., intelligence preparation of the battlefield for complex terrain). The paper also identifies recommended initiatives to enhance the assessment tools and

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capabilities (to include virtual and live M&S) to perform enhanced future assessments of dismounted operations in complex terrain.

1.0 PROBLEM FORMULATION

This paper is based on work that the Analysis Panel performed in support of the U.S. Army Science Board (ASB) 2001 Summer Study on the Objective Force Soldier/Marine Team. The focus of this activity was on dismounted operations in complex terrain.

The Terms of Reference (ToR) for the 2001 ASB Summer Study called out four major objectives:

- Characterize improvements in lethality, survivability, C4ISR, and logistics required to yield a more effective Objective Force Soldier/Marine Team across the operational spectrum.
- Evaluate connectivity between the Future Combat System (FCS) and the Objective Force Soldier/Marine Team.
- Assess current and projected research, development, and acquisition efforts. Focus on effectiveness, weight reduction, power, and affordability.
- Recommend alternative Science & Technology investment strategies and map the technological advances from present to future.

As a benchmark, the Summer Study sought to identify Science & Technology initiatives that, cumulatively, would enhance the effectiveness of the Objective Force team by a factor of ten. Note that these initiatives included improvements in lethality, survivability, C4ISR, and logistics. Thus, although the study was not restricted to C4ISR, that issue area proved to be a dominant dimension of the assessment.

Originally, the Analysis Panel was tasked with helping to synthesize the outputs from other panels to help support the prioritization of recommendations. These other panels included Fightability Technologies, Power System Technologies, and Weight Considerations. It soon became apparent that it was not feasible to implement the role of quantitative synthesizer and prioritizer given the dynamics of the Summer Study. Most of the panels planned to develop their proposed recommendations just prior to the conclusion of the Summer Study. Given the time and resources required to prepare and employ relevant analysis tools, it was not possible to perform the desired assessments.

However, during the nine months prior to the Summer Study, two key roles for the Analysis Panel emerged. First, to provide a context for the other panels, the Analysis Panel was able to perform assessments that identified key initiatives where advances could enhance the effectiveness of operations substantially. These insights enabled the other panels to focus their efforts on areas where the operational payoffs would be greatest. Second, the Analysis Panel was cognizant of the fact that the assessment of dismounted operations in complex terrain was in its infancy. Thus, it also sought to identify options to improve the set of tools that the community had to undertake this difficult and important task. These two objectives became the *real* issues that the Analysis Panel pursued.

To assist in the formulation of the problem, the Analysis Panel undertook two parallel initiatives. First, it began a data mining activity that persisted for the duration of the study. One prong of the data mining focused on reports that documented the results of prior operations. This included assessments of recent dismounted operations in urban theaters such as Somalia and Chechnya (Reference 1). Those assessments served to identify specific C4ISR issues that needed to be addressed (e.g., intelligence preparation of the

battlefield). In addition, the Analysis Panel reviewed the reports of recent experiments that had been conducted using dismounted units employing innovative systems and concepts in urban environments (e.g., the US Marine Corps' Project Metropolis (Reference 2)). Those results also served to identify key issues that required assessment (e.g., the need for enhanced communications at the squad level).

In addition to these data mining efforts, the Analysis Panel visited a wide variety of organizations. These included: training testbeds where the panel was able to observe simulated dismounted operations in small, instrumented villages; operational sites, where the panel was able to speak to the operational community; analysis organizations, where the panel was able to assess the capabilities and limitations of existing assessment tools and to receive briefings on recent analyses; virtual M&S testbeds where the next generation of tools is being developed; and laboratories where the panel was briefed on promising systems and concepts.

The output of these efforts was a rich enumeration of key issues (for both concepts of operations and materiel) and an understanding of the state of the art in existing and emerging assessment tools.

2.0 SCENARIOS

These data mining activities and visits made it clear that dismounted operations in complex terrain had to be assessed in the context of a broad set of stressing scenarios (see Figure 1). These scenarios were selected based on a variety of considerations. First, in analyses performed in support of the 2000 ASB Summer Study, evaluations were performed of the effectiveness of alternative mounted operations in the context of a hypothetical Kosovo scenario. Those analyses revealed that the ensuing dismounted operation would be complex and hazardous. Those results provided the initial conditions for the first scenario, attack of a deeply dug in Red squad by three dismounted Blue squads. Second, in discussions with various operational and analytic organizations, three challenging issues for dismounted operations were identified: protection of a convoy from ambush in an urban environment, interdiction of supplies in an urban environment with minimal collateral damage, and clearing floors in a building occupied by Red forces. Finally, based on operations in East Timor, New Zealand forces expressed interest in the challenges associated with distributing relief supplies to natives using materiel and concepts of operations that minimized the risk to Blue forces. Representatives of Germany also indicated interest in this issue. Thus, a range of contexts was selected that represented stressing situations. Although the set of scenarios was not exhaustive, it served to provide a broad spectrum of challenging perspectives.

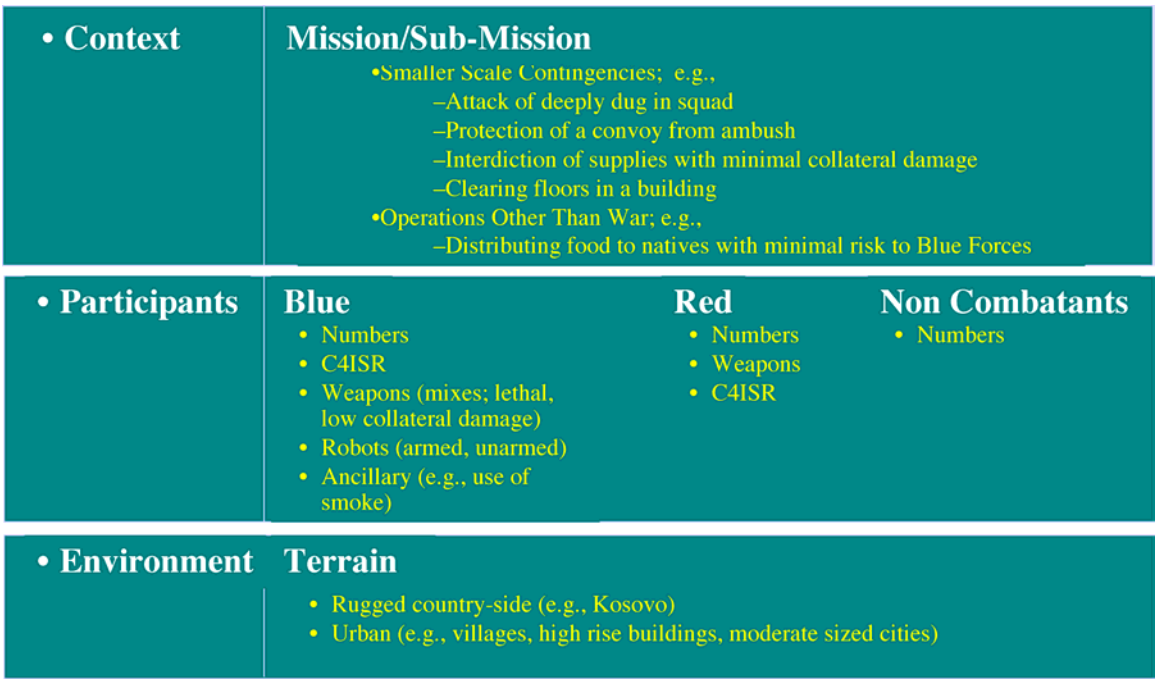

Figure 1: Scenarios.

For each of the contexts selected, several capabilities for the participants were selected, with appropriate variations about those values. In the case of Blue forces, attention was focused on five key variables: the number of Blue personnel in the operation (particularly for the OOTW context); the sophistication of the C4ISR systems (e.g., quality of communications, sensors) and their ability to perform key C4ISR functions (e.g., situation assessment); the type and mix of weapons systems available to Blue (including existing weapons as well as future lethal weapons (e.g., Objective Individual Combat Weapon (OICW)) and low collateral damage weapons (e.g., foam, sedating agents)); the presence of robotic agents with varying levels of functionality (e.g., sense-only; sense and engage capability) and concepts of operation; and the availability of selected ancillary equipments including the use of smoke and exoskeletons. In general, the capabilities of other participants were characterized by selecting representative levels of numbers and, where appropriate, weapons and C4ISR.

Finally, since the focus of the study was on complex terrain, a variety of different terrain conditions were explored. These ranged from a rugged countryside (representative of the terrain characteristic of Kosovo) to a spectrum of urban environments (including small villages, high rise buildings, and moderate sized cities such as Sarajevo). In general, a specific terrain condition was selected for each of the contexts cited above.

3.0 MEASURES OF MERIT

Consistent with the variety of scenarios considered, several hierarchies of Measures of Merit (MoMs) were employed (see Figure 2). For each of the contexts assessed, an appropriate measure of mission accomplishment was selected. These included “taking Red’s position” (for the three Blue squads attacking a deeply dug in Red squad), “surviving the ambush” (for the convoy attacked on the outskirts of Sarajevo), “clearing the building” (for the floor clearing operation in the high rise), “interdicting the flow of supplies”

(for the use of kinetic and LCDW weapons in and around a bridge), and "delivering food to the natives" (for humanitarian operations in East Timor).

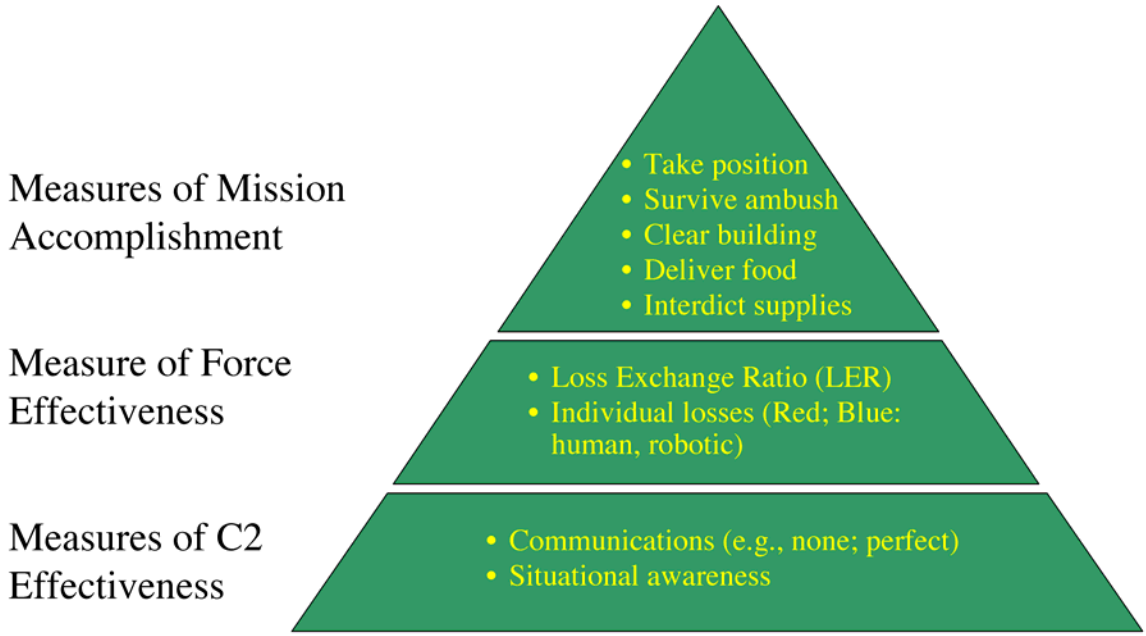

Figure 2: Measures of Merit (MoMs).

At the next level of the hierarchy, Measures of Force Effectiveness were defined. In all cases, the dominant MoMs involved the losses incurred in operations and the loss exchange ratios. For those cases featuring robotic agents, the losses for those entities were monitored.

Finally, measures of C2 effectiveness were tailored for the scenarios of interest. For example in the floor clearing operation, assessments were performed for the bounding cases in which Blue force communications was perfect and non-existent. In addition, in the assessment of three Blue squads attacking a deeply dug in Red squad, effectiveness was evaluated as a function of the quality of Blue's situational awareness.

4.0 HUMAN FACTORS

Since the 2001 ASB Summer Study was specifically interested in a variety of human factors (e.g., the weight of the equipment that an individual could carry and still be mobile and effective), it was important to address human issues directly in the assessments. This was accomplished in two specific ways.

First, data were acquired from Natick, the US Army's Soldier System Laboratory, to characterize the performance of individual soldier as a function of weight carried (e.g., distance covered as a function of weight carried; speed of movement as a function of weight). These results were factored into the assessment of the attack of a deeply dug in squad.

Second, when New Zealand analysts assessed operations in East Timor, they concluded that individual human behavior would have a significant impact on the outcomes. This included consideration of the motivation of

the participants, their discipline, and the change in their behavior when a squad member was injured. This led to the search for tools that had the ability to reflect those factors.

5.0 DATA

During the course of the assessments, the Analysis Panel discovered that data limitations posed significant barriers. These limitations were of particular significance in four key areas.

First, in order to assess small squad operations in complex terrain, it was discovered that terrain resolution on the order of 1 meter (i.e., Digital Terrain Elevation (DTED) Level 5) was needed. Since data to that resolution were unavailable for Kosovo, this posed a dilemma. To resolve the dilemma, the assessment team began with available DTED Level 5 data from Hunter-Liggett, CA, and augmented the terrain with vegetation features to emulate Kosovo terrain.

Second, when the Analysis Panel visited the Shuggart-Gordon Range at Ft. Polk, LA, they found a useful environment for gaining insight into operations in urban environments. Even though many units had employed this environment in exercises, little effort had been made to transform and mine the data. In addition, instrumentation limitations restricted the type of data that could be collected.

Third, the effects of factors such as fatigue, stress, and sleep deprivation were of great interest in the study. However, there are relatively little available data on the effect of these factors on small squad performance.

Finally, there was great interest in assessing mission effectiveness in the 2020 time frame. However, given the relatively primitive state of knowledge about the future concepts and systems that are likely to be in use at that time, the Analysis Panel was compelled to make educated guesses about those data.

6.0 TOOLS

During the course of its visits, the Analysis Panel was able to identify a number of tools that were well suited to the issues of interest. These tools included a variant of JANUS, developed and employed by the RAND Corporation, and the Joint Conflict and Tactical Simulation (JCATS). The later tool, developed by Lawrence Livermore National Laboratory (LLNL), is used widely for the assessment of small unit operations by a variety of institutions (e.g., Joint Warfighting Center, IDA). In addition, the Analysis Panel was introduced to MANA, an Agent Based Model developed by researchers in New Zealand to prepare for OOTW. Taking advantage of these tools and researchers cognizant of their strengths and weaknesses, the Analysis Panel was able to direct studies for the five major scenarios of interest.

While these tools appeared to be adequate to support a preliminary assessment of most of the issues of interest, it was clear that a next generation of tools was needed to explore these issues further. Several promising initiatives were identified during the course of the Analysis Panel's deliberations. In the category of virtual M&S, the USMC Combat Decision Range provides a useful, inexpensive vehicle to explore the effectiveness of alternative mixes of systems in the context of selected scenarios (e.g., peacekeeping in Kosovo). In the longer term, if the individual soldier is represented adequately, the Joint Virtual Battlespace may be able to shed light on issues associated with the interfaces between mounted and dismounted operations. As noted above, several live M&S for urban operations are in existence (e.g., Shuggart-Gordon Range, Ft. Benning) and they could be of increasing value if their instrumentation and data analyses capabilities were to be enhanced.

In the long term, it would be prudent to orchestrate these tools in a model-experiment-model paradigm, to take advantage of the strengths of these tools and to compensate for their weaknesses.

7.0 REPRESENTATIVE FINDINGS

To illustrate the kind of results that the Analysis Panel generated consider the products that emerged from the use of JANUS by RAND to assess the use of dismounted forces to engage a deeply dug in Red squad in complex terrain. Initially, RAND assessed the contributions of options that are indicated in Figure 3, *one at a time:* smoke, Objective Individual Combat Weapon (OICW), body armor, signature reduction, and indirect fire support (IDF). As you can see, several of these options provided some improvement (notably the OICW), none of which would be regarded as spectacular. Note, in particular, that the addition of smoke actually reduced effectiveness because it resulted in shorter range, more lethal engagements for Red.

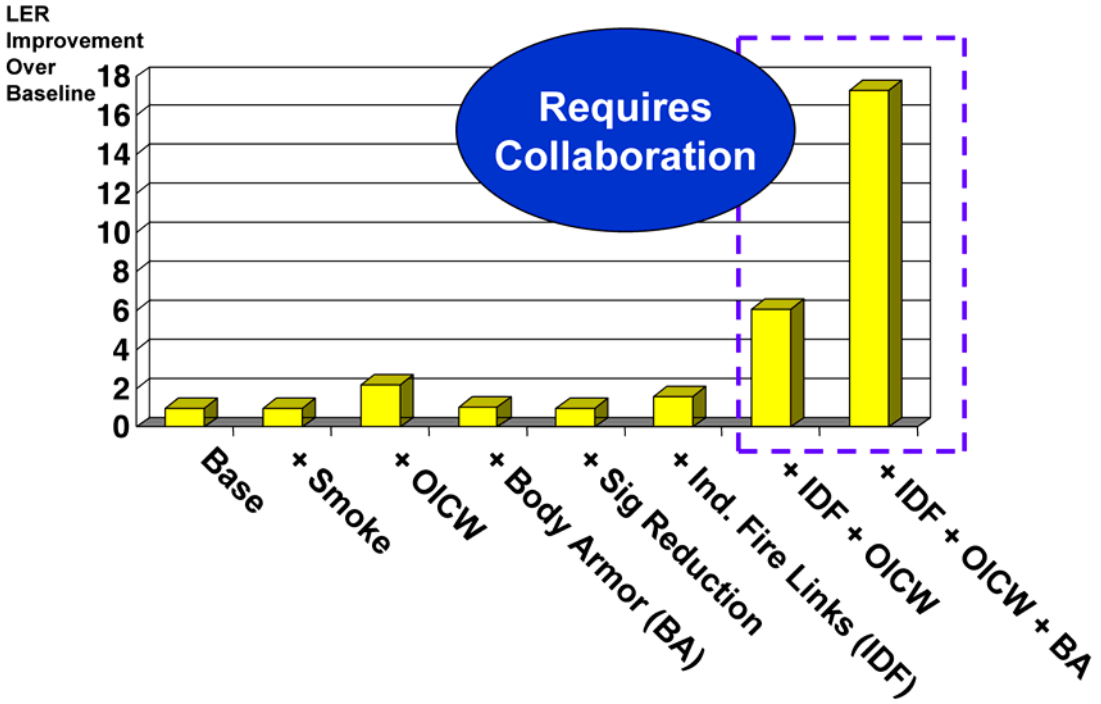

Figure 3: Results for Deeply Dug in Squad in Complex Terrain.

The Analysis Panel then moved to the next phase of the analysis and considered adding *combinations* of these options to 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 the Analysis Panel added the body armor 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. Although it was 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. In addition, this operation requires a sophisticated level of situational awareness by the Blue Force.

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.

8.0 SENSITIVITY ANALYSES

Figure 4 gives some indication of the sensitivity analyses that were performed to determine the robustness of the findings for individual vignettes. The variations refer to excursions around the base case of three Blue squads attacking a deeply dug in Red squad in complex terrain in good weather. It can be seen that among the excursions the assessment team explored the impact of weather, parametric variability of selected factors (e.g., reducing the signatures of Blue forces by 50%, 75% and 88%), alternative concepts of operations (addition of preparatory fires that are either fire for effect or precise), alternative force mixes (e.g., partial fielding of OICW), the addition of new technology (e.g., unattended ground vehicles with weapons), and combinations of options. This systematic approach served to identify options that were worthy of future exploration.

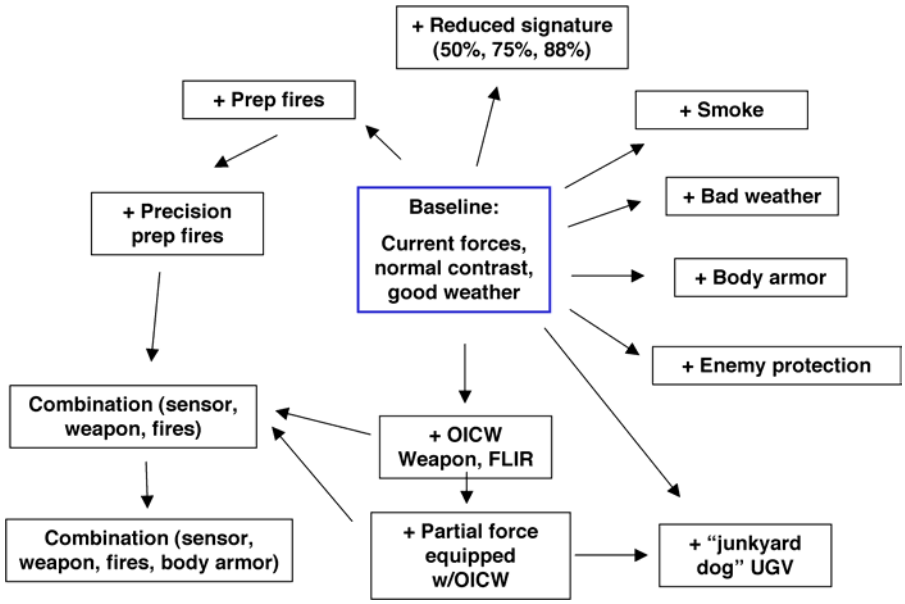

Figure 4: Cases Assessed in Sensitivity Analyses.

9.0 CONCLUSIONS

Based upon the assessment activities, the Analysis Panel identified key capabilities that are needed to perform effective dismounted operations in complex terrain. These potential capabilities have been organized into six categories: lethality, survivability, mobility, C4ISR, sustainability, and foundational (e.g., training, experimentation, systems perspective) (see Figure 5). All of these capabilities are potential areas for improvement. However, there are two key points to emphasize.

• **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 5: Key Capabilities (*Transformative*).

First, the panel reviewed these capabilities and highlighted those that could truly transform the nature of dismounted operations in complex terrain. Those capabilities that, under selected conditions, could give rise to an order of magnitude in improvement are highlighted in Figure 5.

Second, it is interesting to note that the bulk of these "10X" capabilities are clustered in the area of C4ISR. Thus, the primary challenge to the other panels of the ASB Summer Study was to identify and explore the technologies that are needed to make these C4ISR capabilities a reality.

The Analysis Panel derived several broad insights as a consequence of these assessments. First, when comparing options, it proved vital to formulate and compare appropriate mixes of doctrine, organizations, training, materiel, leadership and education, personnel and facilities (DOTML-PF). Thus, it was not adequate to vary a single factor (e.g., materiel) while keeping all of the other factors fixed. This was particularly apparent in the assessment of options featuring the addition of robots. In those cases, the concepts of operation made a major difference in the effectiveness of the options.

Second, many of the results of interest are highly scenario dependent. As an illustration, there was interest in assessing the contribution of smoke (to conceal friendly operations) to operational effectiveness. In the scenario in which several squads attacked a deeply dug in Red squad, the addition of smoke actually decreased the survivability of the attacking Blue force (e.g., it reduced the range at which Blue forces were engaged). However, when smoke was used to counter the effects of a Red ambush of a convoy, it enhanced survivability (e.g., the addition of smoke reduced the loss of Blue trucks by 54% and the loss of Blue scouts

by 37.5%). This example illustrates the importance of assessing options over a broad set of scenarios to ascertain their robustness.

The assessment also served to identify several other important needs. First, there are a significant number of on-going efforts that could be of considerable value if they are exploited adequately. As an example, it is important to enhance the instrumentation of key testbeds (e.g., Shuggart-Gordon) and to evaluate systematically the results from forces employing those testbeds. Second, the Analysis Team gained valuable insights from assessments undertaken by the US Marine Corps. Those activities should be broadened to include joint and combined forces to assess the problem in a broader context. Finally, although existing tools proved useful, they are limited in their flexibility and uncertain in their validity. Steps should be taken to enhance individual tools and to orchestrate them to leverage their strengths.

10.0 COBP LESSONS LEARNED

This activity served to provide insight into the NATO CoBP in two dimensions. First, since one of the authors had participated in the generation of the NATO CoBP, that experience was extremely useful in the planning and execution of the study. It helped guide the formulation of the problem (e.g., stimulated the data mining initiative), led to the selection of a broad set of scenarios, guided the explicit selection of a hierarchy of MoMs, helped in the selection of appropriate tools, and stimulated the systematic implementation of sensitivity studies.

In addition, the NATO CoBP proved to be a valuable tool to guide this *post mortem* of the study. Retrospectively, it has served to help highlight the study's strengths (e.g., the systematic addressal of the major issues highlighted in the NATO CoBP) and weaknesses (e.g., inability to acquire needed data on the environment and on selected human factors). Consistent with the dictum of the NATO CoBP to assess the issues iteratively (going from broad shallow assessments to deeper, more focused assessments), areas for follow-on assessment are relatively clear. In addition, several areas are now apparent that we could have improved. For example, we should have established stronger coordination mechanisms with other stakeholders (e.g., the other panels participating in the Summer Study) to ensure that we were fully conversant with their issues and were able to provide timely feedback and guidance based on the results of our assessments.

11.0 REFERENCES

[1] "Handbook for Joint Urban Operations", Joint Staff, 17 May 2000.

[2] "MOUT Battalion Level Experiments – Experiment After Action Report", Project Metropolis, Marine Corps Warfighting Laboratory, February 2001.

12.0 ACKNOWLEDGMENT

Major contributions to this study were made by Chris Christenson, IDA; Sarah Johnson, MITRE; Mike Macedonia, STRICOM; John Mastumura, RAND; Dan Rondeau, Sandia National Laboratory; and Randy Steeb, RAND.

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Context:ToR for 2001 ASB Summer Study

- Characterize improvements in lethality, survivability, C4ISR and logistics required to yield a more effective Objective Force Soldier/Marine Team across the operational spectrum
- Evaluate connectivity between the Future Combat System (FCS) and the Objective Force Soldier/Marine Team
- Assess current and projected research, development and acquisition (RDA) efforts. Focus on effectiveness, weight reduction, power and affordability
- Recommend alternative Science & Technology (S&T) investment strategies and map the technological advances from present to future

Problem Formulation (1 of 2)

- Issue:
  - Help synthesize outputs from other panels to support prioritization of recommendations
- Real Issue:
  - Identify key initiatives (e.g., technology, systems, concepts of operations) where advances could enhance mission effectiveness significantly
  - Identify needed advances to enhance the ability to assess dismounted operations in complex terrain

Problem Formulation (2 of 2)

- Data mining
  - Results of prior operations
  - Lessons learned from prior assessment, experiments
- Visits
  - Training testbeds (e.g., Ft. Benning, Ft. Polk)
  - Operational sites (e.g., Ft. Bragg)
  - Analysis organizations (e.g., RAND, IDA)
  - Virtual M&S testbeds (e.g., Joint Virtual Battlespace (JVB), institute for creative technologies (ict))
  - Laboratories (e.g., Natick, Marine Corps Warfighting Laboratory (MCWL))

Scenarios (1 of 2)

• Context	Mission/Sub-Mission
	•Smaller Scale Contingencies; e.g., –Attack of deeply dug in squad –Protection of a convoy from ambush –Interdiction of supplies with minimal collateral damage –Clearing floors in a building •Operations Other Than War; e.g., –Distributing food to natives with minimal risk to Blue Forces

Scenarios (2 of 2)

• **Context**	**Mission/Sub-Mission** •Smaller Scale Contingencies; e.g., –Attack of deeply dug in squad –Protection of a convoy from ambush –Interdiction of supplies with minimal collateral damage –Clearing floors in a building •Operations Other Than War; e.g., –Distributing food to natives with minimal risk to Blue Forces		
• **Participants**	**Blue** • Numbers • C4ISR • Weapons (mixes; lethal, low collateral damage) • Robots (armed, unarmed) • Ancillary (e.g., use of smoke)	**Red** • Numbers • Weapons • C4ISR	**Non Combatants** • Numbers
• **Environment**	**Terrain** • Rugged country-side (e.g., Kosovo) • Urban (e.g., villages, high rise buildings, moderate sized cities)		

Measures of Merit (MoMs)

Measures of Mission Accomplishment

- Take position
- Survive ambush
- Clear building
- Deliver food
- Interdict supplies

Measure of Force Effectiveness

- Loss Exchange Ratio (LER)
- Individual losses (Red; Blue: human, robotic)

Measures of C2 Effectiveness

- Communications (e.g., none; perfect)
- Situational awareness

Human Issues

- Human performance; e.g.,
  - Speed of movement as a function of weight carried
- Individual Behavior (in Agent Based Model (ABM))
  - Motivation
  - Discipline
  - Impact of injury

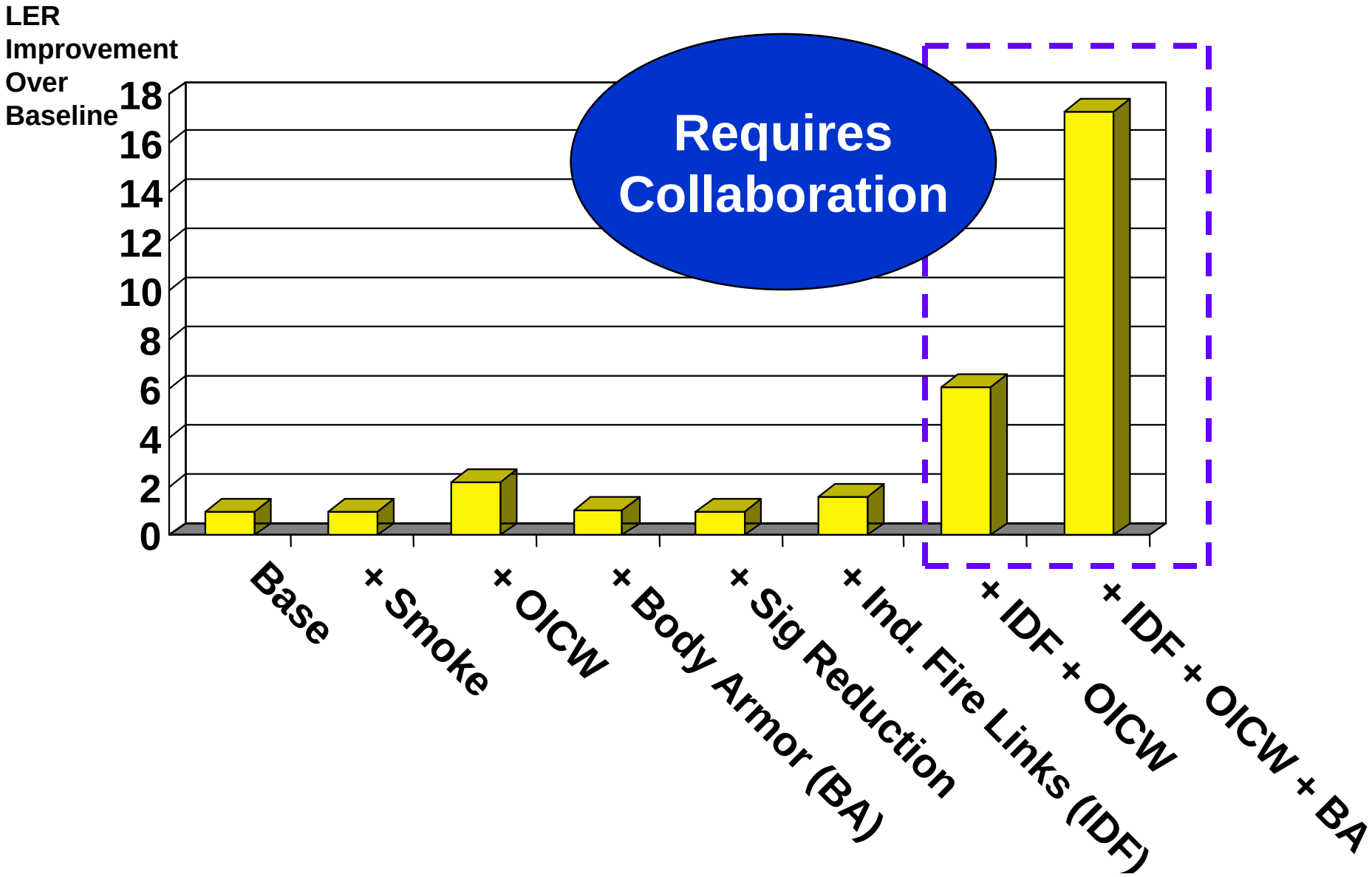
Data: Key Needs

- Environment: Need for Digital Terrain Elevation Data (DTED) Level 5 (1 meter resolution)
- Exercises: Better instrumentation, mining of data
- Human factors: Data on individual performance as a function of fatigue, stress,…
- Future options: Enhanced information for future concepts, systems

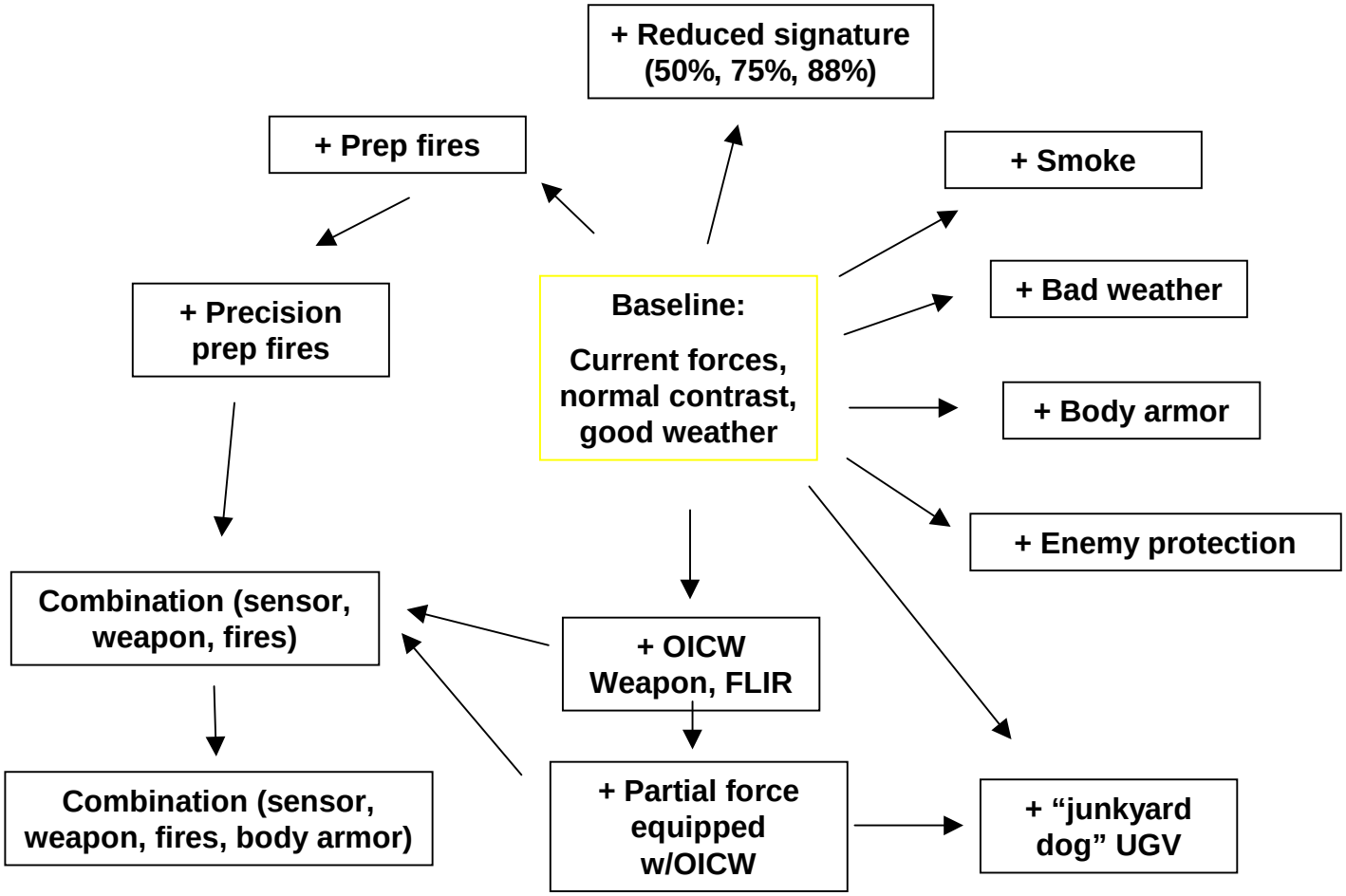
Tools

- Primary
  - Constructive M&S (i.e., JANUS, JCATS)
  - ABM (Mana)
- Future
  - Virtual M&S (e.g., Combat Decision Range; Joint Virtual Battlespace)
  - Live M&S (e.g., Shuggart-Gordon Range; Ft. Benning)
  - Orchestrated mix

Representative Products: RAND Analyses



Sensitivity: Many Different Conditions Were Examined by RAND



Representative Products: 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

Broad Insights Derived

- Need to formulate, compare DOTML-PF mixes (e.g., effectiveness of concepts, use of robots)
- Results are highly scenario dependent; e.g., smoke
  - *Decreased* survivability for attack against small, heavily dug in forces
  - *Enhanced* survivability of ambushed convoy
- Need for
  - Continuing, systematic data mining efforts
  - Joint/combined assessments
  - Better (orchestrated) tools

CoBP Lessons Learned

- CoBP
  - Helped in the planning, execution of the study
  - Useful in the after action assessment, to understand
    - Study's strengths
    - Residual weakness
    - Next steps to take
    - Areas that we could have improved (e.g., coordination with other stakeholders)