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Title: Assessing Options to Enhance Force Protection for Mobile Forces

Dr. Stuart H. Starr (Point of Contact)
Barcroft Research Institute
3430 Mansfield Road
Falls Church, VA 22041
Phone: 703-998-5414
sstarr1@cox.net

Ms. Sarah Johnson
The MITRE Corporation
Phone: 703-580-4303
FAX: 703-580-0597
skjohn@mitre.org

Major Theodore D. Dugone
Army Modeling and Simulation Office (AMSO)
ATTN: DAMO-ZS
400 Army Pentagon
Washington, DC 20310-0400
Phone: 703-601-0011 X49
FAX: 703-601-0018

Assessing Options to Enhance Force Protection for Mobile Forces

Dr. Stuart H. Starr, Barcroft Research Institute
Ms. Sarah Johnson, MITRE
Major Tedd Dugone, AMSO

Abstract

Over the past decade there has been increased interest in options to enhance force protection for forces in operations other than war (OOTW). This was highlighted by actions taken in the Former Republic of Yugoslavia (FRY) where actions to enhance force protection (e.g., mandated use of protective gear; use of multiple vehicles in traveling through the theater) were stressed heavily (Reference 1). More recently, the mission has become a major political-military issue in Iraq where attacks on coalition forces and International Organizations have become common place.

In view of this increasing interest, the Army Science Board was directed to undertake a summer study to identify and assess options to enhance force protection effectiveness and efficiency (Reference 2). Consistent with that direction, the study identified an array of vignettes as a context for exploring promising force protection options. These included four hypothetical vignettes associated with the protection of fixed installations: a biological attack against the Norfolk, VA, area; a chemical attack against the Kandahar airport in Afghanistan; a high explosive attack against a forward operating base in central Asia; and a high explosive attack against a Forward Arming and Refueling Point (FARP)). Furthermore, two hypothetical vignettes were formulated to explore the challenges associated with the protection of mobile Blue forces: a logistical convoy of trucks protected by escort vehicles and small teams patrolling in a market place. This paper describes the analyses that were performed to illuminate the issues associated with the protection of mobile Blue forces. Particular emphasis was placed on assessing the potential impact that C4ISR options would have on force protection effectiveness.

As a context for the analyses, a baseline was established drawing on the results of prior studies by Rand (Reference 3) and Sandia National Laboratories (Reference 4). Those earlier studies employed JANUS, a constructive simulation. However, in light of the nature of the problem and the limited time available to perform the analyses, the study team elected to employ the Mana Distillation, an agent based model developed by the New Zealand Ministry of Defence (Reference 5).

The convoy vignette envisioned a mix of trucks carrying logistical products (e.g., food, petroleum), escorted by armed Humvees, which was subject to a dismounted armed ambush by Red forces. It was assumed that the attack was initiated by the detonation of a land mine. The objective of the analysis was to assess the potential impact of proposed options to mitigate the effects of the attack. These options included modified tactics, techniques and procedures (TTPs), and enhancements in C2 (i.e., enhanced C2 intra-convoy and between the convoy and the command post), improved ISR (i.e., unmanned aerial vehicles (UAVs); armed unmanned ground vehicles (UGVs)), and other materiel actions (e.g., use of obscurants; application of ballistic appliqués and enhanced body armor to harden the convoy vehicles and provide greater personnel protection). Based on

technology assessments, these options were analyzed for near- and far-term timeframes. To calibrate the Mana Distillation, the analysis team first demonstrated that results could be generated that were consistent with Rand's earlier JANUS-based studies. Subsequently, the potential utility of the Blue options was assessed using the Mana Distillation to evaluate the average number of convoy casualties that would be sustained in the attack. Those analyses revealed that several options are particularly promising. These include the addition of UAVs with mine detection capabilities, an armed UGV, and the use of "designer" obscurants (i.e., obscurants that are relatively transparent to Blue forces with their aided vision devices and opaque to Red forces). A follow-on portfolio analysis is required to select the most cost-effective mix of options.

The small unit operations analysis envisions a small Blue force patrolling a market place containing a large mix of non-combatants. However, a few members of the crowd are hostile and will opportunistically engage Blue forces with small arms. The analysis team again employed the Mana Distillation to evaluate a variety of Measures of Merit (MoMs): losses (kills, injuries) sustained by Blue forces, Red forces, and neutrals; and the time that Blue forces required to traverse the market place. The analyses revealed that promising options included enhanced situation awareness, enhanced body armor, and the use of non-lethal weapons. Again, follow-on analyses are required to develop the most cost-effective portfolio of options in the timeframes of interest.

These analyses demonstrated the ability of an interdisciplinary team to gain rapid insights into the potential contribution of C4ISR and other materiel and non-materiel options to enhance force protection effectiveness using agent based models. However, it must be emphasized that these analyses should be viewed as exploratory and that additional, rigorous analyses must be performed (employing a broader set of tools) to confirm and extend these preliminary conclusions.

A. Introduction

In Reference 1, the Army Science Board (ASB) was directed to perform an analysis of the force protection problem. For the purposes of this study, force protection was defined as follows: "Force protection is an overarching security program developed to protect soldiers, civilian employees, family members, facilities, and information and equipment, in all locations and situations. It is a holistic program accomplished through the planned integration of physical security, Information Security (INFOSEC), protective services, law enforcement, and anti-terrorism, all supported by the synchronization of operations, intelligence, training and doctrine, policy and resources"(Reference 6).

In the Terms of Reference, the study team was directed to identify advanced technologies for the 2010-2020 timeframe to support the force protection mission and to use analysis and models to evaluate potential contributions of force protection technologies in specific scenarios.

To achieve those objectives, the study was organized into six panels: review of prior studies; science & technology (S&T) solutions; vulnerability and threat assessment and intelligence requirements; operations; interfaces with local governments, commerce, and infrastructure; and analysis and modeling. The analysis and modeling panel was specifically directed to perform two complementary tasks: identify initiatives to improve the utility of models and simulations in support of key force protection functions; and conduct analyses, in concert with the other panels, to shed light on the contribution that proposed changes in Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel, and Facilities (DOTMLPF) can have on force protection effectiveness and efficiency.

In support of the latter goal, the analysis and modeling panel assessed options to enhance the protection of fixed installations against chemical, biological, and high explosives attacks and the protection of mobile targets (e.g., logistical convoys; small units in complex terrain). This paper is restricted to a discussion of the assessments that the panel performed for mobile targets.

As a foundation for that discussion, this paper first introduces a framework for conceptualizing the force protection problem. Using that framework, it then summarizes and discusses the analyses that were performed for convoys and small units. The paper concludes by summarizing the insights that were derived from the analyses.

B. Nature of the Problem

In order to establish a common framework with the other panels, the force protection problem was initially sub-divided into pre-, trans-, and post-attack phases. As depicted in Figure 1, these phases were subsequently divided into a sequence of functions that must be performed by Blue Forces. During the pre-attack phase, this subsumes the prediction of a potential attack, the monitoring of the environment for signs of a precursor to an attack, the performance of functions to deter an attack (e.g., elevating Force Protection Conditions (FPCONs), as appropriate), and the taking of steps to deny or prevent an attack (e.g., hardening potentially vulnerable areas). During the trans-attack phase, this subsumes functions such as detecting and neutralizing threats beyond appropriate “keep out” ranges; predicting the evolution of the attack to help formulate courses of action; taking actions to protect people and materiel at risk; and confounding the adversary through cover, concealment, and deception actions. During the post-attack phase, this subsumes the response to an attack (e.g., mobilize, coordinate, and control resources to mitigate problems created by the attack), the restoration process (e.g., the reconfiguration of defenses), and the retaliation process (e.g., launching a counter-attack).

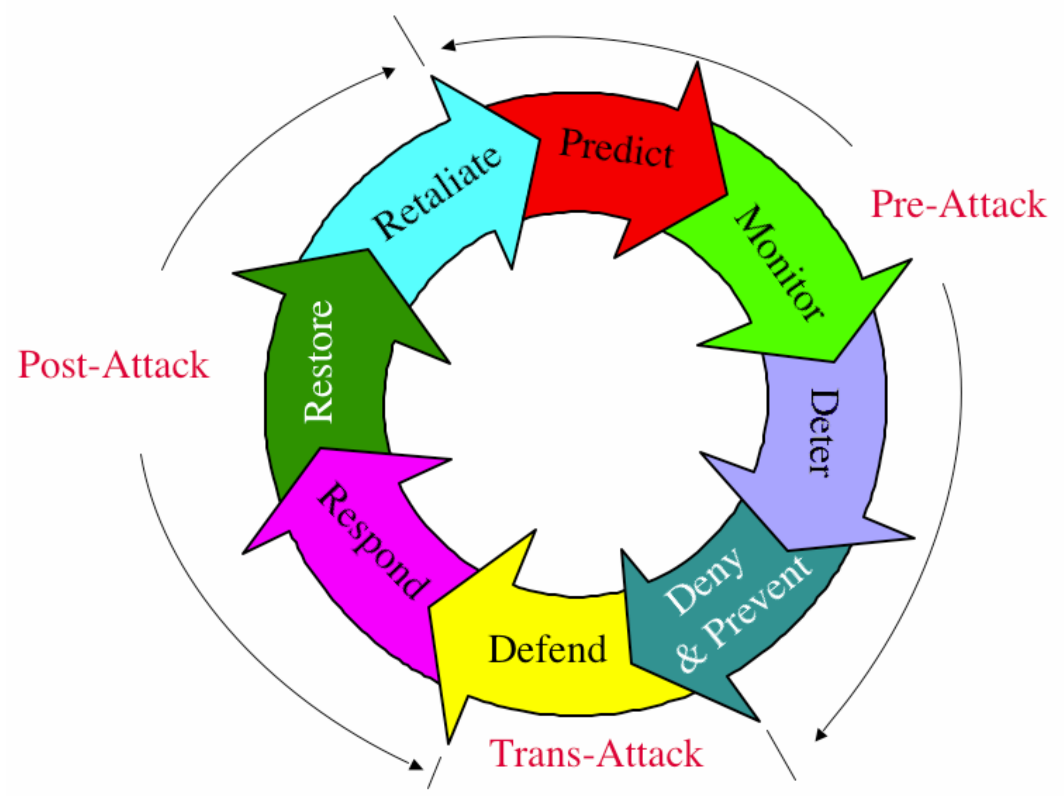

Figure 1. Force Protection Framework: Pre-, Trans-, & Post-Attack

We observe that one of the key objectives in force protection is to invest across these functions in a balanced way to leverage the benefits of proactive actions (e.g., predict and monitor adversary action to preempt potential attacks; take steps to mitigate the effects of an attack) while ensuring effective defense, response, and restoration in the case that an attack is launched.

Given the nature of the problem, we undertook an assessment of tools that would enable us explore DOTMLPF options for the trans-attack phase against mobile targets. As a consequence of this assessment, we selected the Mana Distillation to support our analyses of convoys and small units. The Mana Distillation is a cellular automaton model developed by the New Zealand Defense Technology Agency used to explore military questions (Reference 5). The Mana Distillation is part of the USMC Project Albert suite of tools (Reference 7). The basic, key features of the Mana Distillation include the following: units can be defined in terms of either personnel or equipment characteristics. The model has multiple sides, based upon allegiance – friendly, neutral, or enemy. Basic physical characteristics can be defined for each unit – such as sensor range, firing range, stealth, and communication links, as well as weapons definition. Agent grouping characteristics can be defined, such as a cluster parameter, or “unit cohesion”, which is an attraction to friendly agents until a user-defined numerical threshold has been achieved before agents will move; an advance parameter which is another user-defined threshold that agents must meet before moving toward the goal; and a combat parameter, which is a user-defined numerical advantage for agents before they will move on the enemy. Agents’ movement propensities are determined by attractions toward or away from other agents, whether friendly, neutral, or enemy, and towards or away from waypoints and terrain types. A key feature of the Mana Distillation is triggered events which can cause agent behavior changes. Every agent has a base state, or default behavior state with default ranges; however, users can define other behavioral characteristics based upon certain events, and these triggers can be individual or perpetuated for the whole squad. For instance, an agent or a squad can change from the default when shot at by other agents, upon reaching a waypoint, if injured, or when enemy contact is made. Terrain is represented very simply, and based upon color. Definable terrain features include obstacles (which can impede movement, sight, and firing) and easily traversed terrain (e.g., roads or paths, and dense and light brush).

The following sections describe and discuss the results that were derived for the convoy and small unit Force protection problems. In each case, the section begins with a description of the vignettes that were used in the assessments. That is followed by a discussion of the results that were obtained using the Mana Distillation. The sections conclude by providing additional perspectives on the problem and suggestions for follow on analyses.

C. The Convoy Problem

Analyses. Figure 2 depicts a Mana Distillation screen shot of the convoy vignette. The base vignette illustrates a convoy of Blue trucks with associated escort units in a column formation. The convoy consists of two escort units of 5 HMMWVs each, one in the lead and one in the rear, and a supply unit with 30 trucks. The convoy is traveling in an environment with rolling hill terrain and a partially developed road network. It is assumed that the convoy is en route to a humanitarian assistance site. An ambush has been set up to disrupt the convoy from completing its mission. The ambush party is a dismounted party with 24 members. The ambush party has buried a mine in the road to create an obstacle either to stop or to disable the convoy.

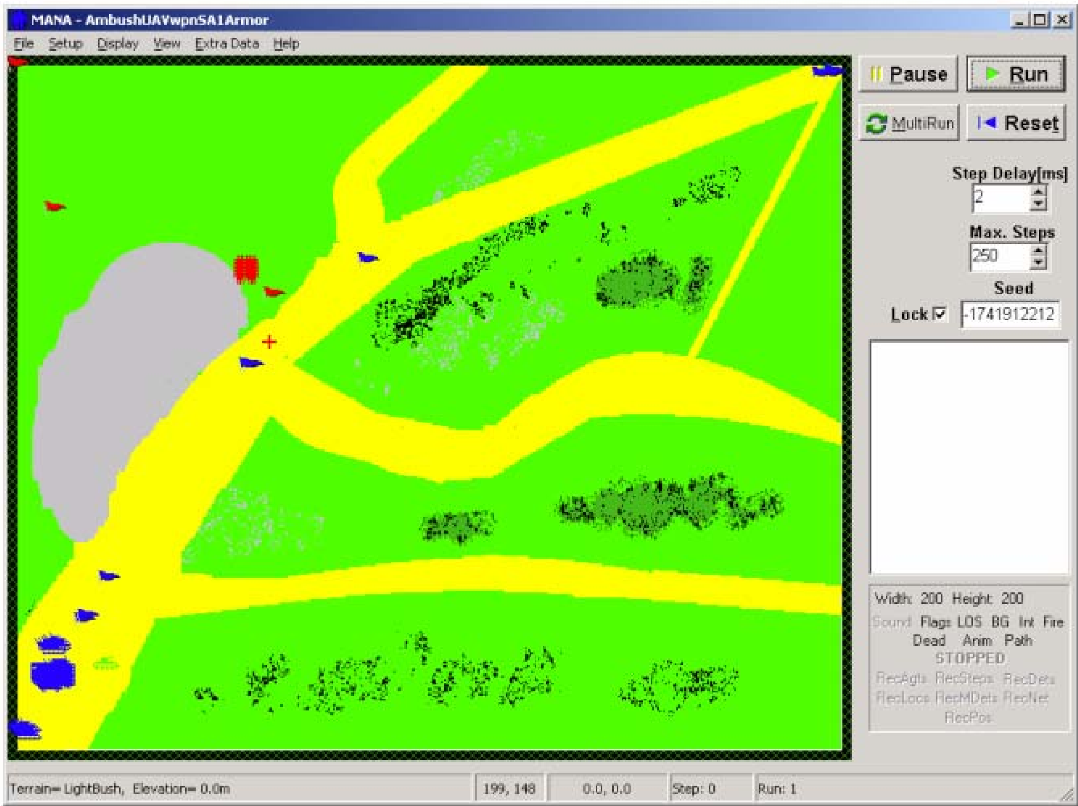

Figure 2. Mana Distillation Convoy Vignette

A variety of issues were addressed during the course of this analysis. These include the losses that are incurred by such an attack, the changes in DOTMLPF that are needed to improve force protection of convoys, and the contribution of near- and far-term materiel enhancement on force protection effectiveness. In the latter area, candidate materiel solutions include armed unmanned ground vehicles (UGVs), unmanned aerial vehicles (UAVs), use of obscurants, ballistic appliqués to harden the convoy vehicles, and improved C2 (i.e., enhanced C2 intra-convoy and between the convoy and home base). In these analyses, the primary measure of merit was the average losses that the convoy sustained in the attack.

To initiate the analyses, we reviewed prior convoy assessments (e.g., RAND's support to the 2001 ASB Summer Study (Reference 3) and the recent Future Combat Systems (FCS) Integrated Study Team (FIST) counter-mine study (Reference 4)) and Sandia's assessments of convoy ambushes. To calibrate our tools, we first demonstrated that we could derive results that were consistent with RAND's earlier JANUS-based studies, using the Mana Distillation. As a second step, parametric studies were used to identify interesting breakpoints in capability and to stimulate dialogue with the Operations and S&T Panels. Subsequently, specific materiel recommendations by the S&T Panel were assessed to help prioritize future actions.

Using the Mana Distillation for the base vignette described in Figure 2, several technologies were modeled to determine if any, or a combination of all of the technologies (representative of an integrated force protection system), would affect the outcome to the convoy ambush. The base vignette models limited, less coordinated communications between members of the convoy, indicative of the fact that not all trucks have radios. Ballistic appliqués and obscurants are not enhanced, but are representative of what would normally be organic to the convoy. No UAV capability is assumed.

In general, the convoy analyses focused on variations from this base case to include: better, more coordinated communication between convoy members; the addition of a UAV *without* mine detection capability to enhance situation awareness; the addition of a UAV *with* mine detection capability to improve survivability of the convoy; use of obscurants; armored appliqués; addition of an armed UGV for mine detection and neutralization; and the combination of all of the technologies, consistent with the appropriate timeframe.

In the near-term, several technologies were identified that could be implemented quickly and could improve force protection for a convoy. Each was explored independently of the others to determine what improvements could be recognized by implementing individual technologies. As can be seen in Figure 3 modest improvements (i.e., 15% to 25% reduction in Blue casualties with respect to the base case) were realized for all of the individual technologies, *except* for the addition of a UAV with mine detection capability, which provides approximately a 55% reduction in Blue casualties with respect to the base case. When all technologies are combined to represent an integrated near-term force protection system, the greatest decreases in convoy losses were observed. However, in this latter case, the reductions in convoy losses were only modestly better than those achieved by adding a UAV equipped with mine detection capability.

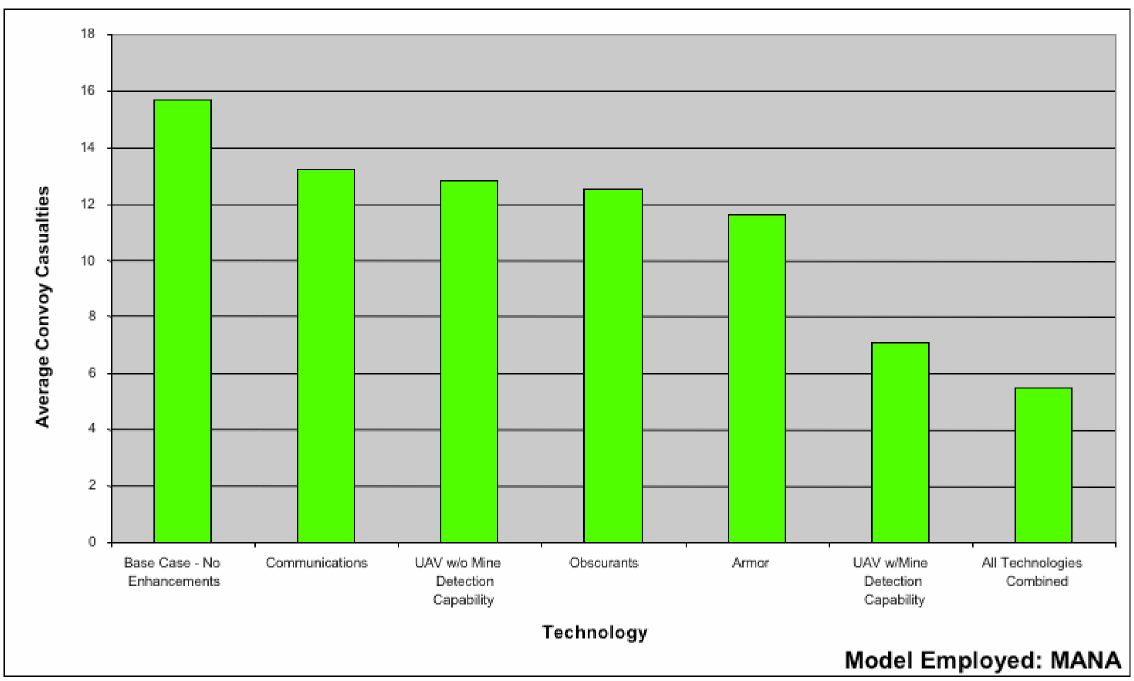

Figure 3. Convoy Vignette -- Cumulative Effects of Near-Term Materiel Enhancements

For the far-term, similar analyses were performed using the Mana Distillation.

Technologies were analyzed individually and then in aggregate. The individual technologies include the list on Figure 4. For the far-term, the performance of each of the technologies was modeled as a substantial enhancement beyond the near-term. Other technologies are included in the far-term that were deemed infeasible to field in the near term (e.g., armed UGV).

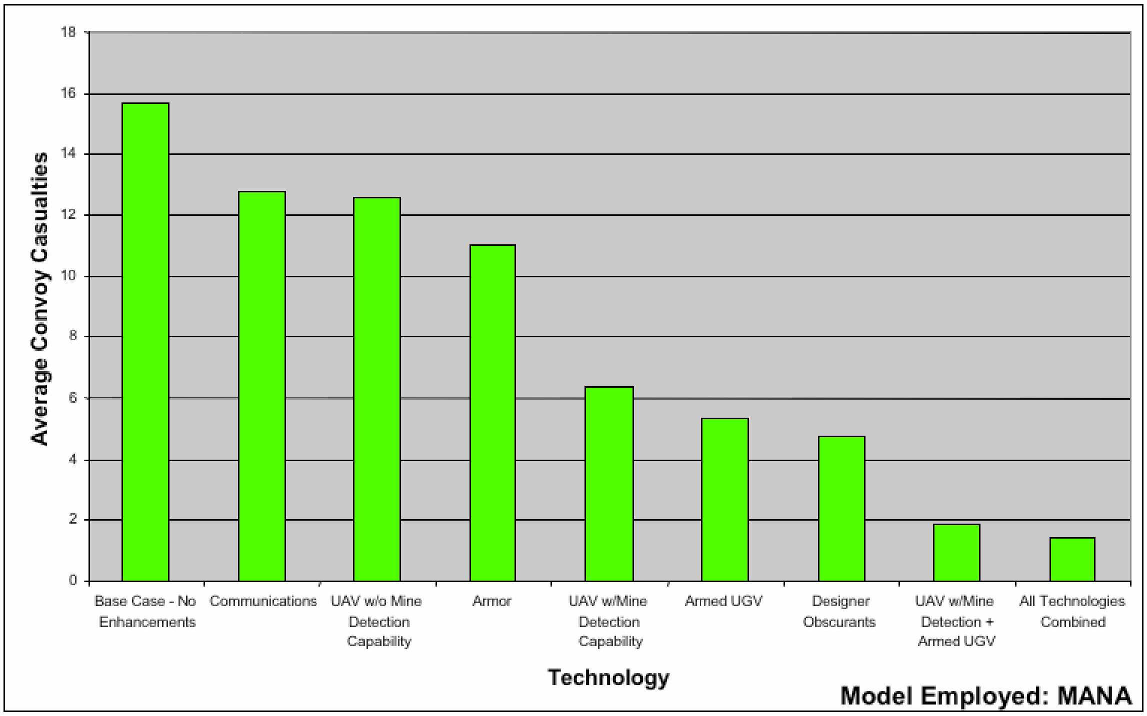

Figure 4. Convoy Vignette -- Cumulative Effects of Far-Term Materiel Enhancements

The effectiveness of the candidate technologies can be aggregated into three broad categories. In the first category, the technologies provide limited enhancements to convoy survivability beyond the base case (i.e., approximately 20% to 30% reduction in Blue casualties). These technologies include enhanced communications, a UAV without mine detecting capabilities, and improved armor. In the second category, appreciable enhancements to convoy survivability are realized (e.g., approximately 60% to 70% better than the base case). These technologies include a UAV with mine detecting capabilities, an armed UGV, and designer obscurants. Finally, the third category provides very substantial enhancements to convoy survivability (e.g., approximately an 85% to 90% improvement beyond the base case). It consists of combinations of technologies: a UAV enhanced with mine detection capabilities plus an armed UGV in the lead to neutralize mines; and a combination of all of the technologies for the far-term. Note that the combination of all technologies for the far-term provides relatively modest improvement over the UAV/UGV addition.

Perspectives. Convoys are very lucrative targets for deadly ambushes and attacks by a variety of mines (e.g., pressure sensitive, command detonated). This observation reflects the results of the analyses performed as well as the day-to-day reality of operations in

Iraq. The S&T Panel identified a relatively extensive set of options to mitigate the effects of those attacks. Consequently, a portfolio approach may be needed to identify a mix of those options that is effective and affordable. One key component of that portfolio should be options to enhance Blue situational awareness. Preliminary analyses of those options (e.g., addition of UAVs with mine detection capabilities) reveals that their addition to the mix appears to have a significant impact on convoy survivability.

There are a variety of mitigating options that should be pursued to deal with this high probability threat. First, a family of decision aids should be developed to support the early steps associated with the pre-attack phase. This would include predictive tools to identify likely locations of ambush sites and route planning tools to identify lower risk routing to avoid ambushes. Second, a mix of DOTMLPF options is needed. It is clear from the preliminary assessments that there is “no silver bullet”. Among the options to consider are modified TTPs (e.g., use a precursor force to sanitize likely ambush spots prior to the arrival of the convoy), materiel solutions (e.g., add robotic vehicles to the convoy, with and without weapons; harden the elements of the convoy against ballistic projectiles or fragments; outfit the convoy with obscurants, preferably “designer” obscurants that are relatively transparent to Blue with its aided vision devices and opaque to Red forces); and C2 enhancements (e.g., improve Blue force tracking so that the Commander is constantly aware of the location and status of his logistical convoys).

Analytically, there are a number of actions that should be taken to enhance our ability to cope with such an attack. First, steps should be taken to provide logistics commanders with a family of enhanced decision aids. These would include improved route planning tools and course of action analysis tools to help defeat adversary counter-mobility actions. Second, to support the assessment community, analysts need a suite of tools to support portfolio analyses of mitigating options. As an example, MITRE has developed and employed the Portfolio Analysis Machine (PALM) (Reference 8) to address a variety of similar portfolio analyses. PALM develops the “efficient” frontier, identifying portfolios (and the elements in each) that provide the most benefit at a specific budget or funding level. It could readily be adapted to identify an efficient mix of investments to enhance convoy survivability.

D. Protection of Small Units.

Analyses. As depicted in Figure 5**,** this scenario envisions a small Blue force of 10 soldiers patrolling a market place containing 100 non-combatants. However, 10 Red forces are spread throughout the market place and they will opportunistically engage Blue forces with small arms.

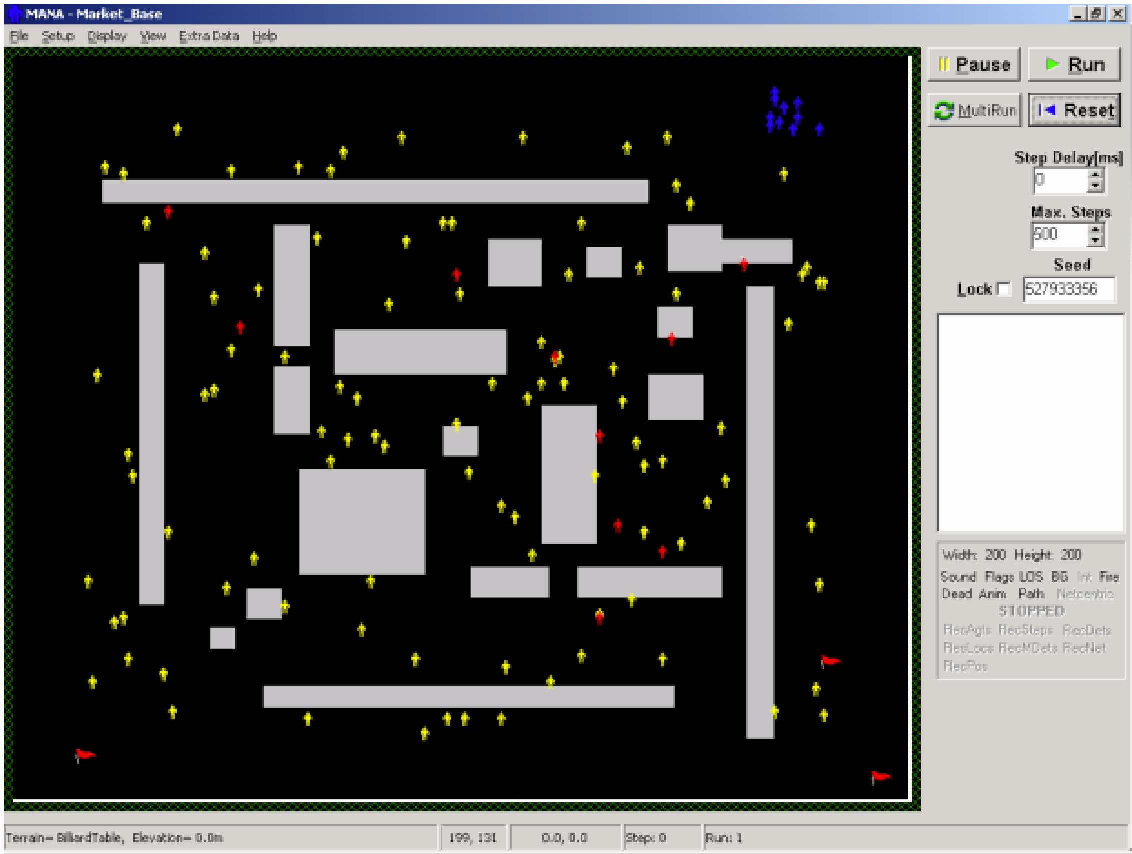

Figure 5. Mana Distillation Marketplace Vignette

A variety of issues were addressed during the course of this analysis. These included the selection of S&T options to mitigate casualties to Blue forces. In addition, there was interest in assessing the value of materiel options (e.g., use of non-lethal weapons, enhanced situation awareness) to minimize potential collateral losses of neutrals. To illuminate those issues, the analyses employed the following measures of merit: losses (kills, injuries) sustained by Blue forces, Red forces, and neutrals. In addition, as a measure of functional performance, estimates were made of the time that Blue required to traverse the market place.

The S&T Panel identified several near- and far-term technologies to enhance force protection for individuals and small units that we assessed, using the Mana Distillation for the market place vignette.

For the near-term timeframe, assessments were conducted for stealthy body suits, body armor, and enhanced situation awareness (via an enhanced Tactical Operational Picture (TOP)). The stealthy body suit provides enhanced concealment for the Blue forces allowing them to blend into the ambient environment (i.e., for the near-term, 25% concealment was assumed). Body armor is modeled through the surrogate of increasing the number of Blue Hits to Kill (from 1 to 2). Situational awareness, representing an increase in the quality, quantity, and timeliness of information passed to the tactical level (through improved sensors and C2), is modeled by increasing the sensor range of the soldiers (from 15 to 30 range boxes in a 200 by 200 grid).

The base case corresponds to an existing small unit without any force protection enhancements. Figure 6 depicts the effect of proposed force protection technologies on average Blue casualties. It can be seen that adding stealthy body suits provides only marginal enhancements to Blue force survivability (i.e., approximately a 15% improvement). Conversely, adding either body armor or enhanced situation awareness provides substantial improvement (i.e., approximately 65% and 70% improvements, respectively). It is notable that these preliminary assessments suggest that implementing all three of the candidate technologies could reduce Blue casualties dramatically (i.e., on the order of 95% improvement). It must be cautioned, however, that these assessments are very preliminary and are merely suggestive of the benefits that could accrue from these enhancements. Rigorous experiments and analyses are required to develop more credible estimates of effectiveness.

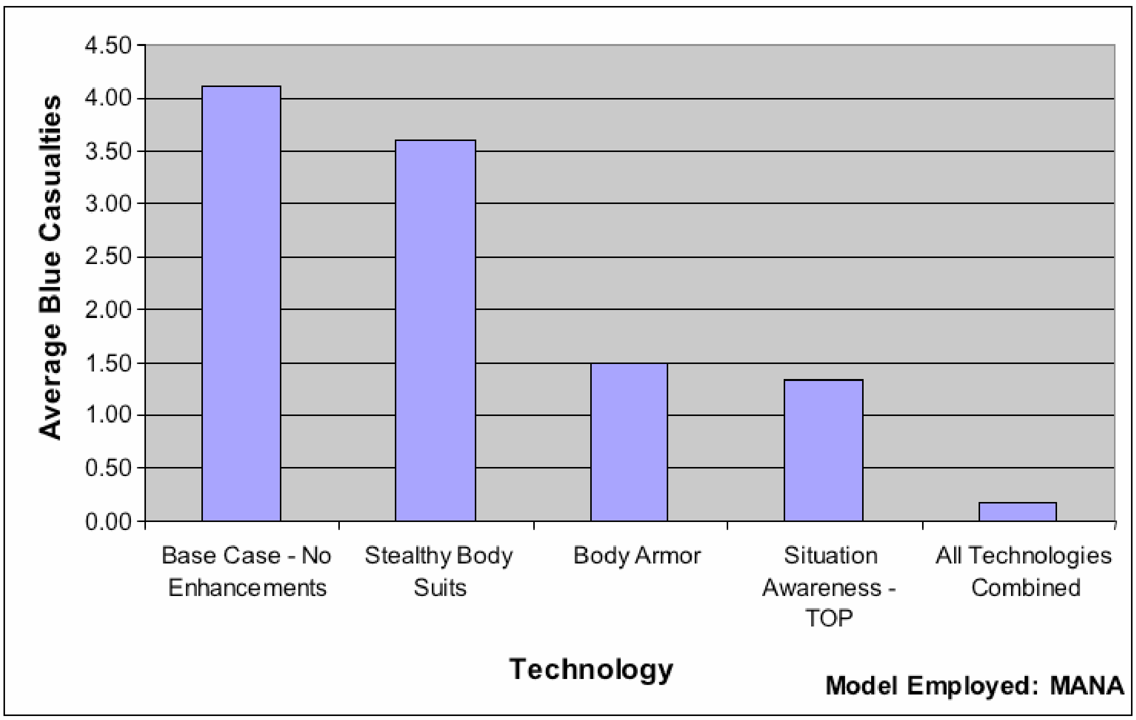

Figure 6. Market Vignette -- Cumulative Effects of Near-Term Materiel Enhancements

Figure 7 depicts the average time steps for Blue to complete its mission as a function of augmenting the Blue unit with additional force protection technologies. It is interesting to observe that when situation awareness was enhanced (either singly or in concert with other technologies), the average time for mission completion was *increased* substantially beyond the comparable average time for the base case (i.e., approximately a 130% increase). The reason for this increase in mission time is that Blue forces use this enhanced situation awareness to select paths through the market place which enable them to minimize their exposure to hostile members of the population and to minimize the exposure of neutrals to potential violence. This behavior is clearly observable in watching playback runs of the simulation. Conversely, if the Blue unit is equipped with either stealthy body suits or body armor, the average time to complete the mission is comparable to the base case.

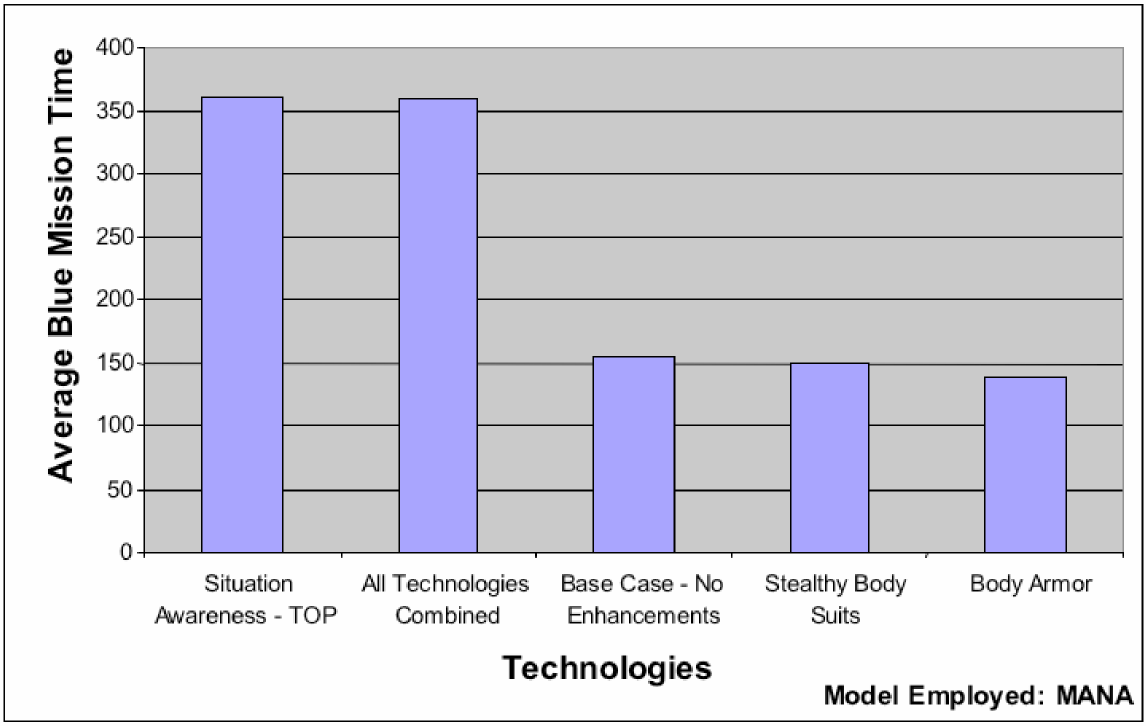

Figure 7. Market Vignette -- Cumulative Effects on Blue Force Mission Time for Near-Term Materiel Enhancements

Figure 8 depicts enemy and neutral losses as a result of Blue's use of near- term technologies. Two broad trends are in evidence. First, with the addition of stealth body suits and (to a lesser extent) body armor, Red and neutral losses *increase* (i.e., for stealthy body suits, Red and neutral losses beyond the base case are approximately 30% and 250%, respectively; for body armor, the corresponding increases are approximately 5% and 80%). The reason is that either of these technologies make Blue forces less vulnerable to enemy fire but do not enhance Blue's ability to distinguish foe from neutral. Blue is therefore able to increase its engagement of other forces in the market place, leading to increased kills of Red as well as of neutrals.

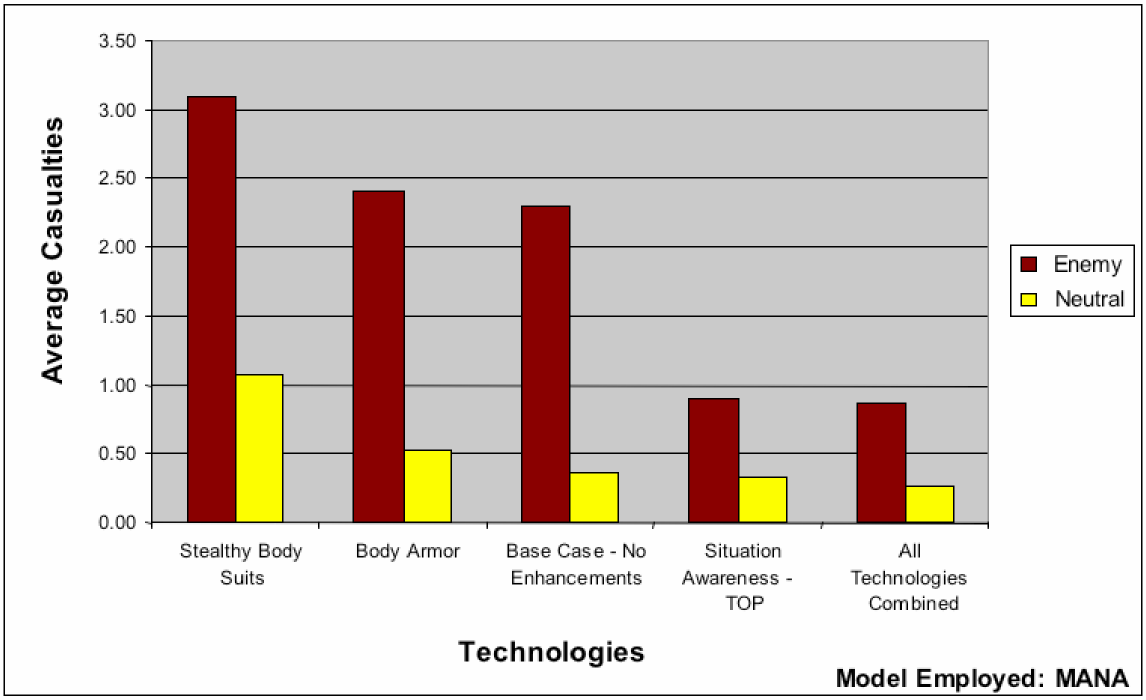

Figure 8. Cumulative Effects of Near-Term Blue Force Materiel Enhancements on Enemy and Neutral Casualties

Second, with the addition of enhanced situation awareness (and any mix of technologies including situation awareness), Red and neutral losses *decrease* (e.g., for enhanced situation awareness, Red and neutral losses are approximately 60% and 25% less, respectively, than the comparable base case values). The reason for these decreases is that with enhanced situation awareness, Blue forces are able to select paths that minimize their exposure to Red forces and are better able to distinguish foe from neutral. The cumulative effect is to decrease both the number of Red and neutral forces killed.

Figure 9 depicts the effect of far-term technology options on Blue force casualties. In this case, stealthy body suits represent uniforms that have an increased capability to blend into the landscape (i.e., 75% concealment was assumed). Situation awareness is enhanced beyond the near-term to represent a more global view of the situation (i.e., a common vice a tactical operational picture, extending to 60 range boxes). Additional technology options include non-lethal weapons as well as enhanced body armor that provides enhanced protection and reduced weight through the use of new materials (e.g., 4 Blue Hits to Kill, representing nanotechnology fibers).

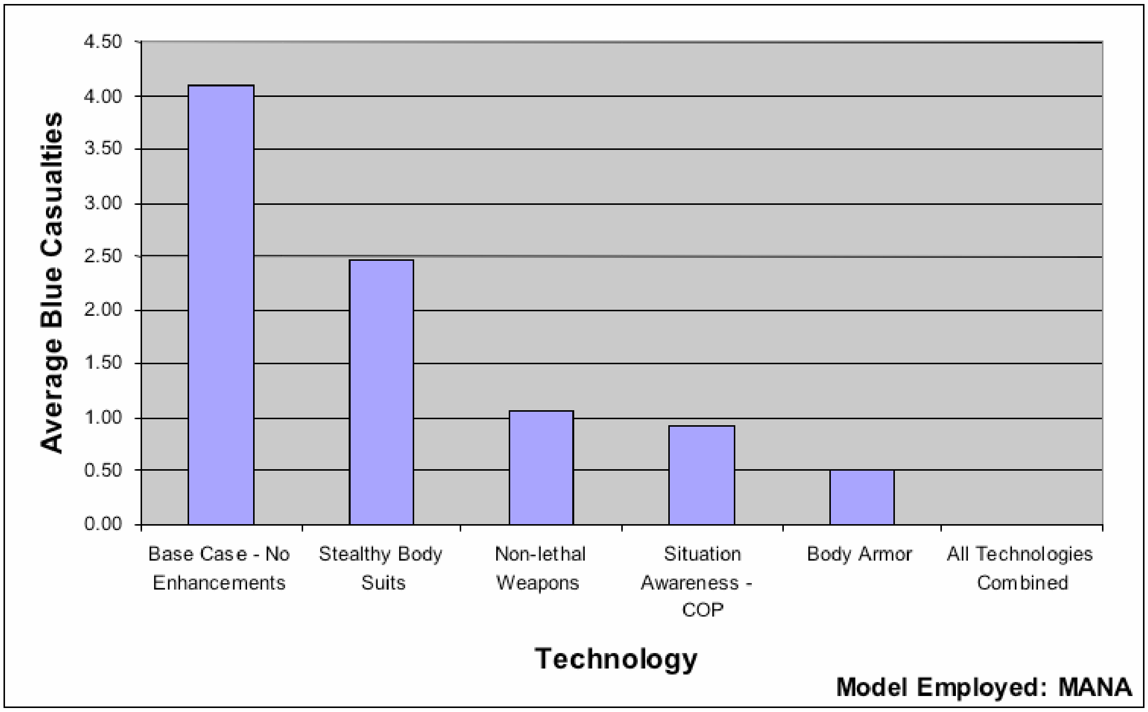

Figure 9. Market Vignette -- Cumulative Effects of Far-Term Materiel Enhancements

As depicted in Figure 9, Blue survivability is progressively enhanced by the addition of stealthy body suits, non-lethal weapons, situation awareness, and body armor. This constitutes a slight departure from the near-term assessment where situation awareness provided a slight improvement in average Blue casualties over the addition of body armor. However, given the preliminary nature of these calculations, these differences are not statistically significant.

In addition, when all of the technologies were implemented, simultaneously, for the market place scenario, the simulation revealed that Blue suffered nearly no losses, on average. Clearly, that result must be reassessed using a broader array of credible tools.

The trend depicted in Figure 10 is comparable to the trend seen in the slide assessing the impact of near-term options on average time of Blue to conduct its mission. Again, the addition of enhanced situation awareness makes extended paths visible through the market that enable Blue forces to minimize simultaneously their exposure to hostile members of the population and the exposure of neutrals to potential violence.

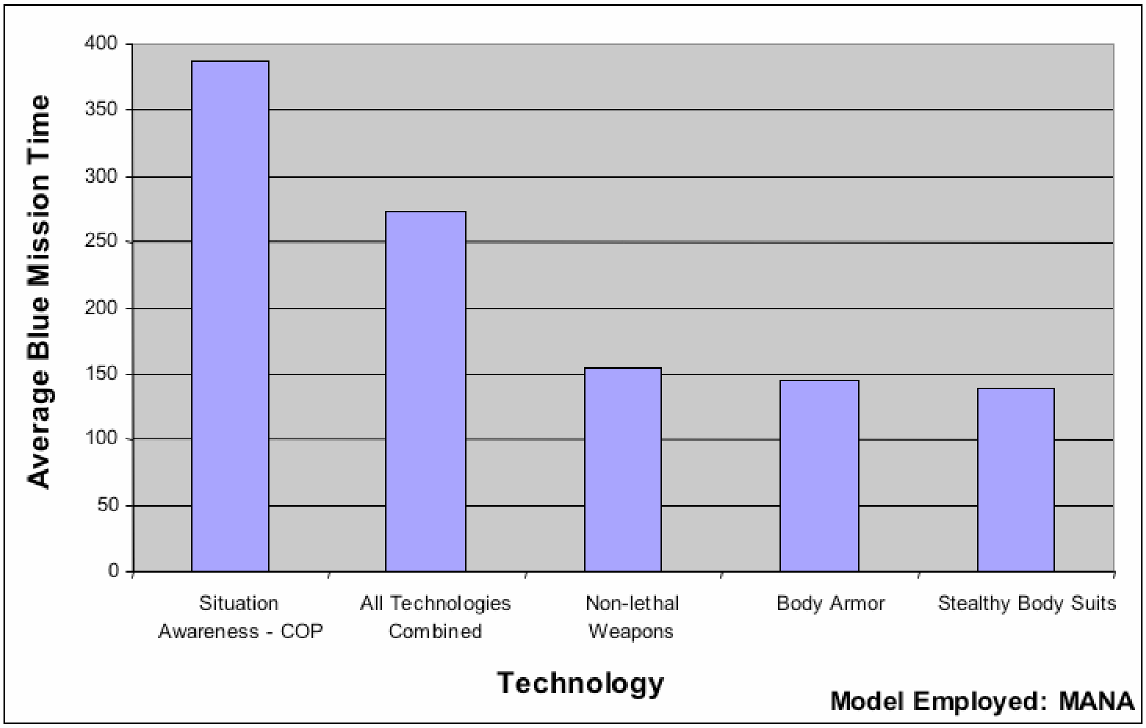

Figure 10. Market Vignette -- Cumulative Effects on Blue Force Mission Time for Far-Term Materiel Enhancements

The trend in average casualties for Red and neutrals depicted in Figure 11 for far-term options is broadly comparable to the near-term case with a few notable differences. For advanced stealth and body armor, the relative magnitude of Red and neutral casualties are reversed, in comparison to near-term stealth and body armor enhancements. Furthermore, the use of non-lethal weapons gives rise to Red losses that are roughly comparable to those for enhanced situation awareness. Note that non-lethal weapons and enhanced situation awareness result in substantial reductions in collateral damage (e.g., in comparison to stealthy body suits, enhanced situation awareness reduces the average neutral casualties by approximately 60% while non-lethal weapons reduce the average neutral casualties by approximately 90%). Finally, for all technologies combined, both Red and neutral losses are reduced appreciably below corresponding near-term values.

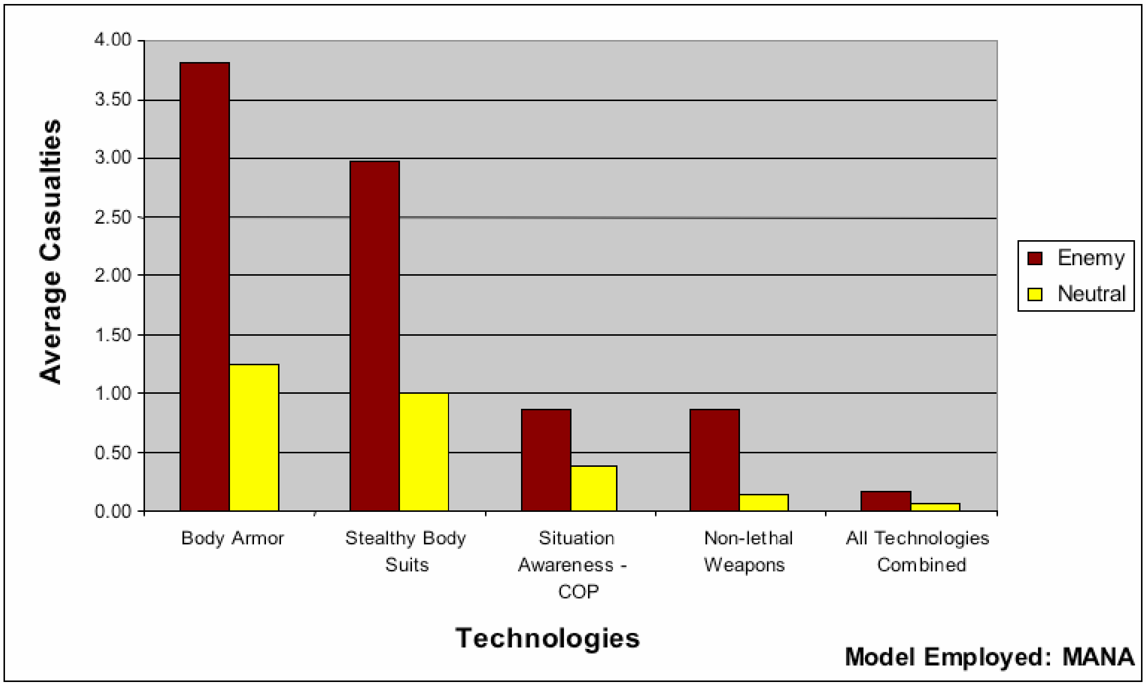

Figure 11. Cumulative Effects of Far-Term Blue Force Materiel Enhancements on Enemy and Neutral Casualties

Perspectives. In these preliminary assessments, measures of merit were considered that subsumed Blue, Red, and neutral losses. For the two timeframes of interest, no single materiel option dominated the others with respect to all of these measures (e.g., in the near-term, options such as enhanced situation awareness led to reduced Blue and neutral casualties, but they also gave rise to reduced Red casualties). If it is assumed that the primary objective is to reduce Blue casualties, then several of the individual options are particularly attractive. These include (in descending order of effectiveness) enhanced situation awareness and body armor, in the near-term, and enhanced body armor, improved situation awareness, and non-lethal weapons, in the far-term. Finally, in both timeframes, combined options subsuming *all* of the technology options identified by the S&T Panel manifest low levels of casualties for Blue, Red, and neutral.

There are a variety of mitigating options that should be pursued to deal with this high probability threat to small Blue forces. First, options should be explored to enhance the Identification, Friend, Foe, or Neutral (IFFN) process (e.g., enhance the quality of HUMINT; develop a target identification capability for dismounts). Second, if the results of these preliminary analyses are confirmed by further study and experimentation, consideration should be given to implementing the most cost-effective mix of DOTMLPF options, cited above. Finally, it is urged that options to enhance the training of small Blue units be pursued. In the near term, this would include enhancements to training in the areas of local culture, history, and language. With respect to the latter, there are cases where locals have tried to warn small units about impending ambushes, but the Blue forces have failed to understand them. In addition, the USMC has used the Combat Decision Range (Reference 9) to enhance squad proficiency in force protection. Since the tool is portable and low cost, consideration should be given to employing it to train small units of the Army. In the longer term, training should be enhanced through the application of several emerging products from the Institute for Creative Technologies (ICT). These include suitable adaptations of Full Spectrum Warrior and Full Spectrum Command, at the squad and company levels, respectively (Reference 10).

Analytically, there are a several actions that should be taken to enhance our ability to cope with such situations. First, it is essential that we pursue an aggressive research program to improve our understanding of the behavior of people from different cultures. This entails exploring the behaviors that are manifested in the context of a crowd as well as for individual actions. In addition, these behaviors need to be understood over a broad set of conditions. These include varying levels of fear, anger, and need (e.g., need for food, water, or sleep). Working with our allies, we should inject the results of this human behavior research into our evolving suite of force protection models. Subsequently, efforts should be undertaken to refine these models through the disciplined application of the model-experimentation-model paradigm.

E. Conclusions.
In order to develop an efficient, effective force protection capability, our preliminary analyses suggest that efforts should be pursued to develop a balanced Defense-in-Depth, force protection capability.

In the pre-attack phase, this implies that a series of options be pursued that enhance a broad set of sub-functions. These include: improving current attack prediction capabilities; extending and enhancing battlespace monitoring; strengthening efforts to deter, deny an attack (e.g., keep threats at or beyond effective ranges; randomize actions); enhancing protection (e.g., selectively hardening key nodes); and improving readiness (e.g., enhance training; set appropriate FPCONs; conduct regular, routine exercises).

In the trans-attack phase, options should be pursued that provide enhanced stand-off and early warning. This includes improvements in sensing (e.g., long range detection, classification, and identification of adversary threats), communicating, hardening, and neutralizing (lethal, non-lethal).

In the post-attack phase, options should be pursued that mitigate the effects of an attack (e.g., enhance responsiveness of emergency responders), facilitate the restoration of breached defenses, and provide the insight needed to enhance the protection of the force against future threats.

It must be emphasized that the substantive assessments that we performed are preliminary in nature. As such, they are suggestive of the DOTMLPF actions that should be taken to enhance force protection effectiveness and efficiency. These preliminary results point to two major conclusions for protecting mobile forces:

- The potential utility of selected materiel and operational actions to enhance the protection of a convoy (e.g., employing armed UGVs and UAVs; developing and deploying “designer” obscurants)
- The value of suitable levels of protection (e.g., enhanced body armor), enhanced situation awareness, and non-lethal weapons in reducing casualties while performing small unit operations.

We recommend strongly that additional, rigorous analyses be performed to confirm and extend these preliminary conclusions.

F. References

1. Larry Wentz, “Lessons From Kosovo: The KFOR Experience”, CCRP, July 2002.
2. Claude Bolton, Assistant Secretary of the Army (Acquisition, Logistics, and Technology), ToR for ASB Summer Study “Force Protection Technologies for the 2010 – 2020 Time Frame”, 9 December 2002.
3. ASB 2001 Summer Study. “The Objective Force Soldier/Soldier Team”, July 2001 (see ASB website https://webportal.saalt.army.mil/sard-asb/).
4. FIST Countermine Phase I Report, Sandia National Labs, July 2002.
5. Michael Lauren, et al, “Modeling Precision Maneuver Using Mana”, Maneuver Warfare Science 2002 (Edited by Gary Horne and Sarah Johnson), June 2002.
6. TRADOC Regulation 525-13, Fort Monroe, VA, 12 December 1997.
7. Gary Horne and Mary Leonardi, editors, Maneuver Warfare Science 2001, Marine Corps Combat Development Command, February 2001.
8. Brian K. Schmidt, T. N. Shimi, “C4ISR Investment Planning with the Portfolio Analysis Machine (PALM)”, MITRE Technical Report, MTR 00B0000057V01, December 2000.
9. Combat Decision Range (CDR). See http://www.mcwl.quantico.usmc.mil/fact_sheets/fs/cdr_h.pdf
10. Full Spectrum Warrior. See http://www.ict.usc.edu/disp.php?bd+proj_games_fsw

G. Abbreviations and Acronyms

Term	Definition
ASB	Army Science Board
C2	Command & Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
COP	Common Operational Picture
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel, and Facilities
FARP	Forward Arming and Refueling Point
FCS	Future Combat Systems
FIST	Future Combat Systems (FCS) Integrated Study Team
FPCONs	Force Protection Conditions
FRY	Former Republic of Yugoslavia
HMMWVs	High Mobility Multipurpose Wheeled Vehicle
HUMINT	Human Intelligence
ICT	Institute for Creative Technologies
IFFN	Identification Friend, Foe, or Neutral
INFOSEC	Information Security
MoMs	Measures of Merit
OOTW	Operations Other Than War
PALM	Portfolio Analysis Machine
S&T	Science & Technology
TOP	Tactical Operational Picture
TTPs	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UGVs	Unmanned Ground Vehicles
USMC	United States Marine Corps