2. Augmenting Allies

It seems clear that the U.S. will seek to employ its forces in a coalition context. These situations appear to be characterized by a wide range of limitations and constraints that arise because of differences in doctrine, communications, training, equipment, and experience in working with U.S. forces. Further, differences in allied ground force capabilities (lack of adequate combat power) and approach to the conflict (excessive aggressiveness or hesitancy) may invite or force close battle with the enemy, thus increasing the need to augment allies and other coalition partners with close support at levels above those that the U.S. would plan for if supporting only U.S. ground forces.

We have selected two vignettes as representative of these battle situations:

- Escort of a Humanitarian Convoy
- Support for an Allied Enclave

Escort of a Humanitarian Convoy

Ambush engagements are typical of light infantry combat and leading edge situations in which large areas are contested. Battlefield situations of this type could be found in each of the major scenarios we examined in the scenario assessment and map exercise phases of this analysis.

Ambush engagements are often characterized by a relatively long preparation phase lasting hours or days (especially if the attacking force is infantry and needs to march to the ambush site) and an intense and short combat phase lasting minutes or tens of minutes, followed by a disengagement/pursuit phase that may be comparable in length to the preparation phase. Typically the force under attack is a large, “lucrative” target (including multiple logistics/troop transport vehicles not well configured for fighting) and is constrained by the terrain (e.g., limited to movement on a road). Historical examples abound; one that is particularly well documented is an ambush that took place on National Highway One during the Vietnam conflict in November of 1966 (Cash, 1985).

JANUS Vignette—Escort of a Humanitarian Convoy

We have developed a prototypical combat situation for JANUS that captures many aspects of the ambush of a convoy when modern weapons are involved. While ambushes could occur in each of the theater-level scenarios we examined, we chose the heavy force contingency in northcentral Europe as the setting for this vignette. In it a RED ambush force consisting of 24 light infantry troops moves in a 13-hour march to an ambush position to set up on an east-west road segment
The team is equipped with man-portable anti-tank weapons and mines; its ammunition is limited to what can practically be carried during the march. As shown in Figure 2.2, the troops follow an indirect route to avoid compromising the location of their ambush site should they be detected.
This vignette is composed of a small BLUE force consisting of 10 M2 .50-caliber machine guns mounted on high-mobility, multipurpose wheeled vehicles (HMMWVs) escorting a GREEN allied convoy consisting of 30 medium tractor-trailer trucks carrying supplies for an allied enclave. The RED force consists of 24 light, irregular infantrymen armed with light machine guns and light to medium anti-tank weapons. The RED force infiltrates into the BLUE/GREEN rear area with the intent of setting up an ambush on the main supply route (MSR). Their mission is to destroy the BLUE/GREEN convoy and the supplies. The ambush is linear and conducted from near to far in range from the MSR. Upon completion of its mission, RED is to egress by foot and exfiltrate back into friendly territory by blending in with the indigenous population.

The terrain on which the vignette is set is rolling hills with moderate foliage with a well-established road network. The weather is good, and the base case is defined by current force capabilities for both RED and BLUE.

The team sets up its killing zone along 3000 meters of road using the range of its missiles to distance itself about 1000 meters from the killing zone in positions on the south side of the road.
At the east and west ends of the killing zone, the road will be cut by cratering devices (shown by a large “C” in the figure). The terrain over the ingress route and in the ambush area is rolling to broken with moderate foliage cover.

A BLUE convoy consisting of 10 escort and 30 support/supply vehicles moves from east to west along the road in a doctrinal road-march convoy. The convoy’s movement from its jump-off point to the killing zone takes about 3.5 hours and covers about 70 km (20 kph).

Situation Assessment

For each of the vignettes used in this study, we determined a success criterion for each of the forces involved in the battle. The assessment took account of the point at which a unit would no longer be able to conduct its immediate mission, whether it was required to conduct other actions without reinforcement in the larger theater-level scenario, and how frequently the situation in the vignette would need to be faced. Our overall scenario analysis (reported on in Appendix A) set the larger context for each of the vignettes used to assess our critical combat situations. This allowed us to make judgments about important considerations beyond the vignettes used in the simulations, which in some cases lasted only minutes. The success criterion for the BLUE/GREEN force in this vignette is determined by how well the convoy can be protected during the ambush. Since the purpose of the convoy is to provide supplies at a given location, not to cause RED casualties, convoy survivability was chosen as the primary measure of effectiveness (MOE). We estimated that BLUE/GREEN would not accept a loss rate of over 4 percent for humanitarian operations over the long run. The losses suffered by the RED force were not included in the success criterion, except for their indirect effect on BLUE/GREEN survivability. This is because an adversary could sustain ambush operations even if high casualties were imposed on such small ambush teams, so long as a sufficient number of the convoys could be subjected to ambush. The success criterion for RED is measured in terms of how much of the convoy the attacking force destroys.

The engagement phase begins when the convoy enters the killing zone and reaches the trigger point. The engagement takes less than 10 minutes to play out and typically results in the loss of about 20 convoy vehicles when RED breaks off the attack and withdraws. This base case situation embodies an escort response but no use of close support assets. The simulation continues through the disengagement/pursuit phase (see Figure 2.2).

The base case results in the attrition shown in Table 2.1. With the loss of about three members of the ambush team, the RED force destroys about half the convoy, approximately 15 trucks. These results make the ambush a very attractive tactic for RED, and make it virtually impossible for BLUE to sustain such losses for even a short time period.
Table 2.1

<table>
<thead>
<tr>
<th>Systems</th>
<th>Start</th>
<th>End</th>
<th>Percent Survived</th>
<th>Percent Total Force Surviving</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLUE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trucks</td>
<td>30</td>
<td>14.6</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>HMMWVs</td>
<td>10</td>
<td>4.7</td>
<td>47</td>
<td>49</td>
</tr>
<tr>
<td>RED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambushers</td>
<td>24</td>
<td>21.7</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

Source: RAND analysis.

Figure 2.3 shows the results for this situation when the ground force is enhanced. The filled-in square in the figure shows the results of the baseline engagement. Roughly 45 percent of the GREEN trucks are destroyed, and only two members of the ambush team are killed. In an attempt to achieve a more desirable outcome, the engagement capability of the BLUE escorts was enhanced. The upgraded force closest to the base case in capabilities had systems with the capability to engage targets in 87.5 percent of the engagement time needed by the systems used by the base case force. The next points represent upgraded forces that took only 75, 50, and 25 percent of the time it took for the base case force systems to engage a new target. The systems in the most capable of the upgraded forces (the point farthest to the right on the chart) are able to engage a new target in essentially zero time. This improved target engagement time can be thought of as a surrogate for improved sensor, cueing, or C4I capability for the BLUE/GREEN forces. The point to the right of Figure 2.3 shows the results when the HMMWV escorts are replaced with Bradley fighting vehicles. Although the Bradleys are more lethal than the HMMWVs, the survivability of the BLUE/GREEN forces is not improved.

The substantial, notional enhancement only improved the GREEN survivability to about 55 percent with three members of the ambush team killed. Improving the offensive capability of the escort forces does little to reduce the negative impact of the ambush. Two interesting results emerge from this chart and are evident in the subsequent cases as well. First, improving the engagement capability of the ground force makes it more lethal, as would be expected. However, upgrading the ground force does not have as pronounced an effect on the BLUE/GREEN survivability.

The introduction of Bradley fighting vehicles in place of the HMMWV escorts may be a partial solution, but it does not solve the basic problem of substantially improving the GREEN survivability. It changes the nature of the deployment and allows the convoy escort to provide a considerably more aggressive execution of its mission. It might, however, change the priority for target selection by the heavy weapons teams of the ambushing force, which would result in the Bradleys being preferentially targeted.
Figure 2.3—Escort of a Humanitarian Convoy: Force Performance When Ground Force Capability Is Enhanced

Figure 2.4 depicts the performance of the BLUE forces when notional close support is employed to reduce the capability of the ambushing forces. The analysis was carried out by parametrically removing the most valuable RED forces from the vignette in order of priority before the battle was joined. In this way we are able to simulate a situation in which close support is used in the most effective manner possible in the scenario (e.g., it was completely effective in eliminating the most valuable targets). The analytic construct simulates the maximum potential effect of some form of close support so that we can understand its greatest potential impact in this combat situation. This also allows us to understand how the effects of close support change the performance of the ground force in the scenario. In this way we can evaluate how the use of close support changes the targets available to the ground force and the attrition it suffers. This does not address the ability of the various systems we are assessing to actually provide these levels of close support. Such issues are addressed in the systems analysis excursions that follow the scenario assessments — if the potential impact of close support indicated by the scenario analysis is sufficient to warrant further examination of the systems.

In the figure, the point closest to the base case had three anti-tank gunners removed from the ambush. The next three points (moving upward on the graph) show the effects of removing six, eight, and 10 anti-tank gunners from the RED force before the ambush commences.

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1 That is, the RED forces that would inflict the greatest damage on BLUE in the base case were removed. The specific force elements that were selected were determined by analysis and computational experiment. Due to the dynamics of combat simulated in these scenarios and the fact that the battle that results after any change in capability is different from the battle that obtains in the base case, this analytic technique can provide only an approximation of the best targets to attack. (See the analysis of the Prepared Defense by Light Forces vignette in Section 4 for a discussion of the improvements in scenario outcome that an adaptive targeting system can provide.)

2 For a host of real-world reasons (e.g., Pk less than one, acquisition constraint, and close support system attrition), the capabilities of the systems assessed in this study have a lesser impact on RED forces in our simulations than does the notional close support used in the scenario assessments.
The clear picture that emerges is that as the close support reduces the initial number of RED forces in the ambush, the GREEN survivability improves substantially, but the number of members of the ambush team killed by the BLUE escort force decreases. This is apparently the result of the reduced availability of targets for the BLUE forces to engage.

Figure 2.5 shows the number of RED ambush team members killed by the combination of notional close support (the number of anti-tank gunners removed is annotated next to the point) and BLUE escorts. Not surprisingly, as the amount of close support increases, the GREEN convoy trucks survive better and more members of the ambush team are killed.
Observations on Future Close Support Needs and Desirable System Characteristics

Actual systems are subject to constraints that limit their capabilities in comparison to the notional close support. Because substantial losses by BLUE/GREEN could not be precluded even in the extreme notional close support cases, we did not conduct a full analysis of the actual, less capable systems. Since the whole engagement is over in 10 minutes, fixed-wing systems would have to be on a local combat air patrol (CAP) in order to arrive in time to make a difference. Target acquisition problems make the fixed-wing option unattractive, even if targets can be designated by the escort force. Advanced artillery systems provide similar challenges. Detailed fire support plans and complex communications would be required, and collateral damage would be a serious consideration.

We did, however, examine some aspects of actual system capabilities. In one of these assessments, four helicopters arrived on the scene 10 minutes after the start of the ambush and conducted a pattern search centered on the ambush site. Within 60 minutes of the start of the ambush, they had detected 23 of 24 members of the ambush team during their egress from the ambush area. This implies that present sensor technology satisfies the close support requirement after the ambush (a much less challenging criterion—significantly damage or destroy the ambush force). However, it must be noted that the members of the ambush team were egressing through
unpopulated countryside, and the requirement to distinguish the enemy from innocent noncombatants was not required.

Our analysis of this vignette resulted in three major observations:

**Responsiveness is a key requirement for close support but masks the need to keep the ambush team from firing at all.** The short duration of the ambush makes responsiveness an almost impossible requirement for close support. Dedicated fixed-wing or attack-helicopter assets flying “CAP” for the convoy can respond in minutes. Helicopters can be sufficiently lethal to impose significant attrition on the members of the ambush team. But neither can respond quickly or lethally enough to preclude the effects of the ambush. Real-world constraints compound this problem. As was observed in Afghanistan, the introduction of shoulder-held SAMs can make the attack helicopters a lucrative target. The requirements for escorting convoys can increase the forces needed for support beyond in-theater capabilities. Advanced artillery support requires an extensive, detailed fire coordination plan, real-time communications, and timely movement of the fire units. In short, we see no practical solution to the ambush problem using close support in a responsive mode.

**Discriminative retribution may have a deterrent value.** If precluding the ambush is not possible, the threat of retribution may deter the enemy from taking part in future ambushes. However, the literature is replete with discussions of the negative implications of indiscriminate retribution. Some form of marking, designating, or tagging the individuals involved in the ambush might be useful so that they could be punished subsequent to the actual ambush. Research into sensing, target discrimination, and marking might prove to be quite beneficial.

**Don’t get ambushed.** Providing enhanced lethality for the escort forces has been shown to be of limited value. Close support kills more members of the ambush team but only marginally limits the losses to the convoy, even in the most effective notional close support case. The importance of avoiding the ambush emphasizes the importance of battlefield information. HUMINT could be quite beneficial in ambush avoidance. Remote sensing could also contribute valuable information. Shoulder-held weapons such as rifles and anti-tank rockets are in effect a dipole. If these could be detected remotely, it could warn of an impending ambush or allow detection of the members of the ambush team on their march to the ambush site. Similarly, high-resolution optical or IR sensors might detect the team as it moves into ambush positions.

**Supporting Allied Enclaves**

History is replete with siege situations where one force is ensconced in a town or fortification and an adversary is attempting to take possession and control of the enclave. For example, the

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3See, for example, Leites and Wolf, 1970.

4In a recent interview, a highly placed Defense official related a discussion with a Russian general commanding troops against the Chechen rebels in 1994 at Grozny. When the Russians captured rebel suspects, they stripped them to the waist to see if they had bruises on their shoulders characteristic of firing shoulder-held weapons, such as the AK-47. The method may be crude, but it testifies to the Russian appreciation for the need to avoid indiscriminate attribution.
Vietnam conflict involved two famous enclave situations: Dien Bien Phu, in which the communist forces prevailed, and Khe Sanh, in which they did not, due largely to massive close support efforts. Because the Balkan situation operation presents numerous opportunities for enclave situations, we chose the peacekeeping contingency in the Balkans as the setting for this vignette.

**JANUS Vignette—Supporting an Allied Enclave**

The enclave is defended by a small BLUE force consisting of four tube-launched, optically tracked, wire command-linked (TOW) missile launchers mounted on HMMWVs and six HMMWV Scouts supporting a GREEN allied force consisting of one company of light, irregular infantry in defense of an enclave on the outskirts of an urban population center.

The enclave is attacked by a RED force consisting of approximately three battalions of heavy and medium tracked armored vehicles supported by several batteries of light to medium cannon artillery. The mission of the GREEN/BLUE allied force is to prevent penetration of the enclave by the RED force, whose mission is to eliminate the enclave by inflicting as much attrition as possible on the allied forces.

In order to accomplish its mission, the RED force attacks, as shown in Figure 2.6, with a main attack on the high-speed avenue of approach from the west and two small supporting attacks from the north and northeast.
Situation Assessment

The vignette is set on hilly, cross-compartmented terrain with limited lines of sight and fields of fire except down the high-speed avenue of approach. The foliage along the avenues of approach on which RED attacks is sparse. The weather is good, and the base case is defined by current, albeit low-end, force capabilities for the RED, GREEN, and BLUE forces.

Source: RAND analysis.

Figure 2.6—Supporting an Allied Enclave: Initial Force Deployments

The survival of the enclave hinges on the attrition of the RED forces to a point at which they can no longer pose a threat without reinforcement. We determined that this would establish a success criterion that required the BLUE force to repulse the RED force while suffering no more
than 25 percent attrition. The mission of the RED force is to seize the enclave with at least one-third of its mounted force intact so it can reconsolidate in the enclave and repel any counterattack conducted by remnants of the GREEN/BLUE defense force. Thus, to be successful, BLUE would need to lose no more than one-quarter of its force while destroying at least two-thirds of the RED force.

The base case results for the Defense of an Allied Enclave are shown in Table 2.2. These results are similar to the attrition that the Chechens inflicted on the Russian forces that were attempting to seize the Chechen capital, Grozny, in 1994.5

Table 2.2

<table>
<thead>
<tr>
<th>Systems</th>
<th>Start</th>
<th>End</th>
<th>Percent Survived</th>
<th>Percent Total Force Surviving</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLUE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMMWV-TOW</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>HMMWV-Scout</td>
<td>6</td>
<td>2</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Machine gunner</td>
<td>20</td>
<td>12</td>
<td>60</td>
<td>47</td>
</tr>
<tr>
<td>Dragon gunner</td>
<td>30</td>
<td>12</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Rifleman/law</td>
<td>40</td>
<td>20</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Grenadier/Law</td>
<td>40</td>
<td>20</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>RED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-72</td>
<td>50</td>
<td>23</td>
<td>46</td>
<td>39</td>
</tr>
<tr>
<td>BMP-2</td>
<td>40</td>
<td>12</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

Source: RAND analysis.

Figure 2.7 shows the performance of the BLUE/GREEN base case forces as a filled-in square. About 52 percent of the BLUE/GREEN force survive, and it kills about 55 of the attacking RED mechanized forces.

5See, for example, Grau, 1995.
The open squares that are up and to the right of the base case depict the performance of the force when it has been given enhanced engagement capability. The upgraded force closest to the base case in capabilities had systems with the capability to engage targets in 87.5 percent of the engagement time needed by the systems used by the base case force. The next points represent upgraded forces that took only 75, 50, and 25 percent of the time it took for the base case force systems to engage a new target. The systems in the most capable of the upgraded forces (the point farthest to the right on the chart) are able to engage a new target in essentially zero time. This improved target engagement time can be thought of as a surrogate for improved sensor, cueing, or C4I capability for the BLUE/GREEN forces.

As previously reported, improving the capability of the ground force makes the BLUE/GREEN forces more lethal, as would be expected. However, enhancing the ground force engagement capability does not have as pronounced an effect on the BLUE/GREEN survivability. In fact, the success criterion is reached only in the case that is probably the least achievable, where it takes almost zero time to acquire a new target.

Figure 2.8 shows the performance of the BLUE/GREEN forces when notional close support has been applied to counter the attacking forces. The analysis was carried out by parametrically removing the most valuable RED forces from the vignette in order of priority before the battle was joined. The point closest to the base case had 10 armored fighting vehicles (AFVs) removed from the main RED axis of attack. The next five points up and to the left on the graph represent the removal of 20, 30, 40, 50, and 60 AFVs from the RED force before the battle commences. In the first four cases, the AFVs were removed from the main RED axis of attack. The last 10 and 20 AFVs removed were taken from the supporting attacks.
The interesting result that emerges from this case (and the subsequent cases) is that although the surrogate close support dramatically improves the BLUE/GREEN survivability, the ground forces kill fewer and fewer RED systems. This is due in part to the fact that there are fewer RED systems for the ground forces to engage. In addition, the BLUE/GREEN forces were initially arrayed so that the majority opposed the RED main axis of attack. Since the first four cases simulated close support by removing targets from the RED main axis of attack, the BLUE/GREEN forces were in essence misallocated. This is not an unrealistic representation. Light forces do not have a lot of firepower, and an additional, often over-looked characteristic is that light forces have even less tactical mobility. In the course of a real engagement, as the close support reduced the RED main axis of attack, the BLUE/GREEN forces would not have the mobility to reposition their firepower in real time.

Figure 2.9 shows the graph of the ground force kills added to the RED forces removed to simulate close support kills. The first notional close support case satisfies the lethality success criterion, but it takes the removal of 40 AFVs to satisfy the BLUE/GREEN survivability success criterion.
Combined Ground Force and Notional Close Support Kills

Note: The number below each point indicates the number of AFVs removed before the simulation began.

Figure 2.9 — Supporting an Allied Enclave: Combined Close Support and Ground Force Effects on the Battle

Observations on Future Close Support Needs and Desirable System Characteristics

Advanced artillery faces a number of employment challenges in the urban environment. The urban environment provides limited locations from which to employ advanced artillery. The attackers probably have sufficient familiarity with the enclave to know the places — e.g., parks, schoolyards, and parking lots — from which artillery can be employed. The weapons and their ammunition stores provide lucrative targets for counterbattery fire.

The use of an external firebase concept also has some inherent limitations. The attacking targets must be serviced in all directions around the enclave. The urban area may mask some targets and prevent them from being fired upon from an external firebase. In addition, the firebase is itself an enclave, susceptible to attack.

The right battlefield information can importantly improve close support system performance. These situation assessments suggested that there is an important payoff for battlefield information. Given that the study team’s analysis was oriented to finding “firepower” answers, these “information” insights are all the more notable. To explore this finding further, the study team conducted a series of excursions to examine the role of information in this battle to illuminate the issue of just how much advantage could be taken of its potential value. Figure 2.10
represents the allocation of the 30 BLUE medium anti-tank weapons to the likely avenues of enemy approach in the base case, based on the preliminary assessment of the characteristics of the avenues of approach.

The arrows represent the allocation of attacking AFVs: 78 percent to the main attack from the west, and 11 percent to each of the two supporting attacks from the north and northeast.

Figure 2.11 represents how the BLUE/GREEN commander would have allocated his medium anti-tanks weapons had he had access to perfect information with respect to RED’s attack allocation.
Figure 2.11—Initial Force Allocation with Perfect Information Concerning Enemy Intentions

Figure 2.12 depicts the final allocation of attacking RED forces after 60 AFVs were removed by notional close support. The BLUE anti-tank weapons were allocated with no prior information concerning RED’s attack intentions and no information concerning the planned close support attacks or their results. This clearly shows that in the absence of these pieces of combat information, the medium anti-tank weapons were badly misallocated.

Figure 2.13 shows how the BLUE commander would allocate his anti-tank weapons if he had perfect initial information concerning the RED attack intentions and perfect prediction of the attrition caused by close support.

Figure 2.12—Force Allocation After Notional Close Support Has Been Applied, But With No Information Concerning Enemy Intentions or Close Support Results
38

Figure 2.13—Force Allocation with Perfect Information Concerning Enemy Attack Intentions and Close Support Results

It seems unlikely that a commander would be so confident in the quality of his intelligence information and the predicted contribution of the close support that he would knowingly misalign his forces to concentrate on the support attacks and count on the close support to counter the main attack. This is undoubtedly true regardless of the close support system involved. However, the ground commander would probably be most confident in his own, organic advanced artillery, somewhat less confident in attack helicopters, and even less confident in the availability of the other service’s fixed-wing close support. This philosophic debate is beyond the scope of this research. However, Figure 2.14 does show the difference in BLUE performance that could result if the sensing and C4I systems were sufficiently developed so that a BLUE commander was willing to depend upon the battlefield information they provided.

Figure 2.14 compares the results of the notional close support runs with no changes to the allocation of firepower by the supported ground force, to cases in which the combat firepower of the ground force was reallocated based on perfect knowledge of what effect the notional close support had on RED in each application.
Figure 2.14—The Value of Varying Amounts of Battlefield Information

In general, we see a translation of the force performance measures (RED attrition, BLUE survivability) moving to the right and up on the graph, reflecting on improvement with respect to both measures of performance.

Figure 2.15 shows the change in each of the notional close support application cases after perfect reallocation of the ground force. Since every case results in a sufficient destruction of RED forces, this figure focuses on BLUE survival. The length of the individual bars shows the value of perfect information in each case. In general, in terms of BLUE survivability, information is more valuable when less firepower is available.

Figure 2.15—Improvement in BLUE Survivability Resulting from the Perfect Reallocation of Ground Force Firepower in Response to the Effects of Close Support
Fixed-wing aircraft or attack helicopters must provide a high AFV kill rate. The notional close support removed as many as 60 AFVs from the attack. To kill this many targets from the confined air space in the vicinity of an enclave will require multiple AFV kills per pass and multiple passes per sortie.

Better target-pattern/munitions-pattern matching would improve fixed-wing capabilities. Table 2.3 shows the munitions patterns used in the JANUS simulation for seven cases in which the F-16s delivered sensor-fuzed weapons (SFWs) against the RED forces. The targets were company-sized formations of armored vehicles. In the first five cases, the attacks were made against moving targets; cases 6 and 7 simulated attacks against the company-sized target arrays prior to the start of their assault (stationary columns in assembly areas).

Table 2.3

<table>
<thead>
<tr>
<th>Case</th>
<th>Munitions Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Base-case SFW footprint, 10 BLU-108s per TMD</td>
</tr>
<tr>
<td>Case 2</td>
<td>4 x base-case SFW footprint, 10 BLU-108s per TMD</td>
</tr>
<tr>
<td>Case 3</td>
<td>16 x base-case SFW footprint, 10 BLU-108s per TMD</td>
</tr>
<tr>
<td>Case 4</td>
<td>16 x base-case SFW footprint, 5 BLU-108s per TMD</td>
</tr>
<tr>
<td>Case 5</td>
<td>16 x base-case SFW footprint, 5 BLU-108s per TMD, 50% improved Pk</td>
</tr>
<tr>
<td>Case 6</td>
<td>Base-case SFW footprint, 10 BLU-108s per TMD</td>
</tr>
<tr>
<td>Case 7</td>
<td>4 x base-case SFW footprint, 10 BLU-108s per TMD</td>
</tr>
</tbody>
</table>

Source: RAND analysis.

The results in Figure 2.16 clearly show that the effectiveness of fixed-wing-delivered SFWs against moving targets is sensitive to the footprint size of the individual sub-munitions. This is caused by the match or mismatch between the configuration (target pattern) that the targets present and the munitions pattern, or footprint. SFW effectiveness is constrained by the limited ability of the aircraft to align the long, narrow SFW footprint with the linear axis of the target vehicle arrays.

Since this weapon-pattern/target-pattern matching is one of the primary determinants of SFW effectiveness, the assessments that result from our analysis of SFW capabilities are generally more pessimistic than those found in most studies. This is because most analyses typically do not model the entire battle situation or aircraft flight paths. They rely instead on assumptions about how well the attack axis is aligned with the target axis. In general, these assumptions are more favorable to fixed-wing capabilities than our analysis found was warranted in the battle situations we simulated.

To explore the munitions characteristics that could improve this situation, we examined wider SFW footprints. The evolution of the cases from 1 to 3 represents improvement in sensor technology on the Skeet sub-munitions without any payload cost. Case 4 represents a 50 percent
payload cost for the sensor technology and deployment mechanism in the TMD, and case 5 represents the recovery of some of the cost in case 4 in the form of a hypothetical 50 percent increase in $P_k$.

Figure 2.16—Supporting an Allied Enclave: Results of Fixed-Wing Systems Using SFW Against Moving Target Arrays

Note that the most realistic case simulated (case 5) still leaves us somewhat below the predefined success criterion for the vignette. As a result, we also explored a change in the employment of the F-16s to increase the effect of their attacks. Figure 2.17 shows the JANUS results for cases 6 and 7, in which F-16s deliver the SFW against the stationary target arrays, attacking the vehicle arrays before they have begun their movement to contact.

The results show that when the target arrays are stationary, an improvement in the sub-munition’s sensor technology that would result in a fourfold increase in the SFW footprint size would allow the fixed-wing attacks to meet the success criterion for the vignette. This is attributable to better matching of the weapons pattern to the size and spacing of the target elements and to the lack of movement during the prior-to-movement posture. These cases, however, also imply the need for an information system that is capable of identifying the targets in such a posture and focusing the airpower on the opportunity. There are also rules of engagement and fratricide issues that must be addressed if such wide-footprint munitions are to be employed in close support.

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6 In addition to sensor improvements, aerodynamic forces may be needed to disperse the sub-munitions away from the attack axis to widen the pattern, as is typically done with mini-missile sub-munitions.
Figure 2.17—Supporting an Allied Enclave: Results of Fixed-Wing Systems Using SFW Against Stationary Target Arrays

This potential lethality improvement due to footprint size (actually, to better matching of the munitions’ footprint with the target’s footprint) occurs because of the typical armored target configurations that occur in battle. In mechanized combat, particularly in the defensive battles where close support may be most critical to battle outcomes, targets present themselves in two general configurations over the course of the battle.

The first is a small formation of platoon to company size (three to 10 vehicles), in attack formation, as illustrated in Figure 2.18. Vehicle spacing is influenced by terrain but is on the order of 100 meters, and the vehicles are arrayed in a line-abreast configuration parallel to the line of defenders and move to contact in a direction perpendicular to the line of defenders. While there are multiple variations of these formations on the battlefield at any given time, and they could be addressed as larger target aggregations for fleeting periods of time, the most consistent target that presents itself is the smaller unit, because it is the fundamental fighting unit on the battlefield. These targets are present throughout the course of the battle and form the majority of targets that must be serviced by systems providing close support.
The second target configuration (Figure 2.19) is a larger, multiple-company or battalion-sized formation (20 to 30 vehicles) intended to effect a tactical breakthrough. Vehicle spacing is 50 to 100 meters in trail, and the formation moves in a line toward the defenders, as a road-march formation does. This target presents itself infrequently over the course of the tactical battle (once or twice during the 60-minute combat period that characterizes each assault). This formation is, of course, a very important target to counter and can be viewed as the primary reason additional close support firepower is needed during the tactical battle.

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7 There is also a distinct difference in the exposure profiles of these two classes of targets. While the fixing attack formations appear all throughout the battle, the appearance of the breakthrough target can not be anticipated with a high degree of confidence. This means that close support systems must insure that they are in a position and status that allow them to respond when the breakthrough attempt does take place. As we have pointed out in the previous discussion of advanced artillery systems, this need to hold some part of the force at the ready can change the way close support systems are employed.

8 The relative importance of target formations in attack versus road march is still to be determined in our scenario work, but we believe the balance will tip toward deeper road-march interdiction (as opposed to the requirement for “close support” in the strictest sense) due to expected U.S. information dominance and firepower flexibility.
Doctrinally, both of these targets are long (.3 to 3 km) and narrow (not much more than a few vehicles across the narrow dimension). During movement on actual terrain, the smaller target tends to be more cluster-like and the breakthrough force tends to “snake” along lines of communication and around obstacles. Thus, even if attacking close support systems could fully exercise a choice of the best attack axis, neither target presents an ideal linear array. The effects of these target configurations stress the ability of the munitions to efficiently regard each target element (vehicle) and dictate munitions characteristics for effective employment.

Three general approaches are available: scattering unguided sub-munitions, using extended range sub-munitions with sensor fuzing, and using homing (sub-)munitions (e.g., laser designated by a forward observer or terminally guided sub-munitions [TGSMs]). A comparison

Figure 2.19 – Battalion-Sized Breakthrough Formations in Mechanized Combat (Battlefield Depiction from the JANUS Combat Simulation)
of these concepts when employing equal payload dispensers of equally lethal\textsuperscript{9} sub-munitions against the two close support target configurations is shown in Figure 2.20.

The left panel of the figure plots the expected kills against the smaller target as a function of the angle between the missile/aircraft attack axis and the long axis of the target; the right panel does the same for the larger breakthrough formation. In both instances, the “smart” sub-munitions concepts prove to be a dominant approach for ideal attack geometry, hitting\textsuperscript{10} about 10 vehicles per engagement in comparison to no more than .5 vehicles for the unguided sub-munitions concept. The order of magnitude difference in effectiveness means that the “smart sub-munitions” concepts could cost 10 times as much as the unguided sub-munitions concept and still be as cost-effective in terms of hits per dollar.\textsuperscript{11} This tracks roughly with ballpark costs of $20,000 for the unguided sub-munitions dispensers and $200,000 for the SFW sub-munitions concepts.\textsuperscript{12} When it is not possible to match the attack axis with the target axis, as is often the case in combat, the SFW concept with its limited cross-range capability degrades in effectiveness by up to an order of magnitude (expected hits dropping from about 10 to only one vehicle in the extreme case). While the unguided sub munitions concept degrades in a similar manner (arguing that the SFW concept and the unguided sub-munitions concept remain comparably cost-effective in the more trying situation), the TGSM concept suffers no comparable degradation. In the

\textsuperscript{9}The sub-munitions have been assumed to be equally effective given a hit for purposes of even-handed comparison.

\textsuperscript{10}For purposes of first-order assessments, we have assumed that the warheads for each of the types of sub-munitions are all equally capable against the targets and, for the two different types of “smart” sub-munitions, equally likely to hit the target if it is within their sensor’s field of view and the sub-munition’s range.

\textsuperscript{11}Combat utility (impact on combat outcomes) is another matter. Tactical-level battle simulations like JANUS have shown that killing rates of one-half vehicle per engagement do not result in a sufficient level of kills to have any effect on combat outcomes during the 60 minutes or so that it takes for a battalion battle to run its course, because attacks can not be conducted rapidly enough during that period.

\textsuperscript{12}Costs are representative of the CBU-87 and CBU-97, as reported in \textit{Air-to-Surface Munitions Handbook}, 1992.
extreme, the TGSM concept is an order of magnitude more effective than the SFW concept. This argues that this concept could cost substantially more and still be the preferred approach. IR versions of these sub-munitions should be producible for roughly the same costs as the Hellfire or Stinger missile (roughly $40,000) due to the rough similarity in technology, so a cluster weapon of 10 sub-munitions such as we used in our example would cost approximately $400,000—twice the cost of the cluster weapon using the SFW concept. Given that the effectiveness differential is a factor of two or greater with target/attack misalignments of only 20 degrees (for the more demanding larger target), the higher unit costs of the TGSM concept would seem warranted.

**Issues and Desirable Characteristics Based on These Combat Vignettes**

**Fixed-Wing Issues: How Can Fixed-Wing Systems Engage More Effectively (With Faster Kill Rate) Within the Attrition Management Window?**

From the results of this scenario (and also the analysis of the Armored Force Meeting Engagement vignette that appears in Section 5) and given the restricted airspace around the enclave and the potential attrition of fixed-wing assets, a desirable way to provide the needed close support is the standoff, lofted delivery of SFWs. The multiple-kills-per-pass capability could provide the needed lethality in the required time. However, as indicated by the analysis of this combat situation, improvements to weapons footprints, particularly those associated with TGSMs, can allow much faster kill rates and better robustness against target configuration than are currently available.

**Attack-Helicopter Issues: What Munitions and Sensor Characteristics Best Match Rotary-Wing Engagement Profiles?**

In our simulation results for the Escort of a Humanitarian Convoy, four helicopters that arrived on the scene 10 minutes after the start of the ambush conducted a pattern search centered on the ambush site. Within 60 minutes of the start of the ambush, they had detected 23 of 24 members of the ambush team egressing from the ambush. This implies that present sensor technology satisfies the close support requirement after the ambush. However, it must be noted that the ambush team was withdrawing through unpopulated countryside, and the requirement to distinguish the enemy from innocent noncombatants was not required. Although we did not simulate the case where the helicopters escorted the convoy, they undoubtedly would have killed all of the team in the first few minutes after the ambush. However, such an approach may be only partially effective in the long run and will not preclude the loss of the convoy being escorted.

These conditions combine to argue that the most effective strategy is to use sensors that can detect the location of the ambush team before the event so that the ambush can be avoided. This
means that instead of seeking ways to allow helicopters to engage the enemy during the ambush, the focus should be on ways to detect the ambush team and how to handle that force once it is located and the ambush avoided. Helicopters have desirable characteristics that may importantly aid this strategy, such as elevated observation positions, the ability to hover, and a speed regime that is compatible with the supported unit.


The analysis of the Escort of a Humanitarian Convoy and Support for an Allied Enclave vignettes provided some valuable insights concerning the desirable characteristics of tactical-battlefield information-gathering systems. The consensus is that the best strategy for defeating an ambush is to avoid it. This strategy depends on battlefield information. The Support for an Allied Enclave analysis explicitly shows the potential contribution of information systems. A number of emerging technologies may help us cope with ambushes. Computer processing power continues to increase exponentially and may enable radar imaging that recognizes the weapons in the hands of the members of the ambush team or the IR signature of the team members themselves. As we previously observed, finding information-based answers while looking for firepower answers makes the insights concerning battlefield information considerations all the more impressive. For further discussion of sensors, cueing, and fire control issues, see Section 3.