Information Asymmetry—The Case of Guerrilla Combat

With rare exception, guerrilla combat shows the insurgents’ superior situational awareness of details in the combat theater despite their lack of sophistication in technology and support. Such knowledge asymmetry grossly twists the expectations borne out of the Mixed Law Guerilla Combat model. We construct a modified mixed law model, an extension of RAND’s (RAND MR 2001) incorporation of “knowledge” in combat analysis. We explicitly differentiate between the level of external and organic knowledge available to each defender and to each guerrilla. Using quantitative analysis we show that to defeat insurgents defenders must greatly advance their capability of sensing the guerrillas’ presence in the combat theater, and also elevate the probability of physically detecting an individual guerrilla through local organic sources. Simultaneously, defenders must neutralize any information advantage guerrillas enjoy in their locale.

Keywords: Guerrilla Combat, Lanchester Mixed Law, Situational Awareness, Knowledge, Information Advantage

1. Introduction

Ever since their original publication by Lanchester (1976) to help understand aerial war and the attrition of combating aircraft, the Lanchester equations have been used to help predict the outcome of military and other two-force encounters given some information about the combating forces. Lanchester’s work has even inspired market strategists (see Yano 2003). Lanchester himself was inspired by earlier work on describing the growth of biological populations subject to certain environmental conditions. In combat, of course, growth was not the goal; rather, the first side whose population reached zero would be the loser. Lanchester specifically modeled two processes governed by “aimed” or direct fire, and “unaimed” or area fire, respectively leading to the famous square and linear laws governing the progress of a combat.

Explanations of these laws, their scope, and their utility in describing a set of strategic and tactical actions and their effect on combat outcome are now easily available (Taylor 1983a, Taylor 1983b, Jaiswal 2003, Teague 2005). We summarize below a lieutenant’s version of the Lanchesterian combat process.
In aimed fire combat the shooter directly shoots at a visible enemy unit (a soldier, a tank, or an aircraft, for instance). If the enemy unit is destroyed the shooter moves his fire to a new visible target. As targets are eliminated, firepower becomes more and more concentrated on those targets that remain. In contrast, in area fire the shooter fires upon an area in which the enemy units are presumed to be present. Here, even if a shooter destroys an enemy unit, fire remains directed at the area as a whole. In many area fires the shooter often does not know if he has hit a target.

The general form of Lanchester equations is as follows. The two combating forces are designated B and R respectively with \( b(t) \) representing the number of B units engaging \( r(t) \) red units at some instant of combat \( t \).

\[
\begin{align*}
\frac{db(t)}{dt} &= -\alpha b(t) r(t) \\
\frac{dr(t)}{dt} &= -\beta r(t) b(t)
\end{align*}
\]

(1)

Parameters \( \alpha \) and \( \beta \) in these two coupled differential equations hold the key to the consequence of the engagement. These are called the lethality or effectiveness coefficients of the combating parties, \( \alpha \) for R and \( \beta \) for B sides respectively. Lanchester used \( \alpha \) and \( \beta \) to respectively represent the combative effectiveness of the forces R and B, \( \alpha \) being the probability that a single unit of force R will succeed in incapacitating (killing, wounding, etc.) a unit of B in one typical round of combat. \( \beta \) similarly represents the effectiveness of a unit of force B. In reality, situation-specific \( \alpha \) and \( \beta \) values have been estimated from historical force attrition data in well-documented combats. For modern weaponry Chang (2005) provides a simple estimation of \( \alpha \) and \( \beta \) as follows:

\[
\begin{align*}
\frac{1}{\alpha} &= \text{time for R to acquire a B target} + \frac{1}{\text{firing rate of } R \times P_{rb}} \\
\frac{1}{\beta} &= \text{time for B to acquire a R target} + \frac{1}{\text{firing rate of } B \times P_{br}}
\end{align*}
\]

(2)

\( P_{rb} \) and \( P_{br} \) here are the single shot kill probability of R firing at B and B firing at R respectively. Note that the above expressions hint about the manner in which technology can influence the values of these effectiveness coefficients.

Lanchester’s area fire and direct fire models are special cases of the general Lanchester equations (1) above. The case \( r = u = 0 \) and \( s = t = 1 \) represents direct fire by both forces. Area fire by both forces is the case \( r = s = t = u = 1 \).

Valuable deductions about the progress of an engagement may be made by examining these models analytically. It is found that according to the Lanchester
direct-fire model, which leads to the “square law of combat” (Taylor 1983b), number of units engaged in combat matter more than the effectiveness of individual guns in determining which force will win. Fighting troops corroborate this as follows. Direct (aimed) fire used by both forces ensures that the side with the lower number of units will lose more units as each round finishes. There will therefore be more firing guns on each of them, some getting double-targeted and a few even multiple-targeted. In response the survivors can only engage an equal (and therefore smaller) number of the larger force.

The smaller force’s return salvos therefore become less and less effective, raising the likelihood of defeat. One well-known attempt to check the utility of this model was made by Engel (1954) for the data mined from the records of the battle of Iwo Jima fought between the Japanese and the landing American Marines. For the Japanese, $\alpha$ was 0.0544 US casualties per Japanese man day while for the Americans, $\beta$ was 0.0106 Japanese casualties per US man day. From the top of the 550-foot cone of Mt. Suribachi, the Japanese gunners zeroed in on every inch of landing approach. Every Marine, everywhere on the Iwo Jima Island, was always in the range of Japanese guns. But with reinforcements landing, US troops outnumbered Japanese troops through most of the battle. The outcome is well-known.

Some caveats apply to the direct fire Lanchester model. Actual lethality coefficients are rarely available—to allow precision in predicting the outcome of a combat. Also, the models work on large scale averaging approximations only, not reflecting the local situations such as competent officers, terrain effect, weather, and all other factors (jamming weapons, misfires, etc.) that one calls luck. Another aspect that the direct-fire Lanchester model does not address is unaimed fire into an area suspected to contain enemy units. In this case, camouflaged tanks or individual soldiers may in addition be moving from place to place. The goal in unaimed or area fire therefore would only be to destroy a certain fraction of targets by applying proportionately greater fire power (mass artillery bombardments on enemy positions or anti-aircraft barrages blasting in the sky). Fire power is not re-aimed in area fire and “dead” targets are as likely to be hit later as live ones.

The general conclusion drawn out of Lanchester model-based analysis, therefore, may be stated as follows: Be more numerous in aimed, direct fire. Lethality of weapons here matters less. On the other hand, be more lethal in area fire. Modern combat, however, is much more complex and technology-loaded. Besides the proverbial smoke generators, thermal pots and infrared targeting systems, combatants now employ C2/C4ISR systems, some battlefield digitization, and tactics such as guerrilla ambushes and insurgency. Army commanders suggest that unless you have an overwhelmingly large force as at Iwo Jima where 70,000 Marines engaged 20,000 Japanese, avoid direct fire. Look for highly effective force multipliers and intelligence gathering. Destroy fuel and other supply lines. If the enemy is better equipped, avoid artillery duels, rather, focus on intelligence and information gathering. In this paper we examine a specific situation—that of information asymmetry in guerrilla combat. Our aim is to infer the effects of vigorous use of intelligence and information by command and control (C2)—on a combat’s effectiveness.
Teague (2005) illustrates the direct fire model’s utility by re-working the example of the Battle of Trafalgar. He uses Euler’s numerical method to simulate the process to show the effect of changing initial fleet ratios on final fleet size remaining at the end of combat. Teague then goes on to model guerrilla warfare by assuming that guerrillas (represented by R) are able to use direct fire on individually located defenders (represented by B), but the defenders can only use area (unaimed) fire on the guerrillas as the guerrillas are “over in that field”. The guerrilla combat model, first published by Deitchman (1962), and expanded to time-dependent weapon-efficiency coefficients by Schaffer (1968), remains essentially unchanged, even in recent literature (for instance, Teague 2005). It is

\[
\begin{align*}
\frac{db(t)}{dt} &= -\alpha r(t) \\
\frac{dr(t)}{dt} &= -\beta r(t)b(t)
\end{align*}
\]

(3)

The inference Teague draws from this model is that to be effective, guerrilla forces must remain small (and hidden). An interesting epilog on the Vietnam War is given here by Teague (2005). Note, however, that model (3) uses the two coefficients of combat effectiveness (\(\alpha\) and \(\beta\)) to be representing the probability of kill by the respective forces (Vietcong and Americans, respectively) only (page 5, Teague 2005). No reference is made to information or intelligence (knowledge) available to either force, even though even medieval Mongol fighters used information about the enemy to strategize their attacks. Later Lanchester models, for instance the Mixed Law Model (RAND MR 1155 2001), have rectified this by incorporating information in the form of “knowledge”.

2. A Knowledge-asymmetric Model of Combat

We depart (3) with the construction of a modified “Mixed law model”—a simple but instructive extension of the Lanchester Mixed Law model given in RAND MR 1155 (2001). The RAND model itself expands the original Lanchester laws to account for knowledge by considering knowledge to be a subcomponent of the fighting unit’s effectiveness score, \(M\) or \(N\), where \(M = P(detection) P(kill/detection)\) is the effectiveness of the defenders (represented henceforth by B). Here \(P(detection)\) is the probability that a target (as enemy—hereafter a guerrilla—represented by R in this paper) will be detected by the defender (B) using locally (organically) acquired information or knowledge. \(P(kill/detection)\) is the probability that a firing by B will successfully kill or incapacitate R, once R has been detected by B. \(P(kill/detection)\) represents the effectiveness of the weapon system selected by B to engage R.

MR 1155 (2001) further defines two quantities—\(c_r\) and \(c_p\)—to represent surveillance knowledge possessed by each defender (B) and each guerrilla (R) respectively. \(c_r\) represents the maximum number of encounters with individual enemy units (guerrillas) that a B may have based on information available to B from
local as well as external sources such as headquarters’ surveillance of the combat theater. Similarly, \( c_b \) is the maximum number of encounters with individual defenders that a guerrilla may have based on his/her own sources of intelligence, information and surveillance. MR 1155 (2001) opines that \( c_r \) will be a function of the knowledge \((K_B)\) available to guerrillas from external or any other means about the presence of \( B \) units, and the total number \( b(t) \) of defenders present at time \( t \) in the combat theater. Similarly, \( c_b \) will be a function of knowledge \((K_B)\) available to each defender from external, imagery, or any other means about the presence of the guerrillas, and the total number \( r(t) \) of guerrillas actually present at an instant of interest in the combat theater. The attrition equations that therefore emerge are

\[
\frac{dr(t)}{dt} = -[b(t)M]c_b \\
\frac{db(t)}{dt} = -[r(t)N]c_r
\]

(Mere model building without understanding its significance often blinds the analyst whereas one makes much progress by standing on the shoulders of correctly chosen “giants”. Our modification of (4) begins as follows. Unlike MR 1155 (2001), we explicitly differentiate between the level of external and organic knowledge available to each defender \((B)\), and to each guerrilla \((R)\). To do this we re-define \( c_r = \theta B \), \( c_b = \delta R \), \( 0 \leq \theta, \delta \leq 1 \)

(5)

Reflecting on actual combats and insurgencies in Vietnam, Middle East, Kashmir and elsewhere, one cannot help but question the use of conventional wisdom to guide combat strategies. Do our decisions get constrained while projecting combat outcomes by our limited representation (modeling) of the reality of combat (see, for instance, normative statements by Teague 2005, page 6) when confronting insurgency? In May 2006 eight thousand soldiers could not find two abducted American GIs south of Baghdad. The heavy and extensive bombing of the Tora Bora Mountain in Afghanistan could not apparently destroy the targeted enemy (Washington Post 2002). At the same time, however, Saddam Hussein and his sons could be physically traced by the Coalition, and in spite of some delay, one did find and kill al-Zarqawi. Must we then infer that in reality, guerrillas (represented by \( R \)) can detect almost all defenders (represented by \( B \)), hence \( \theta \) in (5) is close to 1.0, while normally the defenders can hardly detect the presence of any guerrillas, hence \( \delta \) is very small, or \( 0 < \delta < 1.0 \), but not zero?

Are these assumptions reasonable? Note that these assumptions dispose of the “black-and-white” (area vs. direct fire model—(3)) of guerrilla combat. Furthermore, as in other domains of management involving humans, strategizing to win a war or even a combat would require us to begin the task with a sound understanding of who the principal characters in the combat theater are and how those characters are likely to behave. Realism in models would only take us further. We attempt this by first understanding the capabilities, orientation and the objectives
of guerrillas and insurgents—extracted from sources such as The Minimanual of the Urban Guerrilla and Gombo (1990) available in the public domain.

### 3. How effective are guerrillas? How are they different?

As noted, most of today’s battles witness guerrilla ambushes. Guerrilla action is fluid, light, flexible, mobile, invisible and elusive and the tactics vary widely. It puts down its roots in the population. Under customary law and the Third Geneva Convention (Art. 4), guerrilla fighters of a Party to the conflict are entitled to combatant status. Insurgency and guerrilla combat aims to “distract, wear down, demoralize, attack and destroy the enemy and/or his property.” Even with the latest of technologies engaged in battles, guerrillas continue to operate with tempo be it in Kashmir, Jaffna, Mogadishu or Baghdad—to vex even the largest of modern armies. For many, memory is still fresh from TV shots of surprised GIs ambushed in South East Asian jungles (Gombo 1990). With rare exception these encounters show a guerrilla’s superior situational awareness of details in the combat theater despite his/her lack of sophistication in technology and support. On reflection, therefore, the popularly cited Lanchester model of guerrilla combat (see Teague 2005) appears pitifully simplistic, if not a misleading analytic artifact in want of major overhaul. One appreciates the information asymmetry of guerrilla combat when one obtains only a short glimpse of the features of the urban guerrilla’s world.

A guerrilla operates singly or in very small groups using unconventional methods, characterized by bravery and decisive behavior (The Minimanual of the Urban Guerrilla, Gombo 1990). He/she broadly leads a clandestine existence often using false documents, and is not sufficiently strong in weapons, ammunition or equipment. But a guerrilla establishes dependable ties with the locals for he/she propagandizes to be defending the people’s cause. Thus he/she postures moral superiority with the accepted duty to attack the establishment to cause disruption and damage, and seek organic help from locals to survive. He/she must capture or steal weapons or rob banks and otherwise find means to go on for the chosen cause by being imaginative and creative. Impelled by initiative, mobility, flexibility and versatility, the guerrilla is taught to be in command of any situation, not to ever become confused, or more seriously, to have to wait for instructions. Physically such an individual is a good walker, stands up well against fatigue, hunger, rain or heat, knows where to hide and how to remain calm and cool, while leaving no track or tail.

Guerrillas know how to live among the local people and not to appear strange or different from ordinary folks even in dress. They never reveal their identity to anyone while being well-informed about everything, particularly about the defender’s movements. Highly knowledgeable about the area in which he/she lives and operates or travels through, the guerrilla has the gritty mission of (a) the defender’s physical elimination, and (b) expropriation of the defender’s resources, weapons and wealth.

Technically the guerrilla has a strong physical constitution, can fight unarmed, attack, defend self, and even drive a car, pilot a plane, handle a motor or sail boat. But more importantly, the guerrilla is highly knowledgeable about topographical
information, some rudimentary electronics, reads maps well, performs basic surgery and administers drugs and first aid. The guerrilla, even if the opportunity for his/her formal training is limited, handles weapons and light arms including the submachine gun, revolver, automatic pistol, FAL, various shotguns, carbines, mortars, bazookas, and hand-grenades. Above all, their highest level of training includes the test of fire in actual combat.

Mindful of wasteful use of grenades and ammunition in poor shots, the guerrilla trains hard for good aim and precision firing, generally using the light submachine gun as the basic weapon. He/she uses hand grenades and smoke bombs for cover and withdrawal. At night when precision isn’t much help, he/she fights at close range and point blank with shotguns or homemade weapons. The shot is guerrilla’s reason for existence, so he/she must shoot well. While in conventional warfare combat is generally at a distance with long-range weapons, guerrilla combat is at short range, and often very close. To prevent his/her own death, the guerrilla must shoot first, and he/she cannot afford to err in that shot. Further, when face-to-face with the enemy, the guerrilla must always be moving from one position to another to avoid being vulnerable.

Organized into small firing groups of four or five bodies, guerrillas put their best shot in charge of such groups. The groups avoid rigidity, though tasks planned by the strategic command take preference. No group, however, remains inactive, waiting for orders from above. The obligation is to act, and to operate as an indestructible network of firing groups.

Thus, guerrillas are not an army, but small armed groups deliberately kept fragmented and often operating with precarious and insufficient weaponry and supplies. Their goal is to surprise the enemy and to capture their weapons, ammunition, vehicles and other resources. They realize clearly that they must be aggressive and offensive. To them being defensive is death. They may attack and rapidly withdraw, but their prime mission is to take the enemy by surprise, exploit their own knowledge of the terrain to their best advantage, have greater mobility and speed, use local information better than how the enemy can, and demonstrate decisiveness and command that is inspiring to everyone. These tactics frequently wear out, demoralize and distract the defenders.

Personal valor and good marksmanship aside, perhaps the strongest armament in the guerrilla’s scabbard is precise, local situational awareness, collected with meticulous observation, knowledge of the terrain, local people, buildings, the low and high points, and irregularities in the landscape (Gombo 1990). Since the combat often takes place in the vicinity of the local community, the guerrillas cultivate and exploit their sympathy. This was noted, for instance, in the battle of Tora Bora in Afghanistan (Washington Post 2002). While the enemy often knows nothing about the guerrilla’s strength or movements, they are well aware of the enemy’s. Information in the hands of the guerrilla is an extraordinary force multiplier. With it they know where to hide and can rapidly pass through the area on foot, on bicycle, car, jeep, etc. while rarely be trapped. The ideal firing group operates in its own city or village, thoroughly knows its streets and neighborhoods, and can rendezvous at a pre-determined time and place with ease whereas the outsider is in a clearly weak spot, often thrown off with false information.
In recent times—since the insurgent’s open combat capabilities are now unequal to a well-equipped army’s—attacks are rampant on supply trains and securing forces using hidden explosives made from military-grade materials concealed or camouflaged, as well as ambushes using automatic and antitank weapons. Unarmored targets are commonly attacked. Congested and constricted terrains of cities offer ample cover and concealment acting as force multipliers for guerrillas while being force inhibitors for the defenders. One major fallout of successful ambushes is also that it serves as “proofs” about the guerrilla’s combativeness, decisiveness, firmness, determination and persistence to attack the “enemy”, further raising the sympathy and public support factor. Nevertheless, guerrillas are commanded to avoid open battles and to restrict their combat to brief, rapid attacks to produce lighteningly fast results.

4. Today’s Technology and Enemy Encounters

Information dominance (Gritton et al, in RAND MR 1152 2001) is rapidly gaining ground as a key enabler in winning a combat, regardless of its scope and scale. Gritton et al remark that situational understanding (cf. situational awareness of the guerrilla) would include knowing

− Where am I?
− Where are the other friendlies?
− What’s in the air?
− Where is the enemy (from all sensors) and what is he doing?
− Where are the assets of interest (perhaps guerrilla camps)?
− What is my supply and sustainment status?
− What are our plans of operations?

So, in countering insurgency, the defenders’ effective exploitation of situational understanding (rather than raw fire power) appears to be critical. Where do our capabilities stand today?

Since the present work would confine itself only to hinting at suitable hardware and/or operational initiatives in guerrilla combat, below we make only transitory observations.

First to note is that strong effort is afoot to digitize the battlefield—to link all friendly entities by wireless network. Therefore, aside from technological work under way to improve precision and lethality of weapons, a great deal of effort is getting directed toward understanding the role played by information, and the apparently new roles both commanders and soldiers as decision makers would play in the digitized age. Cares (2005) reports modeling of a combat in the information age when communication networks bring every relevant bit of information not only to the headquarter or the commander, but also to each individual unit on the ground—leaving a lot of autonomous decision making to that individual (a soldier, or a tank, for instance). Command and control (C2) protocols would change. The human decision maker in C2 has been studied by Mason and Moffat (2000). C2
itself has been studied as a causal model (RAND MR 1152 1999) with the conclusion that C2 would be most effective when completely automated.

Sensors have improved, new ones invented, and the value of sensors features still on the drawing board assessed. Defense AT&T (2005) reports that new night vision capability, IR imaging sensors and second generation FLIR are now available to armor, mechanized infantry and reconnaissance forces enabling “vision” that is clearer and goes farther. The LRAS3 vision system has tripled the range of conventional night observation devices and in Iraq it has successfully demonstrated discrimination between a man planting a bomb and children playing several miles away on a moonless night. GPS-and laser guided munitions have expanded both range and accuracy while some US forces are using flat-panel displays of thermal images to allow safer movement. This gives the vehicles 24-hour driving capability. Both lethality and survivability also continue to improve due to rapid detection of targets—to engage them at double the conventional distance. Remotely operated weapon systems (CROWS) now mount on top of a HMMWV to allow a gunner to perform missions from the safety of the inside of armored vehicles (Security 2005). Some non-line-of-sight cannons and unattended ground sensors and armed robotic vehicles are already operating within an integrated network of command (Defense AT&T 2004).

The defender’s organic capabilities (not dependent on headquarters’) would include mini and micro UAVs equipped with multispectral sensors for short range situational understanding. The value of using sensors in an information-enabled combat itself has been studied (Lauren and Baigent 2001). Importantly, recent combat simulators have used “agents”—entities which make their own decisions about how to behave based on the circumstances (Lauren 2001a).

Lauren and Baigent (2001) have also studied the relative value of detection capability (a topic of particular significance in guerrilla combat) when compared with firepower. It is reported that as detection range advantage is gained, the defender’s survivability jumps dramatically, but improvement is only gradual as firepower increases. Likewise, if the enemy can communicate with an aerial observer or UAV, the defenders’ casualties rise dramatically. Thus, a reconnaissance force without the capability to hide from an aerial observer is likely to suffer significant casualties.

A small group of defenders fighting dispersed enemy units akin to the 1993 urban environment in Mogadishu was modeled by Lauren (2001b). An aspect of the Maori culture (an aura of authority and respect) was modeled using automatons in which a foe would not recklessly attack his enemy if he has respect for (or fear of) him. Rather he would wait till an opportune moment arrived. This study showed that the Lanchester equation does not account for spatial and temporal correlation of events. It showed another result—that the combat outcomes were highly variable from run to run, something also observed by the present author in micro-level combat simulations that used terminal force ratio as the measure of a combat’s effectiveness.

In summary, hardware sensors, detectability, weapon lethality, etc. continue to improve and thus lift up $P(\text{kill/detection})$ and $P(\text{detection})$ while actuating the reverse for the enemy. Whatever superiority the defender gains here must be denied to the enemy. Work is also under way to study combats by stochastic simulation,
simulated network-centric warfare, and even by chaos theory, some of the fighters being autonomous agents using networked and shared combat data. The goal is to improve predictability in complex situations and in an environment rich with information exchange capability. Results are still preliminary. However, the key point these developments make is that information and knowledge are rapidly becoming vital and viable components in determining the fate of a combat. The present work attempts to help quantify the defender’s advantage when enabled with knowledge.

5. An Extension of the RAND Model of Knowledge-Enhanced Lanchester

For the defenders (Bs) to wipe out the enemy (Rs) MR-1155 (2001) provides the condition

\[
\frac{M c_b}{N c_r} > \left( \frac{R}{B} \right)^2
\]

As the RAND report notes (MR-1155 2001, page 46), “information” contained on the left-hand side of this inequality has a greater effect on the combat outcome possibility than effectiveness scores \( M \) and \( N \). Both \( c_b \) and \( c_r \) are numbers of units indicating the maximum number of encounters that each B and each R unit may have worked out from external sources (UAV, satellite imagery, etc.) and from information obtained from the respective headquarters. Further on, on substituting

\[ c_r = \theta B, \quad c_b = \delta R \]

and the values for \( M \) and \( N \) one obtains

\[
\frac{P_b (d) P_{br} (kill / detection) \delta R}{P_r (d) P_{rb} (kill / detection) \theta B} > \left( \frac{R}{B} \right)^2
\]

On simplifying,

\[
\frac{P_b (d) P_{br} (kill / detection) \delta}{P_r (d) P_{rb} (kill / detection) \theta} > \frac{R}{B}
\]

is the condition for the defenders to wipe out the guerrillas.

One may now probe into the asymmetry of information available to the two combating forces and its impact on the outcome.

To begin, we recall information asymmetry that exists between the two forces. One such asymmetry is that in the combat theater, defenders can hardly detect the
presence of a guerrilla, so direct fire by the defenders is not frequent. On the other hand, experience with insurgency suggests that guerrillas are much more effective in detecting the presence of defenders. Then, \( P_{rh}(d) \gg P_{br}(d) \) and it also holds that a guerrilla is going to engage in direct fire if he detects a unit of B. Further, locally acquired intelligence possessed by guerrillas is expected to be of much better quality than that acquired by defenders. This leads to \( 0 < \delta, \delta \) being quite small—in fact much smaller than 1, while \( \theta \) is perhaps close to 1.

If we assume that the weapons used by both forces are of comparable lethality, then one may expect that \( P_{br}(\text{kill/detection}) \) and \( P_{rh}(\text{kill/detection}) \) will be of about the same magnitude. This assumption permits us to simplify the condition (8) for defenders to wipe out guerrillas into the relationship

\[
\frac{P_{br}(d)\delta}{P_{rh}(d)\theta} > \frac{R}{B} \tag{9}
\]

Or it says

\[
\frac{B}{R} > \frac{\theta P_{rh}(d)}{\delta P_{br}(d)} \tag{10}
\]

One can produce a table (similar to Table 4.1 of MR 1155 2001) interpreting the different combinations of the parameters—\( \theta, \delta, P_{br}(d) \) and \( P_{rh}(d) \). Independently, entity-level Monte Carlo simulation run by the author suggests that combat outcomes (MOEs or measures of effectiveness) such as force ratios would have high variance. This needs to be studied further for the simulation modeling approach to be of strategic value in decision making particularly when \( \delta \) and \( P_{br}(d) \) are small. However, let us recall for a moment which force has what kind of information, and their relative magnitude.

\( P_{br}(d) \) is the probability of a defender detecting a guerrilla. This probability is expected to be small because of the tactics employed by individual guerrillas (The Minimanual of the Urban Guerrilla, Gombo 1990). \( \delta \) is the fraction among all guerrillas that are known by each defender to be present in the combat theater. This information is typically acquired by UAVs, imagery or other channels of information used by headquarters. Realistically speaking, because of the hiding tactics used by guerrillas, this fraction is going to be small. The implications are as follows. To wipe out the guerrillas defenders themselves must apply guerrilla tactics. Short of this, defenders must greatly improve \( \delta \) (the capability of detecting the presence of guerrillas through UAV, surveillance, winning over the local community, etc.) and \( P_{br}(d) \) (the probability of detecting the presence of guerrillas through local organic sources—spectral sensors and other means). Concurrently, it would behoove defenders to neutralize any information advantage guerrillas may potentially have; there is strong evidence that most of this is derived by cultivating the locals (see the Battle of Tora Bora, Washington Post 2002).

While it is unlikely that guerrillas would always have an uniformly upper hand due to the tactics they use (their determination notwithstanding) or the “sympathy for their cause” amongst the locals clouding the defender’s organic intelligence, this analysis highlights the wrong impression/conclusions one conjures solely on the
basis of Mixed Law Guerrilla Combat model. Realistically, $\delta/\theta$ is likely to be 1/100 and $P_{br}(d)$ is likely to be a tenth or a $10^0$ of $P_{rb}(d)$ (see Table 1). Figure 1 graphically highlights the clearly dramatic advantage insurgents would have when they have knowledge dominance in the theater of combat. In Figure 1 detectability ratio represents the quantity $\theta/\delta$ while kill probability ratio equals $P_{rb}(kill/detection)/P_{br}(kill/detection)$. Figure 1 qualitatively indicates the region defined by these two parameters where their combination turn highly unfavorable to the defenders and their chances of winning the combat become nil.

**Table 1** Typical Minimum Initial (B/R) Force Ratios required to defeat guerrillas

<table>
<thead>
<tr>
<th>Probability of Kill Ratio $P_{rb}(d)/P_{br}(d)$</th>
<th>Detectability Ratio $\theta/\delta$</th>
<th>0.01</th>
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**Figure 1** Defender/Guerrilla Initial Force Ratio required to defeat the guerrillas in an insurgency

Such asymmetry grossly twists the expectations borne out of the Mixed Law Guerrilla Combat model (Dietchman 1962, Schaffer 1968, Teague 2005). To defeat
the guerrillas the defender’s forces must be much larger than even a 10-fold threshold, or have near-perfect knowledge dominance. The present work presents quantitative evidence that such deductions must be properly established utilizing whatever in situ defensive capabilities are available. Second Generation FLIR (SGF) sensors, LRAS3, invisible thermal imaging (see “Sensing Beyond the Visible” Defense AT&T (2005), CROWS (Security 2005), and non-line-of-sight weapons and unattended ground sensors (Defense AT&T 2004) are all very discreet enablers that raise kill probability and/or ratchet up detectability of the guerrilla. Clearly, therefore, Teague’s general remarks about the US requiring more forces than what General Westermoreland requested from Vietnam are correct but his numerical illustration on page 6 masks the direness of guerrilla combat. Later combats in Somalia also bore out similar lopsidedness of a “conventional” force attempting to tackle insurgency (Figure 2.12, RAND MR 1152 1999).

6. Conclusions

A great deal of effort is currently under way to utilize advanced hardware technologies as well as innovations in computer simulation to yield defenders an edge in winning guerrilla combats. In this paper we have successfully investigated the effect of marshalling advanced surveillance and better-quality local intelligence by the defenders in a guerrilla combat. Insurgency or guerrilla combat today continues worldwide. First studied in 1962 as the “Mixed Law” Lanchester model, one assumes that in insurgency guerrillas are able to use direct fire on individually visible defenders but the defenders can only use unaimed fire on them presumed to be present in the area. However, with rare exception, such encounters show a guerrilla’s superior situational awareness of details in the combat theater despite his/her lack of sophistication in technology and support. We show that such intelligence asymmetry grossly twists the expectations borne out of the Mixed Law model.

To conduct the analysis we constructed a modified mixed law model, an extension of RAND’s (2001) incorporation of knowledge in two-force combat analysis. With it we explicitly differentiated between the level of external and organic knowledge available to each defender and to each guerrilla. Subsequently, employing quantitative analysis using the modified knowledge-enhanced guerrilla combat model we showed that to defeat insurgents defenders must greatly advance their capability of sensing the guerrillas’ presence, winning over the local community, etc., and also elevate $P_{br}(d)$, the probability of detecting the guerrilla’s physical attendance through local organic sources—spectral sensors or other technological means.

Information asymmetry makes the job of defenders particularly difficult and in some situations the defenders may be highly vulnerable (Figure 1). The probability of a defender detecting a guerrilla is expected to be small because of the tactics employed by individual guerrillas. Further, the fraction of all guerrillas known to be present in the combat theater may be estimated by UAVs, imagery or other channels. Realistically speaking, because of hiding, this fraction is also going to be small. The implications are as follows. To wipe out the guerrillas defenders
themselves must apply guerrilla tactics. Short of this, defenders must greatly improve $\delta$ (the capability of detecting the prevalence of guerrillas through surveillance, winning over the local community, etc.) and $P_{br}(d)$ (the probability of physically detecting individual guerrillas through local organic sources—spectral sensors and other means). Simultaneously, it would behoove defenders to neutralize any information advantage guerrillas may potentially have; there is strong evidence that guerrillas derive this edge by cultivating the locals (see, for instance, the Battle of Tora Bora, Washington Post 2002).

Our earlier work and experiments with micro-level guerrilla combat simulation incorporating knowledge indicate that the results yielded in such experiments (i.e. the combat outcomes) are highly variable. This needs to be probed further.

7. References


