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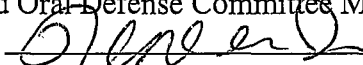
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How Much Risk is Acceptable?

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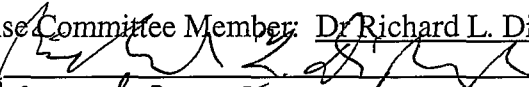
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PREFACE

Are the Department of Defense and the US Marine Corps doing enough to prepare for future conflicts? In the specific area of rotary-wing aviation, I assert that the answer is no. Fundamentally, the character of warfare has changed, as evidenced by the types of conflict this nation and her military forces are and will be committed to in the future. In these types of conflicts, helicopters bring a critical capability. Nonetheless, the impact of a helicopter shootdown or a series of helicopter combat losses now has an impact beyond the actual tactical significance of the events. Therefore, the character change also affects the assumption of risk by tactical and operational commanders. My research into the past and present employment of helicopters reveals a considerable vulnerability with regard to small arms fire. Ultimately, I think the employment of helicopters must be analyzed critically and a determination made to either to find ways to mitigate their vulnerability or understand the implicit risk.

I would like to acknowledge the assistance of several individuals who were instrumental to this paper. First, I would like to thank Dr. Paul D. Gelpi for his mentorship, detailed research guidance, and critical inputs. In addition, I would also like to thank Col. J.D. Canty (USMC), of the Marine Corps War College, for his assistance framing and widening the scope of the work. Also instrumental to the research was CW4 Gregory Calvert (USA), of the US Army Aircraft Shootdown Assessment Team, in Fort Rucker, Alabama, and Lt. Col. "Chuckie" Smith (USMC), at the Marine Corps University. I would also like to thank the staff of the Gray Research Center, particularly Kimberly Adams, Rachael Kingcade, and Pat Lane for their superlative support of my research effort. Finally, I would like to express my gratitude to Dr. Patrice Scanlon and Ms. Andrea Hamlen of the Leadership Communications Skills Center for their help in editing and enhancing this work.

"Helicopters are arguably the most dangerous pieces of hardware in the Pentagon's arsenal."

-Wall Street Journal¹

INTRODUCTION

This paper will address considerations for the employment of Marine helicopters in future conflict. It will examine several examples of helicopter use in counterinsurgent and counterterrorist operations in order to provide a perspective on the utilization of helicopters in future conflicts, with emphasis on the Marine helicopters in the Marine Air Ground Task Force (MAGTF) and an irregular war context. The paper will explore four assessments of helicopters in combat: Vietnam, Rhodesia, Northern Ireland, and Afghanistan in order to illustrate the utility and versatility of helicopters in small wars. Subsequently, the paper will then look at the vulnerability of helicopters to investigate whether the helicopter is a viable option for future conflicts. Finally, some recommendations for short and long term solutions to the aircraft's vulnerability are presented. Ultimately, the paper will demonstrate that by failing to make them less vulnerable to small arms, helicopters become potential operational liabilities, and the United States Marine Corps is yielding a decisive advantage to future adversaries.

The four case studies selected examine past irregular conflicts within the grand strategic context and political factors that lead to the wars in Vietnam, Rhodesia, Northern Ireland and Afghanistan. Further, these case studies illustrate the wide range of roles for helicopters in combat operations. Similarly, the selected conflicts cover the spectrum of operating environments from jungle to savannah and scrub brush, to urban and finally mountainous environments. In addition, an analysis of the utility and vulnerabilities of military helicopters in the conflicts is presented in order to make a case for the future employment of Marine helicopters in future conflict.

THE UTILITY OF HELICOPTERS: FOUR CASE STUDIES

US in Vietnam –The Second Indochina War (1965-1973)

The US involvement in Vietnam began in the late 1950s, as the French withdrew from the country. In December of 1961, American funding and military advisors began to support an effort to counter the growing Communist influence.² In March 1965, the first combat units began to show up in Vietnam and large scale US military involvement would continue until 1973.³ The utility and versatility of the helicopter characterized this conflict. Their deployment in huge numbers afforded the ground forces an unparalleled degree of flexibility, mobility, and fire support.⁴ The analysis of the US experience in Vietnam will focus on two aspects of helicopter support to U.S. and South Vietnamese forces, namely attack helicopter fire support and medical evacuation of casualties. One hundred and fifty-three helicopters were lost in 1966 alone to hostile fire, as compared to the two hundred and fifty-five helicopters lost to hostile fire between 1961 and 1965.⁵ A large part of these relatively high combat losses were attributed in part to shortcomings of the Bell UH-1D Huey gunship with respect to firepower and speed.⁶ These shortcomings ultimately led to the development of the Bell AH-1G Cobra attack helicopter.⁷ Notably, the design of the gunship included a slimmer profile (three-foot wide) and a sixty percent smaller frontal area than the UH-1⁸ to reduce vulnerability to enemy ground fire. The AH-1G was also better armed with two 19- or 7- shot rocket pods and either twin 7.62mm mini-guns or twin 40mm grenade launchers (or one of each).⁹ The next significant development to the helicopter gunship occurred in 1972 as the North Vietnamese Army fielded large numbers of Soviet built T-34 tanks during Operation LAM SON 719. The fact that AH-1 attack helicopters did not have effective weapons against this new threat encouraged the development and addition of Tube fired, Optically tracked Wire guided (TOW) anti tank missiles on the gunships.¹⁰

Casualty evacuation was one of the original roles of the UH-1 Huey aircraft.¹¹ Due to restrictive jungle terrain, the helicopter quickly became the most effective way to move injured personnel from the point of injury to medical facilities. Helicopter crews could not always land to pick up their casualties, and

eventually an electric hoist was installed to allow lifting injured personnel from a high hover.¹² Of the U.S. Army's 120,000 personnel wounded in action, more than 100,000 were evacuated by helicopter.¹³ This factor contributed to the relatively low mortality rate in Vietnam.¹⁴

Although there are many valuable lessons learned from the employment of helicopters in Vietnam, the most germane are air assault (i.e., transport) helicopter routing and helicopter vulnerability.¹⁵ The enemy was equipped mostly with small arms and light caliber weapons. Therefore, helicopters crews could carefully select landing zones that avoided enemy locations, transit at an altitude beyond the range of enemy weapons but within sight of the enemy, and have preparatory bombardment on the zones just prior to the helicopters landing.¹⁶ As the enemy obtained heavier caliber weapons and surface to air missiles, these tactics resulted in unacceptable losses in combat operations, such as during Operation LAM SON 719.¹⁷ During this combat operation executed into Laos, the presence and employment of large quantities of light and medium Anti-Aircraft Artillery (AAA) pieces by the North Vietnamese Army damaged and destroyed a significant number of helicopters. For example, during the extraction phase of the operation, which lasted one week, 25 helicopters were shot down.¹⁸ The number of helicopters lost in Vietnam from all causes was 4,869; of these 2,587 were lost in combat. Of these combat losses, 2,373 helicopters were due to anti-aircraft and small arms fire.¹⁹

Rhodesian Counterinsurgency (1965-1980)

In the early 1960s, Southern Rhodesia (comprising present day Zimbabwe and Zambia) was a resource rich and prosperous British colony that shared a southern border with the Republic of South Africa. Southern Rhodesia had a population of approximately 4.5 million indigenous black and about 250,000 white Africans. In 1970, Southern Rhodesia declared itself the Republic of Rhodesia and established a predominantly white government.²⁰ Between 1960 and 1970, more than a few African nations achieved their independence from European colonial powers. As this wave of independence from colonial subjugation swept across the continent, it created dynamics that eventually resulted in the establishment of a new republic

with an oppressive and non-representative government. This in turn triggered a struggle between the black and white Africans, which devolved into a guerilla war fought between black African nationalist fighters and the Rhodesian government. The Rhodesian government was backed by the powerful minority of Rhodesian white settlers and South Africa, its neighbor to the south.²¹ Ultimately, the guerilla objective for the conflict was a representative government.

Rhodesian counterguerilla operations spanned eight years, from 1972 to 1980.²² Initially, Rhodesian government forces had the conflict largely contained although with poor tactics and a relatively high casualty rate. The guerilla forces were able to take advantage of the destabilization of Mozambique, which shared a border with Rhodesia to the east, to ratchet up incursions and attacks. As an establishment, the Rhodesian military quickly learned to apply the lessons learned on the battlefield and to develop more successful, highly mobile tactics. The government forces had a number of combat experienced veterans who had served with the British Army in Malaya. The Rhodesian Army was composed of light infantry, such as the Rhodesian Light Infantry (RLI), and special operations units, such as the Rhodesian Special Air Services (SAS) and Selous Scouts.²³ RLI forces modified their Aerospatiale Alouette 3 helicopters to serve as gunships and for effective transport aircraft to support ground combat. These aircraft could deliver troops as a small quick reaction force -- known as "Fire Forces" -- or accurate and effective fire from the gunships equipped with 20mm cannons.²⁴ Elements of the RLI forces were trained and capable of being dropped into battle by parachute. For these elements, mobility was provided entirely by C-47 fixed wing aircraft or helicopter. The Rhodesian Air Force also established nine C-47 and helicopter capable sites around the country as Fire Force bases of operation.²⁵

During a typical Fire Force mission, light observation aircraft would detect the guerillas. An RLI ground force of sixteen to twenty troops would embark on the C-47 to parachute in from as low as 300 feet in most cases to serve as a sweeping force. A gunship configured Alouette 3 helicopter, also known as a "K Car", would serve as a command and control platform with the force commander aboard. The blocking force would be inserted by a transport configured "G Car" Alouette under the direction of the force commander on

the K Car. Once blocking force located and engaged the guerillas, the K Car would provide lethal fire support with its door mounted 20mm cannon.

The Rhodesian Army maintained a tactical edge over its adversary by continually refining the tactics and weapons. Fire Force operations inflicted significant casualties on the guerillas in the final stages of the war with ratios as high as ten-to-one.²⁶ From April to December 1979, the RLI killed 1,680 guerillas.²⁷ Rhodesian forces used helicopters to conduct raids, deliberate assaults, and occasional airstrikes, in some instances into neighboring countries to attrite the guerilla forces. Helicopters were also used to insert small teams of trackers to conduct surveillance on and ambush the guerilla bands.

The Rhodesian Air Force played a central role in the effective military strategy.²⁸ The capability and employment of helicopters were essential to the Rhodesian Air Force and Army. The innovative use of helicopters allowed the military commander to bypass obstacles on the terrain and focus combat power (i.e., troops and fire support) at the decisive point on the battlefield. The military strategy effectively contained the guerilla force of over ten thousand men, which had infiltrated into the country.²⁹

One noteworthy and tough lesson for the Rhodesians was the outcome of Operation Uric. This operation was a raid into guerilla territory, which encountered unusually fierce resistance. By all accounts, the outnumbered RLI unit won the tactical battle.³⁰ However, the guerillas shot down two helicopters, one a UH-1 on a casualty evacuation mission with no fatalities from that incident. The second was an Aerospatiale Puma helicopter shot down by a Rocket Propelled Grenade (RPG) killing all personnel on board. This event led directly to the termination of the operation by the commander, due to the loss of "seventeen of his very fine troops and an irreplaceable helicopter."³¹ This instance illustrates an example of the linkage between the vulnerability of helicopters and operational failure, especially in limited objective operations or campaigns that characterize irregular warfare.

British Experience in Northern Ireland (1969-2007)

As a response to a request by the government of Northern Ireland, the British Army, in 1969, began a thirty-seven year struggle against the Official and Provisional Irish Republican Army.³² This struggle evolved into a pitched counterinsurgent fight for the British armed forces that officially ended on 31 July, 2007.³³ The lessons learned from Operation BANNER span many functional areas related to small wars. Focusing on the aviation effort to win the peace, the helicopter emerges in a critical role.

The Royal Army Air Corps (RAAC) shouldered the heaviest helicopter workload.³⁴ The effort was an integrated air and land operation initially supported by Westland Scout and Sioux helicopters, and later Westland Gazelle and Lynx helicopters were used for reconnaissance, surveillance, and troop lift.³⁵ Notably, manned airborne surveillance made a considerable contribution to the intelligence collection effort with real time color video. Additionally, in many instances support helicopters flying different missions were part of the intelligence gathering effort.

The introduction of the Lynx made the troop transport role easier due to its increased capability to move small tactical units. In the early 1990s, Lynx aircraft were armed with door mounted general-purpose machineguns. The Army developed a concept called "Eagle Patrols," which quickly became a significant part of the security framework. Eagle Patrols generally consisted of a pair of Lynx helicopters inserting or extracting airmobile troops to conduct snap Vehicle Check Points (VCPs), or maintaining overwatch of the inserted VCPs with a reaction force. The Lynx was capable of carrying a ground force large enough to survive contact with the terrorists, while having the ability to remain airborne long enough to provide effective support. This force was able to conduct VCPs over a wide geographic area. Royal Navy and Air Force aircraft were needed to meet the sheer magnitude of troop lift required. In addition to routine insertion and extraction of patrols, there was a considerable effort put towards logistic movement in and out of remote sites. Notably, after a bomb attack that targeted a bus full of United Kingdom service members going on leave on 20 August, 1988, routine movement in many cases shifted to helicopters.

Puma and Sikorsky CH-47 Chinook helicopters were used to achieve operational and tactical mobility, which in turn enabled the creation of "operations boxes," that were approximately twenty by thirty kilometers and were saturated with foot patrols delivered by helicopter. The forces often involved several rifle companies operating simultaneously with patrols conducting snap VCPs, random searches, and extensive foot and motorized patrolling.³⁶ These air, foot, and vehicle patrols effectively created a tactical synergy that was difficult to counter.

In the end, the British Army achieved its endstate of allowing the establishment of a political process without exceeding acceptable levels of intimidation to the population. During Operation BANNER, helicopters provided for economy of force by allowing ground commanders secure large geographic areas with fewer troops and vehicles. Tempo could be maintained relative to the terrorists by facilitating air, foot, and vehicle patrols converging and dispersing faster than the terrorists could react. In addition, helicopters afforded tactical mobility by getting forces to the fight quickly and for force protection by reducing force vulnerabilities to attacks by the terrorists. Finally, the use of helicopters as manned surveillance platforms, with real time information capability for a commander's intelligence gathering and decision-making effort.

United Kingdom forces in other theaters, such as Bosnia, Afghanistan, and Iraq, reinforced and applied lessons learned from the Northern Ireland experience. The employment of helicopters in Northern Ireland was not entirely without aircraft loss related to combat. On 17 February, 1978 a RAAC Gazelle crashed near Newry, South Armagh, killing all personnel onboard.³⁷ The helicopter was engaged by small arms just prior to its crash; however, no definitive conclusion was reached regarding the cause of the crash and the role that the small arms fire had on the outcome.

Afghanistan: The Soviet Experience (1979-1989)

On 24 December, 1979, the Soviet Union surprised the world with an invasion and rapid buildup of combat power in Afghanistan. Based on their successes in quelling conflicts in Hungary and Czechoslovakia, the Soviet military's expectation was a quick and decisive military victory followed up by a

transition to support the Afghanistan Army as it conducted a counterinsurgency. The Soviet Army was soon mired in a protracted struggle against a determined, rugged, and adept enemy. Ultimately, the evolution and effective use of air assault and attack helicopter tactics was to be one of the Soviet military's successes in the war.

Helicopters were initially not deployed in sufficient numbers to be effective in the conflict. As the Soviet military leadership fully realized the effect of the enemy and environment, there was a significant reorganization and re-equipping of forces.³⁸ This included an increase in helicopter numbers from sixty to three-hundred.³⁹ Main missions for helicopters in this conflict were troop transport, attack (i.e., fire support), and reconnaissance. The MIL Mi-6 HOOK provided large-scale troop transport and logistical support until the introduction of the MIL Mi-26 HALO in 1983. The MIL Mi-8 HIP provided smaller scale troop inserts for assaults and raids. Finally, the MIL Mi-24 HIND, the first Soviet attack helicopter,⁴⁰ emerged in this conflict as the "signature weapon of the conflict". Soviet employment of the Mi-24 was primarily in the close air support, attack, and armed convoy escort roles. However, the helicopter was used for limited bombing and reconnaissance missions.⁴¹

The evolution of Soviet helicopter tactics against the rugged Afghan guerillas was illustrated in a series of offensives, which occurred in the Panjshir Valley region. After several large-scale (i.e., regimental size) sweep operations, the Soviet military began to employ air assault tactics to insert battalion sized maneuver units to conduct operations against the elusive guerilla force. Helicopter transports were employed to maneuver these troops through rugged mountainous terrain to envelop the enemy. Soviet doctrine and actual tactics relied heavily on combined arms. Therefore, in instances where the infantry units were inserted beyond the effective range of supporting artillery, the helicopterborne unit would lift its own organic field artillery to provide indirect fire support. The employment of combined arms continued, however, emphasis shifted from tanks and artillery supporting infantry and mechanized attacks to aviation delivered fire support for the ground force. Due to enemy small force size, effective concealment, and lack of high altitude targeting capability, the Soviet fixed wing aircraft delivered their munitions from low to medium altitudes.

Loss of the element of surprise by flying at low altitudes enabled the guerillas ample warning to seek cover, or disperse. As a result, the Mi-24 HIND became the primary platform for effective aviation delivered fire support.

The Soviet Union eventually lost the will to fight in Afghanistan and commenced a withdrawal from 1986 to 1989. Politically, the Soviet Union was not willing to commit the numbers of military personnel required to accomplish the military strategy. As a result, there were operational and tactical disconnects due to a significant lack of troops to secure critical areas. In addition, the Soviet military model and operational art was optimized against a large conventional fight in the open terrain of Europe vice the small bands of determined fighters on the restricted and rugged terrain of Afghanistan. Helicopters were utilized for assault support, the logistical effort, and most notably as the primary means of aviation fire support in this conflict. Without the Mi-24 HIND helicopter gunship, the Soviets may have been forced to withdraw years earlier,⁴² its firepower and mobility and initial invulnerability put the guerrillas on the defensive. The Soviet Union lost 333 helicopters to hostile fire;⁴³ there is not sufficient information to ascertain the proportion of helicopters brought down by small arms and anti-aircraft artillery fire.⁴⁴

VULNERABILITY OF HELICOPTERS

In addition to illustrating the versatility and utility of helicopters, the case studies from Vietnam, Rhodesia, Northern Ireland and Afghanistan, also demonstrate a common thread related to the vulnerability of helicopters. Small arms fire, light AAA and RPGs have accounted for a significant majority of helicopter combat losses. As combat helicopters have become more effective, the threats to helicopters have also become more capable and lethal. Helicopter survivability is a product of several probabilities. A combat helicopter should be difficult to detect, difficult to hit if detected, capable of continuing the mission in the event that it is hit, and, finally, crashworthy if it is shot down.⁴⁵ Helicopter design is tasked with, in order of priority, saving the man, the machine and the mission. These tasks require that a delicate balance be struck between vulnerability to threats (to man and machine) and payload to accomplish the mission. Recent

combat experiences in Iraq and Afghanistan have rekindled the now familiar rhetoric grappling with the question of whether the helicopter has outlived its utility on the modern battlefield. These discussions revolve around the vulnerability of helicopters in combat and whether their utility outweighs the cost in lives and materiel lost as a result of enemy action.

Two specific examples of the vulnerability of helicopters in recent US combat operations along with the emotive response beyond the mere significance of the events are: First, on March 23, 2003, during major combat operations in support of Operation IRAQI FREEDOM, thirty-three AH-64 Apache attack helicopters from the US Army 11th Attack Helicopter Regiment, were tasked with conducting a deep attack against the Iraqi Medina Division south of Baghdad.⁴⁶ The mission was aborted due to extensive battle damage to all the aircraft from small arms and rocket propelled grenade fire. One aircraft was shot down and its crew captured, and the remaining twenty seven were too severely damaged to return to flight status without repair.⁴⁷ The outcome of this battle prompted a deluge of questions about the relevance of the helicopter concepts and future use of attack helicopters from the military, political leadership as well as the media.⁴⁸ Notably, while this event occurred during major combat operations (the conventional fight), it is the asymmetric nature of the enemy's action which makes it relevant to this discourse. The second recent example is the extensive media coverage in February 2007 after a total of seven (six military and one contract civilian) helicopters were brought down by enemy action in a period of three weeks⁴⁹. Military leadership, critics and think tanks struggled comprehend the reasons for the spate of aircraft losses. These examples point to the fact that although the helicopter is a tactical asset, a downed helicopter is very likely an operationally significant event especially in an irregular or asymmetric warfare context –and potentially a significant strategic victory for an adversary. Improved tactics in shooting down helicopters have proved to be important factors in conflicts in which guerrillas have achieved victories against major powers, including battles in Somalia, Afghanistan and Vietnam.

It follows to take into consideration what threats the enemy can bring to bear against helicopters in order to hone in on helicopter's vulnerabilities. Generally, for a conventional force the tasks to destroy,

suppress or neutralize helicopters falls to the enemy's air forces and ground based air defense assets.⁵⁰

Looking at the threats to helicopters from the perspective of an irregular war adversary, a probable hypothesis is that the most likely threat will come from the lower end of the spectrum --small arms and light weapons. Analysis of an unclassified multiple source assessment made by the U.S. Army shows that between 1963 and 2004 the percentage of US helicopters downed due to enemy small arms engagements was 97%.⁵¹ Due to the security classification of recent operations in support of the Long War, detailed data for more recent helicopter losses in combat cannot be included in this analysis.⁵² However, working with the US Army Combat Assessment Team in Fort Rucker Alabama a comprehensive percentage is that 75% of US helicopters brought down by enemy action were as a result of small arms fire (including RPGs and other light weapons).⁵³

As of January, 2008, 67 US helicopters have been lost in support of Operation IRAQI FREEDOM as a result of enemy action.⁵⁴ Open media sources highlight unconfirmed reports indicating that insurgents in Iraq (indigenous and foreign) may have access to modern and more lethal surface to air missiles than originally assessed.⁵⁵ At the same time, other reports indicate that the spike in helicopter shoot downs are as a result of more effective ground fire, in some instances coordinated ambushes with effective aimed small arms fire. Regardless of which of the reports may be more accurate, the irrefutable fact is that insurgents have adapted their tactics and used whatever weapon system they have to target helicopters effectively. This fact coupled with the statistic which show that the preponderance of helicopters have been shot down by small arms and balanced against the fact that very little has been done to reduce the susceptibility of helicopters to small arms. In a classic asymmetric approach, the adversary has identified a vulnerability -- a high payoff target (HPT), the successful destruction of which has tactical and operational implications.

WHY EMPLOY HELICOPTERS? ALTERNATIVES EXIST

The capabilities which helicopters bring to a MAGTF or Joint Force Commander can be achieved with less casualties and erosion of popular support (political will) by leveraging emerging technology.

“Helicopters are arguably the most dangerous pieces of hardware in the Pentagon’s arsenal.” This quote by staff reporters from the Wall Street Journal illustrates the view of critics of future helicopter employment.⁵⁶ Helicopters essentially bring tactical mobility, limited reconnaissance, logistical and fire support to the battlefield.⁵⁷ The question of logistical support can be answered by employing systems such as the Joint Precision Airdrop Delivery System (JPADS) and the Sherpa Guided Parachute Cargo System. This combat proven system delivers a payload from 50 to 2,200 pounds to a precise location with a Circular Error Probability of 100 meters.⁵⁸ The family of systems developed also includes a Wind Supported Aerial Delivery System (WSADS) originally developed for leaflet drops but expanded to deliver fragile payloads such as blood and trauma kits, and also being considered for communications relay and Intelligence Surveillance and Reconnaissance functions.

Regarding helicopter delivered fire support from attack and utility helicopters, the capabilities provided by current fixed wing platforms equipped with modern targeting pods and precision guided munitions can accomplish the desired kinetic effect on the enemy. Specific to the MAGTF, aircrew flying F/A-18 Hornets and AV-8 Harriers equipped with the LITENING II Pod are afforded a Forward Looking Infrared (FLIR) or Charge Coupled Device (CCD) image in the cockpit, for targeting as well as reconnaissance. This image is superior to all but one helicopter based sensor. The advanced targeting pod combined with the aircraft’s ability to maintain standoff from enemy weapons by remaining at medium altitudes such as between 10,000 and 20,000 feet, yield a better picture of the battlefield than the helicopter may be able to achieve especially in an urban fight. The introduction of Unmanned Combat Aerial Vehicles (UCAVs) also supplements aviation delivered fire support available on the battlefield.⁵⁹ These platforms are envisioned as providing complimentary roles with manned platforms in strike, Suppression of Enemy Air Defenses (SEAD), and intelligence gathering mission sets, but at a fraction of the cost and risk.⁶⁰ In addition, the U.S. Air Force is developing a weapon dubbed the “Small Diameter Bomb.” This munition will provide the ability to engage and destroy more targets per flight on fixed wing attack aircraft. Because of its smaller size and precision accuracy the bomb will also reduce the collateral damage to areas adjacent to the intended

target while maintaining desired effects on target.⁶¹ Both of these advantages negate some of the advantages of attack helicopters. This niche was previously the domain of attack helicopters armed with HELLFIRE missiles. The precision of these missiles coupled with their low yield compare to the higher explosive power of fixed wing ordnance has been an ideal option in many attacks to precisely engage the enemy while minimizing collateral damage.

The remaining capability which helicopters bring to the battlefield is tactical mobility. In this regard, the transformation is already underway to procure and field vehicles with mobility and significant protection from mines and Improvised Explosive Devices (IEDs) to support the U.S. Army and Marine Corps ground troops. One such family of vehicles is the Mine Resistant Ambush Protected (MRAP) which an upgraded ground tactical system developed as a result of the very high incidences of death and serious injury from roadside and other explosive devices.⁶²

Finally, in order to reduce helicopter vulnerability to small arms threats, more armor plating needs to be installed. This additional armor will come with a very high weight penalty on the airframes. The cost of the additional weight on the helicopters will be manifested in decreased payload (fuel or role equipment). If the fuel load is reduced, there will be a corresponding decrease in range (distance to an objective and back) or endurance (time on station) for the helicopter. If the payload is reduced the ability of an assault support (transport) aircraft to carry troops or equipment will be diminished. For attack helicopters or utility helicopters in the armed role, the payload reduction would impact the type and quantities of ordnance the helicopter is able to carry and employ⁶³. In total, the effect of putting armor on helicopters in order to reduce susceptibility will dramatically reduce its role and utility. Taking this consideration and the current and emerging logistical, fire support and mobility capabilities in to account the helicopter may very well be obsolescent on the future battlefield.

THE ANSWER

The design and employment of helicopters has transformed over time respect to with emerging technology such as lighter weight gas turbine engines, composite material, aerial weapon systems, and the advent of equipment to support nighttime operations. Simultaneously, threats to the helicopter have also improved and diversified. One such example of an advanced Anti Aircraft Artillery systems is the Italian Oto Melara Sidam 25, a 25mm self propelled anti aircraft weapons system designed specifically to counter low flying aircraft and attack helicopters. In addition, the myriad of first thru third generation of Man Portable Air Defense Systems (MANPADS), present an evolving and sophisticated threat to military aviation in general and helicopters specifically. The US military has done a decent job of equipping helicopters with effective countermeasures and other survivability equipment, as well as training aircrews in appropriate tactics to mitigate the threat posed by MANPADs. On the other hand, statistics and anecdotal sources point out that the most likely threat to military helicopters is small arms fire. In this regard the military leadership has done very little to address this persistent threat.

As a result of the spike in helicopters damaged and shot down by ground fire during recent combat operations in Iraq; Army, Marine Corps and Air Force helicopter pilots have modified their tactics. Helicopters crews have varied their flight routes to mitigate predictability, and fly at higher altitudes, in most cases 1,500 feet or above ground level in order to deal with the threat of effective small arms fire.⁶⁴ This represents a significant paradigm shift for helicopter flight modes in a high threat environment. Typically, high threat tactics for helicopter crews drive them towards low altitude and Nap-Of-the Earth (NOE) flight profiles. This paradigm shift for helicopter pilots is analogous to the change in fixed wing strike mindset pre-1973 which previously established that the best way to defeat an enemy Integrated Air Defense System (IADS) was to attack from low altitude and with high airspeed.⁶⁵ The shift was as a result of the high Israeli losses against Soviet built air defense systems during the Yom Kippur War in 1973. By mid 1978 the U. S. Air Force led the shift in tactics, doctrine and equipment to fly in high altitude above lethal AAA and SAMs, focus on methodologically rolling the IADS back. Applying the analogy precisely to the situation with

helicopters, tactics and doctrine changed but new equipment also followed suit. In that instance, precision guided munitions for delivery above 20,000 feet along with targeting pods were fielded. Tactics and doctrine changes alone cannot support change of this magnitude without equipment.

The ability of helicopters to move personnel and materiel directly to locations, which may not be easily accessible to other modes of transportation, is a unique capability. This capability is in such demand that almost every military organization on this planet now contains some sort of rotary wing element.⁶⁶ Military helicopters are and will probably always be vulnerable to small arms fire due to its requirement to be light enough to be airworthy and accomplish its role (assault, utility or attack). Additionally, there is not always an option to overfly or out maneuver threat systems. Assault helicopters must land in close proximity to the threat to be effective at their task of getting ground troops to the fight. From the MAGTF perspective, helicopters provide options at the tactical level for speed, mobility and fire support. Loss of this option confines the MAGTF to one dimension –surface means to conduct its operations. Imagine the prospect of an opposed amphibious assault utilizing only landing craft against a competent adversary. Even Tiltrotor aircraft range and speed advantages are eclipsed by their payload shortfalls relative to helicopters.⁶⁷ Therefore, it will take longer to insert combat power and be even more challenging to support the force logistically. Without the appreciation and adaptation of the roles of its helicopter assets, the Soviet forces in Afghanistan would have had a much more devastating experience in that conflict. Loss of helicopter capability will have a significant negative effect on the mobility and logistical support afforded to the MAGTF and Joint forces in major combat operations or small wars.

Another facet of the loss of helicopter capability is the recent instances where US Army and Marine units fighting in the vicinity of Ar Ramadi, in western Iraq were systematically denied the use of Marine AH-1 and UH-1 aircraft in pre-planned combat operations to their area.⁶⁸ The decision to service preplanned requests to certain areas with fixed wing aircraft only was based on an Operational Risk Management (ORM) misapplication. The impetus for applying the ORM was based on a perception that the Marine attack and utility helicopters were too vulnerable to enemy fire, and therefore fixed wing attacks would be preferred.

The reality was that rotary wing attack aircraft were still required by the ground units, and they were forced to rely on Army Apache helicopters to provide fire support. The Apache aircraft sustained four battle damaged aircraft in one month; three of these were within a ten day period. The Marine Light/Attack helicopter squadron sustained five battle damaged aircraft in their entire seven month deployment.⁶⁹ Once the Apache crews began flying with Marine tactics they suffered no battle damage to the aircraft.⁷⁰ In this instance, the perceived vulnerability of helicopters led to commanders making decisions which marginalized a capability which was being requested. Considering that the weapons to target match from the H-1s favored the urban environment, this was potentially an operationally significant void in capability.⁷¹

The increased capability by fixed wing attack aircraft is complemented by attack helicopters on the battlefield. From March 20 to 17 April, 2003 during Operation IRAQI FREEDOM AH-1W (and UH-1N) aircraft executing Close Air Support and Armed Reconnaissance missions inflicted significant damage on Iraqi forces in support of rapid march to Baghdad by I MEF and 1st Marine Division⁷². Attack helicopters provided responsive and lethal fire support during major combat operations in a complementary fashion alongside fixed wing assets. In addition, analyses from Operating ANACONDA, indicate that attack helicopters proved to be rapidly deployable, survivable and highly effective.⁷³ Projecting into the missions of the future, concepts like Ship-To-Objective-Maneuver (STOM)⁷⁴, helicopters play a key role alongside other current and emergent capabilities such as the MAGTF Expeditionary Family of Fighting Vehicles (MEFFV), MV-22 Osprey and the Lightweight 155mm Howitzer M-777. The objectives of the concept(s) are to facilitate power projection and forcible entry from the sea ultimately bypassing enemy strengths and pitting ours against his vulnerabilities. Military helicopters are central to this. With all these considerations, it is evident that the past, present and future utility of helicopter capability warrants an effort to make them less vulnerable.

The recommended solution falls into two categories: Short term and Long Term. The short term solutions will focus on between 2008 and 2020 based on the assumption that there are no new aircraft slated to replace the current fleet.⁷⁵ It will recommend changes to the equipping and employment of the helicopters

organic to the MAGTF. An overarching issue is that helicopter vulnerability shortfalls quite significant and require a change (higher) in prioritization of funding to address for both short and long term.

Short Term Solutions

Fund research to better document the vulnerability of current Marine helicopters in order to better understand and assume the risks from small arms. In addition, the research should identify what caliber/ size round must be defeated by measures taken. All the Marine helicopters fielded and projected to remain in service through 2020 were originally developed in the 1960s. Therefore, assumptions upon which performance parameters for each of the aircraft's ballistic tolerance are outdated with respect to the current threat. In addition, the modeling, technology or testing procedures have been updated by the experts in most cases. The benefit would be more fidelity for assessments of effectiveness, and ultimately a better capability to understand the risks of a threat system to a particular airframe, so that aircrew and other higher level decision makers can make the correct call, as opposed to being overly conservative.⁷⁶ A case in point is the fidelity of documented testing for the MV-22B with regard to ballistic tolerance yields a better empirical understanding of its vulnerability than any other helicopter in service.⁷⁷ Data from testing to determine current aircraft vulnerabilities to the pertinent caliber of small arms or AAA as well as lessons learned from recent combat must be incorporated to the training regime.

The Department of Defense and specifically the Marine Corps must leverage current and emergent technology to find ways to lighten the airframes, components, and other equipment on helicopters. Accordingly demand more results from industry. The associated weight reduction can be put to use by allowing for armor installation without a corresponding capability loss. Based on the assumption that current aircraft will be modified and refitted periodically, establish lighter and more durable components as the standard, and demand these results from the helicopter industry. An example of emerging science is the 'liquid armor technology' being developed at the University of Delaware.⁷⁸ This product or its derivatives may be applicable to developing lightweight, effective aircraft armor. It is hard to fathom the fact that radar absorbent material for stealth aircraft, and material that protects a Space Shuttle from re-entry extreme

temperatures have been developed, while the transmission on a Marine combat helicopter carrying troops into harm's way will only last a few minutes without cooling oil before it seizes and causes a catastrophic crash.

For assault helicopters, the focus should be on better armor to protect aircrew, critical components and embarked personnel. Recently developed military aircraft such as the Eurocopter Tiger have aircraft skin based on Carbon Epoxy composite panels which offer secondary ballistic protection, in addition to armor installed around pilots and critical components.⁷⁹ Attack helicopters would benefit from the same armor. Additionally, procuring and fielding better targeting sensors would allow attack aircrews to detect, recognize and identify hostile targets at better standoff ranges, thereby reducing aircraft vulnerability by standoff. Similarly, continuing to develop weapons such as the HELLFIRE missile, and future munitions which should incorporate fire-and-forget technology would enhance attack helicopter survivability. Finally, prioritized fielding equipment that fosters generation and digital sharing of targeting information with other assets on the battlefield such as fixed wing assets, UASs, UCAVs and most importantly the Joint Terminal Attack Controller (JTAC) will also enhance survivability.

The preceding section addressed recommended measures to improve the military helicopter's ability to continue with the mission if detected, engaged and hit by enemy small arms. In the event the aircraft cannot continue on the mission, the aircrew would have a better chance of diverting and landing at a suitable site. In order to make helicopters more difficult to successfully engage, the aircraft's agility must be improved. Generally, a helicopter's agility hinges on the design of its main rotor head and the power available to maneuver. To that end, aircraft like the AH-1W and UH-1N which are designed with rigid two-bladed under slung rotor systems are at a significant disadvantage. Fielding more powerful engines on the aircraft and exploring the feasibility of upgrading to composite main rotor heads would improve the ability of these aircraft to effectively maneuver to counter accurate aimed small arms and AAA fire.

Long Term Solutions

Projecting past 2020, Marine aviation leadership will need to scrutinize carefully the role which helicopter capabilities will play in the overall military effort across the full spectrum of operations. The requirement to insert and extract troops, provide reconnaissance whether armed or visual on the enemy and movement of troops and supplies around the battlefield will probably not change. However, the means by which these tasks are accomplished probably will. While it may be evident that helicopter capabilities will likely be required on the future battlefield, manned helicopters may be obsolescent. In attack and reconnaissance roles the future may be already here. UAS and UCAV collect intelligence and employ weapons respectively, on the enemy. For assault support and utility missions involving the transport of troops, unmanned platforms performing those tasks are harder to grasp and accept. Obviously this will require a significant advance over current technology (and confidence) in unmanned systems. The rifleman of the future may step off the ramp into a hot landing zone from an air vehicle with vertical takeoff and landing capabilities which is remotely piloted from the ground or air. The idea being, without the pilots and crew chiefs and all the equipment required to support them, additional weight is available to add armor to the platform in order better protect vulnerable components and cargo, increase payload or support the technology to fly it remotely.

More realistically, future advances in No Tail Rotor (NOTAR) or similar technology will remove a serious liability. The tail rotor is a critical component of flight providing counter torque and directional stability to certain helicopter configurations. It is a factor with regards to safety and maneuverability.⁸⁰ Additionally, not having the power requirement to drive a tail rotor results in more power available to the helicopter for lift, speed or maneuver. Older alternatives to tail rotor configuration are the tandem rotor configuration in which the forward and rear rotor systems spin in opposite directions therefore nullifying the requirement for a counter torque device. Newer helicopters such as the K-Max with intermeshing rotors and the Russian Kamov Ka-50 HOKUM with co-axial rotors are recent examples of successful alternatives to the tail rotor. The final long term consideration for helicopter vulnerability is that these developments require

time, funding and most importantly a demand. The sooner the shortfalls are recognized and prioritized accordingly, the better the solution.

To prepare for future conflict the MAGTF must anticipate requirements and accurately assess shortfalls especially with regards to its helicopter assets. As an establishment, it must learn from and adapt to lessons learned on the battlefield. Helicopters are relevant to current and future conflict regardless of the scale and scope. They have been instrumental particularly in small wars and irregular conflict and will likely continue be an essential capability. Helicopters in general, and Marine helicopters specifically are vulnerable to small arms, and our future adversaries will likely choose to fight in a way which exploits this vulnerability. The loss or degradation of helicopter capability due to enemy action, military risk aversion or political constraints will remove critical organic fire support, mobility to rapidly cover distance on the battlefield and hinder the ability to logistically support combat troops.

The helicopter especially in modern conflict arguably has been viewed as a tactical asset but a significant operational liability. With that has come a lack of impetus for support to change. To an extent tactics and doctrine have changed to counter the threat. Without a dramatic change of equipment, future adversaries being well aware of the vulnerability of helicopters to ubiquitous weapons such as small arms and the strategic impact of successfully shooting down a U.S. helicopter will do just that. Moving forward without addressing this vulnerability, our future adversaries gain a potentially decisive advantage. To fix the problem, time and resources are invaluable. How much risk will the MAGTF commander be willing to take with helicopters on the modern battlefield?

Notes

¹ Nicholas Kulish and Anne Marie Squeo, "The Future of Helicopters in Battle Looks Choppy." *New York Times*, July 23, 2003.

² John Everett-Heath, *Helicopters In Combat: The First Fifty Years*. (London: Arms and Armour, 1993), 64.

³ Ibid.,

⁴ Ibid.,

⁵ Everett-Heath, *Helicopters in Combat* 84.

⁶ Ibid.,

⁷ Ibid.,

⁸ Ibid.,

⁹ The aircraft had four wing stub mounted pylons which could carry either the 19 or 7 shot 2.75" rocket pods, the fixed 7.62mm gun pod, or fixed 20mm gun pod. Ibid.,

¹⁰ The first TOW missile fired in combat was from a section of UH-1Bs on May 2 1972. Everett-Heath, *Helicopters in Combat* 102.

¹¹ Ibid.,

¹² Everett-Heath, *Helicopters in Combat* 104.

¹³ Everett-Heath, *Helicopters in Combat* 105.

¹⁴ *Global Security.org: UH-1 Iroquis Huey*. <http://www.globalsecurity.org/military/systems/aircraft/uh-1-history.htm> (accessed March 11, 2008).

¹⁵ Everett-Heath, *Helicopters in Combat* 111.

¹⁶ Ibid.,

¹⁷ Ibid.,

¹⁸ This operation was considered a significant test of the battle effectiveness of the helicopter against a formidable conventional force employing much more than small arms and light AAA. The objective area covered thirty five by sixty kilometers but was densely packed with nineteen NVA AAA battalions equipped with 23mm, 37mm and 57mm AAA weapons and integrated with highly mobile 12.7mm heavy machine gun teams. Ohio State University, Origins: eHistory. *Chapter 11: The Marines in Operation Lam Son 719* n.d. <http://ehistory.osu.edu/vietnam/books/vietnamization/0195.cfm> (accessed March 9, 2008)

¹⁹ Ibid.,

²⁰ Britain intended to relinquish colonial control and establish an independent Rhodesian government. The established white minority power base tried to keep political power from the country's black majority. In 1965, the negotiations fell apart resulting in the white minority seceding and declaring an independent republic. Bruce Hoffman, Jennifer Taw, and David Arnold. *Lessons for Contemporary Counterinsurgencies: The Rhodesian Experience*. (Prepared for the U.S Army Santa Monica, CA: RAND, 1991), 6.

²¹ James Corum, and Wray Johnson. (*Airpower in Small Wars: Fighting Insurgents and Terrorists*. Kansas: University Press of Kansas, 2003), 292.

²² Ibid.,

²³ Hoffman, Taw, and Arnold, 55-56.

²⁴ Corum and Johnson, 298.

²⁵ Ibid.,

²⁶ Ibid.,

²⁷ Ibid.,

²⁸ Ibid.,

²⁹ The guerillas were unable to inflict major casualties on the Rhodesian forces or the white settlers. Ultimately, despite the military outcome, the Rhodesian government lost the will to continue the counterguerilla struggle against the persistent guerilla pressure. In 1980, after a negotiated settlement and election the country now called Zimbabwe had a new government and its first black president. Alex Binda. "Operation Uric - Gaza Mozambique 1-7 September, 1979." *Memories of Rhodesia*. 2007. <http://www.memoriesofrhodesia.com/media/documents/Op-Uric.pdf> (accessed March 11, 2008).

³⁰ OP URIC is the controversial operation of The Rhodesian War. Though it resulted in over 300 enemy dead for the loss of 15 of their own (the highest of the war) the Rhodesians did not regard it as a success. There was bitterness too, as for the first time the Rhodesians were unable to recover the bodies of their fallen comrades; for the first time also the lightly armed Rhodesians were stopped in their tracks and forced to abandon their objective in the face of a more numerous and well dug in enemy, who, for a time at least, displayed a fighting tenacity not encountered before. Despite being armed with anti-aircraft guns and Strela (Soviet name for SAM-7 surface-to-air missile), the most effective enemy weapon proved to be the comparatively simple RPG-7 (a rocket fired from a hand held launcher) which, in the event, was responsible for all the Rhodesian fatalities. Alex Binda. "Operation Uric - Gaza Mozambique 1-7 September, 1979." *Memories of Rhodesia*. 2007. <http://www.memoriesofrhodesia.com/media/documents/Op-Uric.pdf> (accessed March 11, 2008).

³¹ Ibid.,

³² United Kingdom, Ministry of Defense, Operation BANNER: An analysis of Military Operations in Northern Ireland. July 2006. <http://www.serve.com/pfc/misc/opbanner.pdf> (accessed November 30, 2007), 6-2.

³³ Ibid.,

³⁴ Ibid.,

³⁵ Ibid.,

³⁶ Ibid.,

³⁷ Helicopters came under fire on various occasions in this region; the preferred weapon by the IRA was an M-60 medium machinegun. The passenger onboard the aircraft in this incident was the commanding officer of the 2nd Battalion, The Royal Green Jackets, an English light infantry regiment. David Wragg, *Helicopters at War: A Pictorial History*, (New York: St Martin's Press 1983), 143.

³⁸ Urban, 68.

³⁹ Urban, 68.

⁴⁰ The Soviet Union developed HIND while paying close attention to U.S. evolution of UH-1 missions from utility, to multi-role (with the gunship) and finally branching to dedicated attack helicopters (AH-1G) during the Vietnam War. The need to have the capability of a flying tank unhindered by terrain or minefields also influenced their design. As a result the Soviets opted for a heavily armored multi-role helicopter with integrated weapons. (Wragg, 118).

⁴¹ Everett-Heath *Helicopters in Combat*, 127

⁴² Lester Grau. *The Bear Went Over the Mountain*, (Portland: Frank Cass, 1998), 17.

⁴³ General Mohammad Yahya Nawro, Army of Afghanistan(Ret), and Lester Grau. "The Soviet War in Afghanistan: History and Harbinger of Future War?" *Columbia International Affairs Online*. http://ciaonet.org/cbr/cbr00/video/cbr_ctd/cbr_ctd_52.html (accessed November 27, 2007).

⁴⁴ Prior to 1986, the mujahedeen's most effective anti-aircraft weapon proved to be the 12.7 mm and the 14.5 mm heavy machine-guns. These heavy machine-guns began arriving in greater numbers as a result of increasing Chinese deliveries. For instance, there were only 13 mujahedeen heavy machine-guns in the Panjshir Valley in 1982, but, by the end of 1984, there were almost 250 and the mujahedeen became quite proficient in the use of these weapons to conduct "lateral ambushes." They situated gun sites at positions along opposing ridgelines in order to provide enfilade fire of Soviet aircraft operating in the area below the ridge or along the valley floor. Edward B Westermann, "The Limits of Soviet Airpower: The Failure of Military Coercion in Afghanistan, 1979-89." *The Journal of Conflict Studies*, Vol. XIX No.2 (Fall 1999). <http://www.lib.unb.ca/Texts/JCS/bin/get5.cgi?directory=fall99/&filename=WESTERMA.htm#1> (accessed March 11, 2008)

⁴⁵ Everett-Heath, and others, *Military Helicopters*, 95.

⁴⁶ Douglas L. Brockhard Jr., "Will United States Army Attack Aviation be a Relevant Combat Multiplier in Future Conflicts," (master's thesis, U.S. Army Command and General Staff College, 2004), 7.

⁴⁷ Ibid.,

⁴⁸ –"The Apache is the most sophisticated attack helicopter ever built, so if it can't operate safely in a place like Iraq, that has to raise questions about the whole concept of attack helicopters." Quote attributed to Dr Loren Thompson, director of Lexington Institute. Nicholas Kulish and Anne Marie Squeo, "The Future of Helicopters in Battle Looks Choppy." *Wall Street Journal*, July 23, 2003.

⁴⁹ Michael Gordon and David Cloud. "Planning Seen in Iraqi Attacks on US Copters" *New York Times* February, 18 2007
http://www.nytimes.com/2007/02/18/world/middleeast/18helicopter.html?_r=1&scp=2&sq=18+february+2007&st=nyt&oref=slogin (accessed February 12, 2008)

⁵⁰ Everett-Heath, *Helicopters in Combat*, 161.

⁵¹ Unclassified Multiple Source Historical Helicopter Combat Loss Data from 1963-2004. E-mail to author from CW4 Gregory Calvert, U.S. Army.

⁵² Any data relating to operations within Operation ENDURING FREEDOM / Operation IRAQI FREEDOM related to shoot down statistics broken down by where, when, and/or mechanism of loss, no matter how vague, are considered classified.

⁵³ CW4 Gregory Calvert, e-mail message to author January 7, 2008.

⁵⁴ Brookings Institution, *Iraq Index: Tracking Variables of Reconstruction and Stability in Post Saddam Iraq*, February 28, 2008 <http://www.brookings.edu/saban/iraq-index.aspx> (accessed March 14, 2008)

⁵⁵ Andrew Mc Gregor. "Iraqi Insurgents Claim New Generation of Missiles Being Used." *The Jamestown Foundation*. February 14, 2007. <http://www.jamestown.org/terrorism/news/article.php?articleid=2370245> (accessed January 24, 2008).

⁵⁶ Kulish and Squeo, "The Future of Helicopters in Battle Looks Choppy."

⁵⁷ Headquarters U.S. Marine Corps. *Assault Support*. MCWP 3-24. (Washington, DC: Headquarters U.S. Marine Corps), May, 20 2004, 1-1.

⁵⁸ "MMIST Sherpa GPS guided Parafoil." *MMIST*. 2004. <http://www.mmist.ca/Sherpa.asp> (accessed January 25, 2008).

⁵⁹ John Pike, *X-45 Unmanned Combat Aerial Vehicles*. December 1, 2005. <http://www.fas.org/man/dod-101/sys/ac/ucav.htm> (accessed Jan 27, 2008).

⁶⁰ Ibid.,

⁶¹ GlobalSecurity.org *Small Diameter Bomb*.

<http://www.globalsecurity.org/military/systems/munitions/sdb.htm> (accessed January 26, 2008).

⁶² GlobalSecurity.org. *Mine Resistant Ambush Protected (MRAP) Vehicles*.

<http://www.globalsecurity.org/military/systems/ground/mrap.htm> (accessed January 26, 2008).

⁶³ Everett-Heath, and others, *Military Helicopters*, 95

⁶⁴ Jim Slife, *Armed Forces Journal*. June 2007. <http://www.armedforcesjournal.com/2007/06/2649720> (accessed January 26, 2008).

⁶⁵ Ibid.,

⁶⁶ Tim Ripley, *The Global Helicopter Industry: Rising to Demand*. Jane's Defence Weekly, January 11, 2006 <http://www8.janes.com/Search/printFriendlyView.do?docId=/content1/janesdata/mags/jdw> (accessed January 29, 2008)

⁶⁷ The MV-22 can roughly carry as much as the CH-46E. Tiltrotor technology will have to be advanced to support heavy lift capabilities supported by the Marine CH-53E.

⁶⁸ Marine gunships were only allowed to launch into certain areas on Troop-In-Contact missions primarily due to the urgent nature of the situation. For preplanned missions, the senior aviation commander would only authorize fixed wing aircraft to service those requests. The ORM matrix was based on rudimentary guidelines, but became a risk avoidance tool due to a perception of helicopter vulnerabilities, and not taking into account the larger picture such as tactics and Close Air Support proficiency. The second and third order effects of the decision were significant. Maj Michael Grice "Fear of Flying: The Unintended Consequences of ORM" *Marine Corps Gazette*, Vol. 91, No. 6 (June 2007): 15-18.

⁶⁹ One of the Marine incidents was an aircraft shoot down, which preceded the heavy handed ORM application. Ibid.,

⁷⁰ Ibid.,

⁷¹ "Fixed Wing CAS can provide many benefits to the maneuver commander but cannot fill the void left by absent H-1s. Kinetic attacks from H-1s can be performed in seconds while fixed wing aircraft take anywhere from 5-10 minutes to set up and prosecute." Ibid.,

⁷² Allen Grinalds. "Cobras Rock in Iraqi Freedom." *United States Naval Institute. Proceedings*. Vol 130, Iss. 3 (March 2004): 72-76. <http://www.proquest.com/>.

⁷³ Anthony Cordesman. *The Lessons of Afghanistan: Warfighting, Intelligence and Force Transformation*. (Washington, DC: 2002), 150.

⁷⁴ Ship-to-Objective-Maneuver includes combined arms penetration and exploitation from over the horizon to by both air and surface means, with forces moving rapidly to operational objectives without stopping to seize, defend and build up beachheads or landing zones. Headquarters, U.S. Marine Corps. *United States Marine Corps Concepts & Programs 2007*. (Washington, D.C: Headquarters U.S. Marine Corps), 2007, 21.

⁷⁵ The exceptions are the AH-1Z, UH-1Y and CH-53K which are in various stages of development and production. Headquarters, U.S. Marine Corps. *United States Marine Corps Concepts & Programs 2007*, 9.

⁷⁶ Grice, *Fear of Flying*

⁷⁷ The V-22, in comparison with other recent US aircraft, has been designed to minimize the extent of its vulnerable area, by separating and duplicating critical components and protecting key areas: the V-22's vulnerable area to a single 23mm hit is equal to that of the much smaller H-60 series. In case of the worst scenario occurring, the V-22 is designed so that its occupants will survive a vertical impact of 11m/s. The wings break off outboard of the fuselage, the landing gear slows the descending body by one-third and the seats move 23cm in a downwards direction to help absorb the impact. Bill Sweetman. "Dossier, Helicopter Development Hanging in the Balance: Mixed Fortunes for Manufacturers," *Jane's International Defense Review*, 29, no. 6 (June 1996): 89-97

⁷⁸ The technology uses a thickening fluid added to certain armor fabric which make them flexible under normal wear but have the ability to resist penetration when struck by a knife, spike or high velocity projectile or fragment by effectively spreading the impact over a large area. This product or derivatives of it may be applicable to designing lightweight, effective aircraft armor. Neil Thomas. *University of Delaware: Liquid Armor Technology Licensed by UD*. February 24, 2006.
<http://www.udel.edu/PR/UDaily/2006/feb/armor022406.html> (accessed January 26, 2008).

⁷⁹ Australian Government, *Ballistic and Material Testing Procedures for Composite Samples for the TIGER Helicopter Vulnerability Project*, (Edinburgh: DSTO Systems Sciences Laboratory, 2004),1.

⁸⁰ Tail rotors are a big factor in aircraft crashes/losses due to the tail rotor contacting terrain and trees. Reports from OIF indicate insurgents targeting tail rotors with weapons in order to shoot them down. Finally, the side and rear speed limits for helicopters are a function of the tail rotor.

APPENDIX A

Unclassified Multiple Source Historical Helicopter Combat Loss Data from 1963-2004

Small Arms Engagements

Small Arms Engagements														Vietnam										ROK	UF	JC	DS	GS	ROK	EF	IF	Totals
	1983	1984	1985	1986	1987	1988	1989	1970	1971	1972	1973	1974	1975	1977	1983	1989	1991	1993	1994	2002	2003	2004										
AH-1						6	28	23	14	9					1		1	1					84									
UH-1				18	25	43	62	63	52	22	7	1										1	295									
HH-3						3	1	1	1								1															
OH-13				1	2	4	7																									
OH-23						3	3	1															7									
UH-34	1	4	11	17	20	11																	64									
CH-21	1																															
CH-37	1																						2									
HH-43				1				1	1																							
CH-46				8	17	36	31	13	3														108									
CH-47					1	4	3	5	1	1													15									
CH-53								2	2	1				2									7									
CH-54						1				11																						
OH/AH-6						24	55	37	23							3				1			142									
OH-58								3	6				2										13									
UH/MH-60															1	1	1	2				7	12									
MH-47																				2			2									
AH-64																	1															
Totals	3	4	32	53	91	155	183	137	71	29	1	2	2	0	2	4	5	3	1	2	10	1	751									

SAM Engagements

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1977	1983	1989	1991	1993	1994	2002	2003	2004	Totals
AH-1									1														1
UH-1									1	1													3
CH-53										1													1
OH/AH-6									1														1
CH/MH-47																					1		1
UH/MH-60																						1	1
Totals	0	0	0	0	0	0	0	1	2	3	0	0	0	0	0	0	0	0	0	0	1	1	7

Other

Other	(Mine, Boobytrap, Air to Air Engagement)																							
	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1977	1983	1979	1991	1993	1994	2002	2003	2004	Totals	
AH-1									1															1
UH-1				2	3																			5
OH/AH-6									1		2													3
CH/MH-47										1				1										2
UH/MH-60																				2				2
Totals	0	0	0	2	3	0	0	2	0	3	0	0	0	1	0	0	0	0	2	2	0	0	0	13

All data collected from Unclassified Open Source Material
 Defense Intelligence Agency Helicopter Loss database
 Survivability/Vulnerability Information Analysis Center Helicopter database
 Internet Studies
 Vietnam Veterans Pilot Association / Both US Army and Marine

Data collected does not include accidents or "Lost to Inventory" (Vietnam) Classification where cause of loss is not clearly identified in historical files

Summary:

Total Helicopters Lost to Enemy Action	771	
Total Helicopter losses due to Small Arms (20mm and below/RPGs)	751	97%
Total Helicopters Lost to Surface to Air Missiles	7	1%
Total Helicopters Lost to "Other" Enemy Activity	13	2%

IF- Operation IRAQI FREEDOM
 EF- Operation ENDURING FREEDOM
 ROK- Republic Of Korea
 GS- Operation GOTHIC SERPENT (Somalia)
 DS- Operation DESERT STORM
 JC- Operation JUST CAUSE
 UF- Operation URGENT FURY

Source: CW4 Gregory Calvert U.S. Army, obtained from various database compilations.

APPENDIX B

Department of Defense Helicopter Combat Loss Data 2002- January, 2008

Year	Number of Helicopters
2002	2
2003	14
2004	15
2005	8
2006	9
2007	15
2008	0

Source: CW4 Gregory Calvert U. S. Army. E-mail and telephone interview.

Bibliography

- Australian Government. *Ballistic and Material Testing Procedures for Composite Samples for the TIGER Helicopter Vulnerability Project*, Edinburgh: DSTO Systems Sciences Laboratory, 2004.
- Baumann, Robert. "Compound War Case Study: The Soviets in Afghanistan." *Global Security.org*. 2001. http://globalsecurity.org/military/library/report/2001/soviet-afghan_compound-warfare.htm (accessed November 20, 2007).
- Binda, Alex. "Operation Uric - Gaza Mozambique 1-7 September, 1979." *Memories of Rhodesia*. 2007. <http://www.memoriesofrhodesia.com/media/documents/Op-Uric.pdf> (accessed March 11, 2008).
- Cordesman, Anthony. *The Lessons of Afghanistan: Warfighting, Intelligence and Force Transformation*. Washington, DC: CSIS Press, 2002.
- Corum, James F, and Wray R Johnson. *Airpower in Small Wars: Fighting Insurgents and Terrorists*. Kansas: University Press of Kansas, 2003.
- Daniel, Eric. "Up in The Sky: Sherpa Guided Parachute Cargo System." *Military.com*. 2004. http://www.military.com/soldiertech/0,14632,Soldiertech_SHERPA,,00.html (accessed January 26, 2008).
- Directorate of Intelligence, Central Intelligence Agency. "The Soviet Invasion of Afghaistan: Five Years After." *The National Security Archive, The George Washington University Website*. <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB57/us5.pdf> (accessed November 20, 2007).
- Everett-Heath, E. J, G.M Moss, A. W Mowatt, and K. E. Reid. *Military Helicopters*. London: Brassey's, 1990.
- Everett-Heath, John. *Helicopters In Combat: The First Fifty Years*. London: Arms and Armour, 1993.
- Girardet, Edward. *Afghanistan: The Soviet War*. New York: St. Martin's Press, 1985.
- GlobalSecurity.org Small Diameter Bomb*. <http://www.globalsecurity.org/military/systems/munitions/sdb.htm> (accessed January 26, 2008).

GlobalSecurity.org : Mine Resistant Ambush Protected (MRAP) Vehicles.

<http://www.globalsecurity.org/military/systems/ground/mrap.htm> (accessed January 26, 2008).

Global Security.org: UH-1 Iroquis Huey. <http://www.globalsecurity.org/military/systems/aircraft/uh-1-history.htm> (accessed March 11, 2008).

Grau, Lester. *The Bear Went Over the Mountain*. Portland: Frank Cass, 1998.

—. "The Soviet-Afghan War: A Superpower Mired in the Mountains." *Foreign Military Studies Office Publications*. <http://fmso.leavenworth.army.mil/documents/miredinmount.htm> (accessed November 27, 2007).

Grice, Michael D. "Fear of Flying: The Unintended Consequences of ORM" *Marine Corps Gazette*, Vol. 91, No. 6 (June 2007): 15-18.

Grinalds, Allen, D.

Headquarters, U.S. Marine Corps. *Assault Support*. MCWP 3-24. Washington D.C: Headquarters U.S. Marine Corps, May 20, 2004.

Kulish, Nicholas and Squeo, Anne Marie. "The Future of Helicopters in Battle Looks Choppy." *New York Times*, July 23, 2003.

Liles, Christian F, and Christopher Bolkom. *Military Helicopter Modernization: Background and History for Congress*. Congressional Report for Congress, Washington, D.C.: Library of Congress, 2004.

Mc Gregor, Andrew. "Iraqi Insurgents Claim New Generation of Missiles Being Used." *The Jamestown Foundation*. February 14, 2007.
<http://www.jamestown.org/terrorism/news/article.php?articleid=2370245> (accessed January 24, 2008).

Minaya, Zeke. *General: Ground Fire likely downed 4 helos*. New York Times February 5, 2007.
<http://www.globalsecurity.org/org/news/2007/070205-downed-helos.htm> (accessed January 24, 2008).

Mohammad Yahya Nawro, General, Army of Afghanistan (Ret), and Lester Grau. "The Soviet War in Afghanistan: History and Harbinger of Future War?" *Columbia International Affairs Online*. http://ciaonet.org/cbr/cbr00/video/cbr_ctd/cbr_ctd_52.html (accessed November 27, 2007). "MMIST Sherpa GPS guided Parafoil." *MMIST*. 2004. <http://www.mmist.ca/Sherpa.asp> (accessed January 25, 2008).

"MMIST: CQ-10A SnowGoose." *MMIST*. 2004. <http://www.mmist.ca/SnowGoose.asp> (accessed January 26, 2008).

Mobile Helicopter Killers Found and Destroyed in Iraq. January 24, 2008.

<http://www.strategypage.com/htm/htada/articles/20070319.aspx> (accessed January 28, 2008).

Ohio State University, Origins: eHistory. *Chapter 11: The Marines in Operation Lam Son 719* n.d.

<http://ehistory.osu.edu/vietnam/books/vietnamization/0195.cfm> (accessed March 9, 2008).

Pike, John. *X-45 Unmanned Combat Aerial Vehicles*. December 1, 2005. <http://www.fas.org/man/dod-101/sys/ac/ucav.htm> (accessed Jan 27, 2008).

Slife, Jim. *Armed Forces Journal*. June 2007. <http://www.armedforcesjournal.com/2007/06/2649720> (accessed January 26, 2008).

Thomas, Neil. *University of Delaware: Liquid Armor Technology Licensed by UD*. February 24, 2006.

<http://www.udel.edu/PR/UDaily/2006/feb/armor022406.html> (accessed January 26, 2008).

Turbiville, Jr., Graham. "Ambush! The Road War in Afghanistan." *Foreign Military Studies Office Publications*. <http://leav-www.army.mil/fmsso/documents/ambush-road/ambush-road.HTM> (accessed November 20, 2007).

U.S. Department of Defense, Department of the Army. "Lessons from the War in Afghanistan." *The National Security Archive, The George Washington University Website*. May 1989.

<http://www2.gwu.edu/~nsarchiv/NSAEBB/NSAEBB57/us11.pdf> (accessed November 20, 2007).

United Kingdom, Ministry of Defence. *Operation BANNER: An Analysis of Military Operations in Northern Ireland*. July, 2006. www.serve.com/pfc/misc/opbanner.pdf (accessed November 20, 2007).

Urban, Mark. *War in Afghanistan*. New York: St. Martin's Press, 1988.

Bibliography

- Australian Government. *Ballistic and Material Testing Procedures for Composite Samples for the TIGER Helicopter Vulnerability Project*, Edinburgh: DSTO Systems Sciences Laboratory, 2004.
- Baumann, Robert. "Compound War Case Study: The Soviets in Afghanistan." *Global Security.org*. 2001. http://globalsecurity.org/military/library/report/2001/soviet-afghan_compound-warfare.htm (accessed November 20, 2007).
- Binda, Alex. "Operation Uric - Gaza Mozambique 1-7 September, 1979." *Memories of Rhodesia*. 2007. <http://www.memoriesofrhodesia.com/media/documents/Op-Uric.pdf> (accessed March 11, 2008).
- Brockhard Jr., Douglas L. "Will United States Army Attack Aviation be a Relevant Combat Multiplier in Future Conflicts," Master's thesis, U.S. Army Command and General Staff College, 2004.
- Brookings Institution, *Iraq Index: Tracking Variables of Reconstruction and Stability in Post Saddam Iraq*, February 28, 2008 <http://www.brookings.edu/saban/iraq-index.aspx> (accessed March 14, 2008)
- Cordesman, Anthony. *The Lessons of Afghanistan: Warfighting, Intelligence and Force Transformation*. Washington, DC: CSIS Press, 2002
- Corum, James F, and Wray R Johnson. *Airpower in Small Wars: Fighting Insurgents and Terrorists*. Kansas: University Press of Kansas, 2003.
- Daniel, Eric. "Up in The Sky: Sherpa Guided Parachute Cargo System." *Military.com*. 2004. http://www.military.com/soldiertech/0,14632,Soldiertech_SHERPA,,00.html (accessed January 26, 2008).
- Directorate of Intelligence, Central Intelligence Agency. "The Soviet Invasion of Afghaistan: Five Years After." *The National Security Archive, The George Washington University Website*. <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB57/us5.pdf> (accessed November 20, 2007).
- Everett-Heath, E. J, G.M Moss, A. W Mowatt, and K. E. Reid. *Military Helicopters*. London: Brassey's, 1990.
- Everett-Heath, John. *Helicopters In Combat: The First Fifty Years*. London: Arms and Armour, 1993.
- Gordon, Michael and Cloud, David. "Planning Seen in Iraqi Attacks on US Copters" *New York Times* February, 18 2007 http://www.nytimes.com/2007/02/18/world/middleeast/18helicopter.html?_r=1&scp=2&sq=18+february+2007&st=nyt&oref=slogin (accessed February 12, 2008).
- Girardet, Edward. *Afghanistan: The Soviet War*. New York: St. Martin's Press, 1985.
- GlobalSecurity.org Small Diameter Bomb*. <http://www.globalsecurity.org/military/systems/munitions/sdb.htm> (accessed January 26, 2008).

GlobalSecurity.org : Mine Resistant Ambush Protected (MRAP) Vehicles.

<http://www.globalsecurity.org/military/systems/ground/mrap.htm> (accessed January 26, 2008).

Global Security.org: UH-1 Iroquis Huey. <http://www.globalsecurity.org/military/systems/aircraft/uh-1-history.htm> (accessed March 11, 2008). Grau, Lester. *The Bear Went Over the Mountain*. Portland: Frank Cass, 1998.

—. "The Soviet-Afghan War: A Superpower Mired in the Mountains." *Foreign Military Studies Office Publications*. <http://fmso.leavenworth.army.mil/documents/miredinmount.htm> (accessed November 27, 2007).

Grice, Michael D. "Fear of Flying: The Unintended Consequences of ORM" *Marine Corps Gazette* Vol. 91, no. 6 (June 2007): 15-18.

Grinalds, Allen, D. "Cobras Rock Iraqi Freedom" *United States Naval Institute. Proceedings* Vol 130, Iss. 3 (March 2004): 72-76. <http://www.proquest.com/>.

Headquarters, U.S. Marine Corps. *Assault Support*. MCWP 3-24. Washington D.C: Headquarters U.S. Marine Corps, May 20, 2004.

Headquarters, U.S. Marine Corps. *United States Marine Corps Concepts & Programs 2007*. Washington, D.C: Headquarters U.S. Marine Corps, 2007.

Knights, Michael. "Unfriendly Skies- Iraq's Sunni Insurgents Focus on Air Defence" *Jane's Intelligence Review*, May 01, 2007.

Kulish, Nicholas and Squeo, Anne Marie. "The Future of Helicopters in Battle Looks Choppy." *New York Times*, July 23, 2003.

Liles, Christian F, and Christopher Bolkom. *Military Helicopter Modernization: Background and History for Congress*. Congressional Report for Congress, Washington, D.C.: Library of Congress, 2004.

Mc Gregor, Andrew. "Iraqi Insurgents Claim New Generation of Missiles Being Used." *The Jamestown Foundation*. February 14, 2007.
<http://www.jamestown.org/terrorism/news/article.php?articleid=2370245> (accessed January 24, 2008).

Minaya, Zeke. *General: Ground Fire likely downed 4 helos*. *New York Times* February 5, 2007.
<http://www.globalsecurity.org/org/news/2007/070205-downed-helos.htm> (accessed January 24, 2008).

Mohammad Yahya Nawro, General, Army of Afghanistan (Ret), and Lester Grau. "The Soviet War in Afghanistan: History and Harbinger of Future War?" *Columbia International Affairs Online*.
http://ciaonet.org/cbr/cbr00/video/cbr_ctd/cbr_ctd_52.html (accessed November 27, 2007). "MMIST Sherpa GPS guided Parafoil." *MMIST*. 2004. <http://www.mmist.ca/Sherpa.asp> (accessed January 25, 2008).

"MMIST: CQ-10A SnowGoose." *MMIST*. 2004. <http://www.mmist.ca/SnowGoose.asp> (accessed January 26, 2008).

Mobile Helicopter Killers Found and Destroyed in Iraq. January 24, 2008.

<http://www.strategypage.com/htm/htada/articles/20070319.aspx> (accessed January 28, 2008).

Ohio State University, Origins: eHistory. *Chapter 11: The Marines in Operation Lam Son 719* n.d.

<http://ehistory.osu.edu/vietnam/books/vietnamization/0195.cfm> (accessed March 9, 2008).

Pike, John. *X-45 Unmanned Combat Aerial Vehicles*. December 1, 2005. <http://www.fas.org/man/dod-101/sys/ac/ucav.htm> (accessed Jan 27, 2008).

Ripley, Tim. "The Global Helicopter Industry: Rising to Demand". *Jane's Defence Weekly*, January 11, 2006 <http://www8.janes.com/Search/printFriendlyView.do?docId=/content1/janesdata/mags/jdw> (accessed January 29, 2008)

Slife, Jim. *Armed Forces Journal*. June 2007. <http://www.armedforcesjournal.com/2007/06/2649720> (accessed January 26, 2008).

Sweetman, Bill. "Dossier, Helicopter Development Hanging in the Balance: Mixed Fortunes for Manufacturers," *Jane's International Defense Review* 29, no. 6 (June 1996): 89-97

Thomas, Neil. *University of Delaware: Liquid Armor Technology Licensed by UD*. February 24, 2006. <http://www.udel.edu/PR/UDaily/2006/feb/armor022406.html> (accessed January 26, 2008).

Turbiville, Jr., Graham. "Ambush! The Road War in Afghanistan." *Foreign Military Studies Office Publications*. <http://leav-www.army.mil/fmso/documents/ambush-road/ambush-road.HTM> (accessed November 20, 2007).

U.S. Department of Defense, Department of the Army. "Lessons from the War in Afghanistan." *The National Security Archive, The George Washington University Website*. May 1989. <http://www2.gwu.edu/~nsarchiv/NSAEBB/NSAEBB57/us11.pdf> (accessed November 20, 2007).

United Kingdom, Ministry of Defence. *Operation BANNER: An Analysis of Military Operations in Northern Ireland*. July, 2006. www.serve.com/pfc/misc/opbanner.pdf (accessed November 20, 2007).

Urban, Mark. *War in Afghanistan*. New York: St. Martin's Press, 1988.

Westermann, Edward B. "The Limits of Soviet Airpower: The Failure of Military Coercion in Afghanistan, 1979-89." *The Journal of Conflict Studies* Vol. 19, no.2 (Fall 1999). <http://www.lib.unb.ca/Texts/JCS/bin/get5.cgi?directory=fall99/&filename=WESTERMA.htm#1> (accessed March 11, 2008)