

ARE HELICOPTERS VULNERABLE?



by Dr Carlo Kopp

US Air Force HH-60 Pave Hawk CSAR helicopters are equipped with a comprehensive electronic warfare self protection suite. (USAF)

The survivability of rotary wing aircraft has been an ongoing issue since their advent in combat operations during the 1940s. Through the Korean War, the Vietnam conflict, and the ongoing series of low and high intensity conflicts since then, helicopter losses or damage in combat continue to be an issue.

The reality which cannot be avoided is that any slow moving, noisy and relatively soft vehicle operating in close proximity to the ground and hostile ground forces is an inviting target for a wide range of weapons, be they man portable or carried by vehicles or other aircraft.

The survivability issue has yet again achieved prominence with the losses incurred by the US Army in Iraq, and reported constraints being imposed on aid delivery helicopters in Aceh. With the not inconsiderable costs of modern helicopters and the potential for appreciable personnel losses in crews and infantry payload, helicopters have remained a popular target for insurgents since the Vietnam conflict.

Publicly available data detailing helicopter losses in Iraq during and since the invasion are a useful indicator of the risks involved. Of the 40 or so helicopters lost to date, around half were reported to have been lost due to hostile fire, the remainder crashing due to midair collisions or other flying accidents. These statistics clearly show that rotary wing combat losses do not dominate over accidental losses, unlike the Vietnam era.

To best appreciate the risks helicopters are exposed to it is useful to explore the threat environment versus the roles and missions spectrum performed by modern military helicopters.

THREATS VS ROLES AND MISSIONS

The most numerous category of military helicopters are utility or assault helicopters, used to move personnel and materiel around the battlefield. Less numerous are reconnaissance and attack helicopters, used to locate and engage ground targets, either independently or in support of ground forces during an engagement.

The 'classical' role for military helicopters is insertion and extraction of infantry and materiel in a combat area, flying in and out of unsecured landing zones. A large proportion of US helicopter losses in Vietnam and subsequent conflicts resulted from utility or assault helicopters performing this role, and their attack helicopter escorts, coming under fire in the area of landing zones by hostile small arms, especially the 7.62mm AK-47/AKM, Rocket Propelled Grenades (RPG), machine guns - especially the 50 cal class weapons, 23mm guns like the ZU-23 and ZSU-23-4P, occasionally 57mm guns, mortars, artillery of various calibres, and guided or unguided rockets. Enroute to and from landing zones, helicopters were engaged most frequently by small arms, machine guns and Man Portable Air Defence Systems (MANPADS, or shoulder launched SAMs).

Assessing the lethality of any of these weapons against helicopters can be difficult, as many factors come into play. The type of helicopter, the type of weapon, the impact velocity, round mass, explosive payload, shrapnel/spall mass, velocity and dispersion pattern, all play a role.

Since the Vietnam conflict we have seen refinements in airborne assault tactics, but also decreasing numbers of conflicts in which large heliborne assaults are performed. This

exposes a shift in the roles/missions spectrum which began during Vietnam and will likely continue over coming decades – the use of helicopters for special forces insertion/extraction, and combat search and rescue. While these two roles are usually discussed separately, the trend for some years has been to use the same helicopters and crews to perform either role. The most evolved examples are the MH-47 Chinooks, the HH-53 Pave Low family and HH-60 Pave Hawks, equipped with aerial refuelling probes, long range tanks, extensive EWSP and communications systems.

Special operations roles of this kind typically involve small numbers of helicopters penetrating often hundreds of miles into enemy territory to insert and recover special forces, intelligence operatives, or recover downed aircrew. As a result helicopters performing such tasks are exposed to a wider range of threats, and frequently these include elements of army or corp level air defences, and national air defences. Performing such tasks, helicopters may be engaged by self propelled guns, point defence SAMs and area defence SAMs, as well as many of the weapons encountered in battlefield assault roles.

The lethality of a larger point defence SAMs or radar guided area defence SAMs against a helicopter can be very high, as these are weapons built to kill high performance aircraft at all altitudes and speeds and weather conditions, often under conditions where direct hits are difficult to achieve. The reality is that a helicopter performing a deep penetration task is an attractive target for an S-300PMU or S-300V series missile battery.

There are also important differences in the mission profiles involved, as helicopters performing assault roles will typically arrive at a landing zone (LZ), touch down for long enough to disgorge or load troops, and then immediately depart, with LZs often chosen carefully to minimise exposure. Often special operations and CSAR tasks force the helicopter to hover in an exposed position to winch up personnel, as there may be no viable alternative.

The War on Terror and aid delivery operations have both seen an increasing fraction of circumstances where helicopters are exposed to fire. Perhaps the best publicised case study is the loss of two US Army Special Operations MH-60s in Mogadishu, both taken down by RPGs while operating at low speed and altitude over complex urban terrain, largely as a result of poor tactical flying.

As the Somalia aid operation demonstrated, delivery of international aid can become dangerous as aid perturbs the economic equilibrium and thus political power balance in such problematic regions. Therefore parties delivering aid become high priority targets for local tribal, nationalist, political or militant religious movements - a problem exacerbated by the mass media publicity which comes from shooting down a helicopter and capturing personnel as hostages.

We should not be surprised if helicopters used for aid delivery in Aceh come under insurgent fire at some point, as the aid operation wins over hearts and minds - at the expense of Indonesia's Islamic extremists.

With an increasing shift to urban combat, where opponents rely on the use of complex urban terrain for concealment and 'human shielding' from air attack, helicopters may be confronted with any of the full spectrum of weapons. Urban terrain is often well suited to concealing even larger weapons, such as ZPU anti-aircraft machine guns, ZU-23-2 dual 23mm guns on light trucks or 4WDs, or even the ZSU-23-4P self propelled air-to-air gun. While insertions and extractions in urban terrain can be problematic as it can be



US Marines and Army Special Forces maintain a security perimeter as a UH-60 Black Hawk helicopter lifts off for a medical evacuation south of Camp Blessing, Afghanistan. (Lance Cpl Justin Mason, USMC)

very difficult to secure landing zones, and very difficult to establish beforehand whether an arbitrary area is occupied by hostiles, clever use of urban terrain can also afford some concealment for helicopters.

There are indications that the demand for special operations style profiles will increase at the expense of the 'classical' day VFR battlefield insertion/extraction role, reflecting increased use of special operations forces. With NVG and often good EWSP capabilities on conventional utility/assault helicopters, the capability gap between special operations and utility/assault helicopters is much narrower than two decades ago.

In practical terms this means that utility/assault helicopters may be pressed into special operations style profiles simply because there are not enough dedicated special operations helicopters available.

Australia for instance operates mostly S-70A Black Hawks equipped for NVGs, and will operate an NH 90 derivative in the future. There are no indications that either are planned to be equipped in the manner of a HH-60 Pave Hawk. Therefore where a need exists for a special operations style profile, a standard fleet utility/assault helicopter would likely be used for this purpose.

If we are to map the threat spectrum against the category of operation to be performed, we quickly find that the traditional divisions are beginning to blur.

1. Battlefield insertion/extraction – exposure to small arms, machine guns, SPAAGs and semi-mobile AAA, mortar, RPG, artillery, artillery rockets, direct fire from armoured vehicles, and MANPADS. In some circumstances concealed mobile point defence SAMs will be a threat.

2. Urban combat insertion/extraction – exposure to small arms, machine guns, mortar, RPG, artillery rockets, and MANPADS. Hidden armoured vehicles, SPAAGs and point defence SAMs may be an issue in areas not cleared by fixed wing suppression of air defence and close air support sorties.

3. Special operations and combat SAR - exposure to the full spectrum of point defence and air defence weapons as well as the full spectrum of infantry and armour weapons. History illustrates repeatedly the attractiveness of setting up ambushes for combat SAR helicopters.

4. Humanitarian operations - exposure to small arms, machine guns, mortar, RPG, artillery rockets, and MANPADS. As with combat SAR sorties, there is a genuine risk of prepared ambushes to aid delivery sites.

“any slow moving, noisy and relatively soft vehicle operating in close proximity to the ground and hostile ground forces is an inviting target for a wide range of weapons”



Since the Vietnam era there has been a progressive evolution in defensive capabilities for helicopters. First generation defensive suites included a basic radar warning receiver, undirected IR jammers and chaff/flare dispensers. Current suites, especially for helicopters intended for special operations and rescue roles, typically include radar and laser warning receivers, missile approach warning systems, directed IR jammers, and both radio-frequency and IR expendables. (Author)

Perhaps the most important long term consideration is that general purpose utility/assault helicopters will be increasingly used in situations which historically were the domain of much better equipped special operations and combat SAR helicopters. It is reasonable to surmise that in time the only distinction between 'standard' utility/assault helicopters and their special operations and combat SAR siblings will lie in long range communications equipment and aerial refuelling capabilities of the latter.

SURVIVABILITY AND THREAT LETHALITY

Survivability revolves around avoiding hits and if hit, surviving the damage caused by the hit. Neither are necessarily simple problems to solve.

Avoiding hits is not easy. For high performance combat aircraft the earliest solutions revolved around speed and altitude performance and electronic warfare, to prevent an opponent from getting into weapons range, and if in range, to degrade the performance of the guided weapons being used. By the 1980s focus had shifted to the use of stealth to deny the opponent acquisition and tracking, and degrade weapons guidance. This has since been supplemented by the use of networking to aid threat avoidance. Networking is often

cited as a cure-all for helicopter survivability, but that doesn't stand up given the realities of the game.

To date the most widely used technique for avoiding hits on helicopters has been nap-of-the-earth flight and terrain masking, as this denies line of sight tracking and weapon aiming or guidance. More recently we have seen helicopters acquire often comprehensive electronic warfare self protection (EWSP) suites to help avoidance and jam opposing air defence weapons. A modern helicopter will often be equipped with a radar warning receiver, laser warning receiver, UV or IR missile approach warning system, a defensive jammer to degrade radar guided SAMs and AAA, and increasingly, undirected or directed infrared jammers to defeat MANPADS.

With costs in the millions of dollars per shipset, any decent EWSP suite will amount to a large proportion of the unit cost of a modern military helicopter. Adding a good networking suite for enhanced situational awareness for threat avoidance and deconfliction adds even more.

What a comprehensive EWSP suite, networking and good tactical flying provide is avoidance and degradation of threats most likely encountered in transit to and from a LZ in contested territory. The EWSP components are most effective against technologically sophisticated opponents, especially those employing modern and highly mobile air defence systems like SPAAGs and SAM systems. A good directed IR jammer can significantly degrade or defeat a wide range of MANPADS.

The strategy of threat avoidance and using EWSP to degrade guided weapons accuracy or function is clearly worth doing, but a large proportion of helicopter losses in recent times has been due to close quarters fire by visually aimed weapons, such as AK-47/AKM assault rifles, the RPG-7 and machine guns.

At distances of tens to hundreds of yards an RPG-7 can be a much more dangerous threat than a MANPADS worth a hundred times the value of the grenade launcher round – although at hundreds of yards the accuracy of the RPG will decline considerably. This is the reality of helicopters being exposed in urban combat, combat SAR, special operations and other situations where the rotary wing aircraft must operate in close proximity to an opponent. At close quarters a sword is just as lethal as an assault rifle, and this argument remains as true as ever - low tech weapons can kill just as effectively as high tech weapons.

This raises the issue of helicopter vulnerability and techniques for hardening them against hits, usually bundled under the term 'ballistic tolerance'. After the Vietnam experience where thousands of UH-1/AH-1 family helicopters were lost to a combination of AK-47/AKM rifles, ZPU, ZU-23 and ZSU-23-4P guns and MANPADS, the US embarked on a major rethink of helicopter design. Much effort was invested to define new ballistic tolerance and crashworthiness specifications for the new UH-60 Black Hawk and AH-64 Apache helicopters. The ballistic tolerance and crashworthiness

Obsolete Soviet air defence weapons are ubiquitous in the third world and continue to represent high risks for helicopters operating in such environments. Other than the AK-47/AKM assault rifles, likely risks include semi-mobile and improvised mobile ZPU-1, ZPU-2 and ZPU-4 14.5mm anti-aircraft machine guns, semi-mobile and improvised mobile twin ZU-23-2 23mm guns and the ever present ZSU-23-4P SPAAG. (US DoD)



standard defined for the UH-60 has become effectively the benchmark for all modern utility/assault helicopters.

Achieving high ballistic tolerance in a helicopter is not a simple task. An example are the measures adopted for the AH-64 series.

The AH-64 has grease filled gearboxes designed for ballistic tolerance to 14.5mm and 23mm hits. Dual redundancy is used in the critical flight control channels and the 3000psi hydraulic system. Twin GE T700 engines are used with sufficient reserve power to limp home on one powerplant. The tailshaft is designed to absorb hits and if cut by fire, not to chop the tail off - a problem frequently observed in the UH-1 Iroquois/AH-1 Cobra series (Early model UH-1s and AH-1 shared the same engines, tails and dynamics components). The AH-64 also makes extensive use of composite armour to absorb low calibre fire, shrapnel and spall from weapon hits. Seat shock absorbers were used and structural design was developed to absorb extremely high sink rates.

The difference in the cost of the basic AH-64 airframe against the basic AH-1 airframe, as is the case with the UH-60 to the UH-1, owes much to the ballistic tolerance and crashworthiness measures in the basic airframe and system design. As always, adding ballistic tolerance will also add to the empty weight of the design, at the expense of fuel and useful payload.

Photographs of AH-64s severely damaged or lost during the Iraq campaign are illustrative. Most of these helicopters were able to get home, those that did not often managed to limp clear of the battlefield before making forced landings.

There is little doubt that the significant ballistic tolerance to 7.62mm and 23mm weapons designed into the UH-60/AH-64 and subsequent helicopter designs has had a large impact on fleet survivability and saved many lives. However, it is also the reason why we have observed more frequent attacks on helicopters using MANPADS and especially RPGs. Exploring publicly available data indicates that a good fraction of losses were due to RPGs, as the typical armour piercing shaped charge warheads were able to inflict much heavier damage than 7.62mm, 14.5mm and 23mm weapons.

The damage effects which are most likely to cause the loss of a helicopter, preventing it from limping away a safe distance, involve primarily damage to the flight critical systems and airframe components. Heavy damage to engines, gearboxes, rotor heads and blades, flight controls and hydraulics are most prominent.

MANPADS are most likely to strike in the vicinity of the engines, main rotor gearbox and rotor head, and even if the warhead fails to initiate can cause severe damage by kinetic energy alone given the missile's far greater speed compared to the helicopter. RPGs on the other hand can hit anywhere, and if the helicopter is moving will be more likely to hit the aft of the airframe due to shooter errors in estimating lead for the RPG shot.

While the good ballistic tolerance of tailshaft and tail rotor assemblies may afford good resistance to low calibre weapons, this level of hardening is clearly inadequate for RPG rounds designed to kill armoured vehicles. While an unjammed missile is more likely to hit a helicopter than an RPG round, the high level of hardening around the engine/main rotor head/gearbox may result in only modest levels of damage. An RPG hit, though less likely, is almost guaranteed to produce much more severe damage by blast, shaped charge jet, spall and shrapnel.

The increasing frequency of RPG use against helicopters, especially when used in urban combat, is a good indication of an evolving threat. As infrared jammers have proliferated, and newer helicopters with better tolerance to 7.62/14.5/23mm fire have replaced 1960s technology helicop-



Following appalling losses of UH-1 and AH-1 helicopters during the Vietnam conflict, the US Army defined tough survivability requirements for the UH-60 Black Hawk and AH-64 Apache. The ballistic tolerance and crashworthiness requirements for the UH-60 have become the defacto benchmark followed by most modern military helicopter designs. (Sikorsky)

ters, opponents have been progressively shifting to the use of RPGs to overcome improved survivability measures. The abundance and low cost of RPGs also suggests that evolving tactics will see increased use of salvo fired RPGs in urban combat, the idea being to maximise the odds of visually aimed weapons scoring a hit.

IMPROVING HELICOPTER SURVIVABILITY

The question of how to further improve the survivability of helicopters amounts to a loaded question - survivability against what threat system?

Improving MANPADS guidance technologies will see an ongoing contest between Missile Approach Warning Systems (MAWS) and directed IR (DIRCM) jammers, pitted against the designers of MANPADS seekers. This contest will primarily affect scenarios where the enemy has access to the latest MANPADS technology. In many of the scenarios expected in the War on Terror, and humanitarian operations in contested areas, virtually all of the MANPADS in use will be older designs, mainly SA-7 Grail derivatives. So it is a prerequisite today that a helicopter be equipped with a good MAWS and DIRCM package, especially if it is a larger utility/assault helicopter.

The emerging weapon of choice for attacks on helicopters in urban terrain is the widely used Soviet era RPG-7 rocket propelled grenade launcher (Ruchnoi Protivotankoviy Granatomet - Handheld Antitank Grenade-launcher). While not particularly accurate at hundreds of metres, the RPGs have considerable killing power and are very widely available in trouble spots. RPGs are one of the leading causes of combat related losses of US helicopters in Iraq. Depicted is the paratrooper's variant or RPG-7D (Desantniy). (via pvo.guns.ru)





Special operations and combat SAR helicopters such as this MH-53J Pave Low III were the first to acquire comprehensive EWSP suites, as they are required to often penetrate deep into hostile air defence coverage to insert/extract special operations forces and recover downed aircrew. Helicopters performing such roles are exposed to the full spectrum of mobile and semi-mobile air defence weapons, including high performance SAMs like the SA-2, SA-3, SA-6, SA-8, SA-10, SA-11, SA-12, SA-15 and SA-20. (US DoD)

Radar guided SAMs and SPAAGs will continue to present a serious risk to helicopters. While good Radar Warning Receivers and defensive jammers, supplemented by good tactical flying techniques, are a must, helicopters can benefit further from the use of fixed wing support jamming and defence suppression aircraft, and networking to allow threat avoidance. Surviving radar guided SAMs and SPAAGs is an issue primarily for helicopters tasked with special operations and combat SAR.

The largest current US programs in this area are the ITT AN/ALQ-211 Suite of RF Countermeasures (SIRFC) comprising a pulse, pulse Doppler and continuous wave warning receiver, a pulse and continuous wave jammer and RF expendable jammers, and the BAE Systems AN/ALQ-212 Suite of Infrared Countermeasures (SIIRCM Advanced Threat IR Counter Measures/Common Missile Warning System) comprising a lamp or laser directed IR jammer, an ALE-47 dispenser and an AAR-57 passive UV Common Missile Warning System. These systems are now entering service, initially on helicopters tasked with special operations and combat search and rescue.

Ballistic tolerance to 7.62/14.5/23mm fire is generally addressed well in most current production designs. This could be incrementally improved by the application of Kevlar or metal alloy armour panels. In environments where close quarters automatic weapon fire is a high risk, one can never have enough armour.

The biggest issue for helicopter survivability in the near term is dealing with the RPG, especially in complex urban terrain which affords shooters opportunities for concealment and ambushes, and particularly against helicopters operating near LZs or hovering to deploy or recover troops.

Tolerance to RPG damage is problematic given the killing power of such weapons. While additional armour may help, no helicopter can ever carry enough armour to defeat an anti-tank weapon built to kill or cripple heavy armoured vehicles.

The US will often fit 7.62mm rotary miniguns or other automatic weapons on pintle or gimbal mounts to permit gunners to engage RPG shooters. However those gunners need to see and 'neutralise' the RPG shooter before he can take a shot at the helicopter.

One technique which could be viable is the use of a visible band dazzling laser, designed to sweep the lower hemisphere

of the helicopter. This approach presents its own problems with the need to equip friendlys with anti-dazzle goggles, and the risk of eye damage to civilians.

Another emerging technology is the millimetric band 'pain beam' microwave riot control device, which is a non-lethal weapon producing an intolerable but temporary burning sensation on the skin of a person illuminated with the beam. Again, problem issues arise with collateral effects, and also power levels required to sweep an area from which an RPG could be fired accurately.

Early warning of an inbound RPG shot may prove viable by permitting a pilot to effect an evasive manoeuvre to spoil the shot. Existing radar based MAWS technology could be adapted for this purpose, as well as to detect the source of incoming small arms or machine gun fire. As RPGs are unguided, a violent and rapid manoeuvre could ruin even a well aimed shot during the flight of the weapon. Achieving good enough reaction times will be the principal obstacle - in MAWS applications the weapon may be detected miles away affording time for a measured reaction. The same is not true for a close quarters RPG shot.

Helicopter survivability will become an increasing issue for the ADF in coming years, as the character of many of the operations conducted by the Army, and possibly the Navy, will see increased exposure to weapons like MANPADS and RPGs. With the intended shift to larger NH 90 derivatives for the utility/assault role, and the need to cover conventional assault and battlefield lift tasks as well as special operations and combat SAR tasks with a small fleet, equipping these helicopters with good EWSP suites will be an expensive necessity.

There is also a good case to be made for intensive study and development of urban combat techniques to minimise helicopter exposure, and further hardening of ADF helicopter types to maximise ballistic tolerance, especially against heavier weapons.

If there is any certainty in the survivability game, it is that opponents will continuously evolve their technique. For the foreseeable future helicopters will remain the most susceptible aircraft in military use. ➔

MANPADS are one of the most serious threats to all categories of military helicopter, as they are easily deployed and concealed, and ideal for ambush engagements. In recent times the proportion of helicopter losses to MANPADS has declined, reflecting the wide use of infrared jammers, infrared exhaust suppressors, and the prevalence of obsolete SA-7 derivatives in key trouble spots. MANPADS in the third world are dominated by original Soviet SA-7 and its especially Chinese and other clones.

