Helicopter combat survivability

Dr Carlo Kopp

The global counter-insurgency campaign, which followed the 9-11 attacks produced the highest sustained operational tempo in helicopter operations since the Vietnam War of four decades ago. There have been much lower helicopter loss rates compared to Vietnam, due in large part to more survivable designs. Even so, helicopter loss rates are still high relative to fixed wing aircraft. Future conflicts, which might be conducted against nation state opponents, however, present an entirely different picture. This is due to the proliferation of advanced short-range air defence weapons, which are highly lethal against helicopters.

Of all modern aircraft, helicopters are the least survivable due to their low altitude and relatively low speed flight profiles compared with jet aircraft, and their high acoustic and radar signatures. These are inherent limitations of rotary wing aircraft, which cannot be easily or affordably designed out.

Formal survivability analysis is centred on two components: the first being susceptibility analysis that aims to measure the probability of an aircraft being hit; and the second vulnerability analysis, which aims to measure the probability of a hit with a given weapon inflicting fatal damage to the aircraft.

Central to discussion of helicopter survivability is the threat environment in which the aircraft must operate.

During the invasion of Iraq in 2003 and the subsequent counter-insurgency campaign the US Army experimented with a range of tactics, including the use of the AH-64D Longbow Apache to directly attack targets in the manner fighter aircraft would do, but suffered heavy losses in airframes due to concentrated gunfire.

The insurgents in Iraq had an abundant supply of Soviet supplied SA-7 SAMs and Chinese clones, and there are claims that newer Russian SA-16 and SA-18s may have been used. These have generally proven less than effective since much of the coalition helicopter fleet was equipped with infrared exhaust suppressors, active infrared jammers and flare dispensers. Many larger helicopters were also equipped with missile approach warning systems to cue countermeasures deployment. The most prominent kills achieved by MANPADS were transport aircraft, spurring the deployment of infrared jammers across coalition fleets.

While MANPADS have not produced the losses many anticipated, mostly due to good pre-emptive installation of countermeasures, losses due to larger calibre gunfire and rocket propelled grenades, from the RPG-7 upward, have remained a consideration. Tactics for the evasion of MANPADS involve low flying, which exposes helicopters to gunfire and RPG fire. Recent statistics in the media suggest that 40 per cent of US helicopter losses are due to RPGs and 20 per cent due to gunfire.

The latter are all short-range line of sight direct fire weapons, which typically have limited signatures compared to MANPADS. Muzzle flash and RPG motor burn flash are detectable but the shorter ranges compared to MANPADS shots result typically in less warning time for crews. The only redeeming aspect of the RPG, for its target, is that the RPG is unguided and accuracy declines strongly with distance, especially if crosswinds are present. This is often compensated for by operators who fire multiple round RPG salvoes to improve the odds of a hit.

With shaped charge warheads built to defeat tank armour, RPGs are absolutely lethal if they can score a hit on any key structural

The Longbow radar and MMW Hellfire were developed to defeat the SA-15 Gauntlet and SA-19 battlefield air defence weapons.

Countermeasures effective against older MANPADS are ineffective against modern two colour seekers and laser beamriding or RT command link weapons.

or power train components of a helicopter. While modern helicopter designs have robust measures to survive gunfire up to 23 mm calibre, including features like dry running gearboxes, large shaped charges produce far greater damage.

Numerous schemes have been proposed for the defeat of RPGs. These include a US inventor's proposal for rocket launched deployable steel and Kevlar nets which are launched into the path of the RPG, or a Bulgarian metal alloy armour system which is claimed to be highly effective at defeating shaped charge RPG warheads.

Other than armour or countermeasures, evasive manoeuvre can be very effective in evading both RPGs and gunfire, but this is predicated on the pilot knowing he is under attack, and knowing where the attack is coming from.

A promising technology are acoustic detection systems, which use directional microphones and smart digital processing to detect the source of gun or RPG fire, and provide warning to the pilot to facilitate evasion. As with missile attacks, knowing where the attack is coming from as early as possible can mean the difference between life and death.

Another technology with much promise are smart mission management systems, which make use of digital terrain elevation maps and radio modems to link to battlefield intelligence databases and ISR sensors. The author was recently given a demonstration by Elbit of their system, which has been installed in a range of Israeli military helicopters.

A very interesting and useful capability in this system is the ability to mark on the digital map, in colour, areas where the helicopter is within the line of sight of any specified point on the map. An operator can thus mark the known location of a MANPADS team, machine gun nest or RPG shooter team, and then use terrain masking to avoid detection and weapons fire. The system is integrated with a ruggedized tablet computer carried by infantry or special forces, which allows them to upload via radio datalink such threat information as the helicopter approaches. Whether the helicopter is being used to extract troops or provide fire support, this type of situational awareness aid can provide a major tactical advantage.

Other anti-helicopter weapons have emerged. An idea the Soviets introduced was a proximity fused 'anti-helicopter mine' which used a rocket charge to propel an explosive warhead upwardly, detonated by a proximity fuse, spraying the victim helo with spall and shrapnel. Some sources claim that Iraqi insurgents improvised a similar weapon, which would launch a warhead to a height of 50 ft to act as a backyard-built anti-helicopter mine.

The ongoing counter-insurgency effort will continue to drive evolution of helicopter survivability aids, and we are likely to see more sensors, better armour, and more situational awareness aids exploiting computer technology. What the campaign to date has demonstrated is that opponents frustrated with the ineffectiveness of high technology MANPADS have turned to creative tactics applied to the use of low technology weapons.

On the sophisticated high technology end of the threat spectrum, used by nation states to provide air defence for ground forces, there are numerous recent advances that will impact the survivability of helicopters.

There have been important advancements in the radar capabilities used for battlefield point defence weapons, which are now being adapted to intercept smart bombs and guided missiles. The latest Tor M2 / SA-15D has a digital phased array engagement radar, as does the new Pantsyr S1 / SA-22, based on the SA-19 Grison SPAAGM. While both new weapons are offered on wheeled chassis as part of integrated air defence systems, they still remain on offer, hosted on their original tracked chassis as battlefield point defence weapons. The very short reaction times and high rate multiple target tracking capabilities will allow these weapons to intercept guided missiles fired by helicopters, and fire at the launching helicopter concurrently.

In the longer term high power lasers are emerging as a preferred C-RAM (Counter Rocket Artillery Mortar) solution, and will thus likely be applied to the defence of ground forces against missile firing helicopters.

While signature reduction has been proposed for helicopters and considerable effort invested into the stillborn Comanche project, the likely solution for dealing with advanced battlefield air defences will be Digital Radio Frequency Memory based deception jammers, intended to frustrate the engagement radars used to aim/guide the weapons.

Historical Perspective

The Vietnam war was the first conflict in which helicopters were used heavily, both for fire support and mobility of troops. The principal US Army helicopter was the lightly built UH-1 Iroquois or 'Huey' series, later supplemented by the heavy CH-47 Chinook. The Marines entered the conflict with the CH-34 Choctaw (S-58/Wessex), replacing it with the CH-46 Sea Knight, and from 1967 the CH-53 Sea Stallion. The Air Force operated the HH-3 initially for deep penetration search and rescue, or special forces raids, later supplementing them with HH-53B/C.

Most of the survivability measures incorporated in the airframe, engine and transmission design of modern Western military helicopters were based on the lessons of the Vietnam conflict.

Helicopters were subjected to fire from all calibres of small arms, heavy anti-aircraft machine guns of 12.7 mm through to 14.5 millimetre, 23 mm automatic guns, both the manually aimed ZU-23 and later radar-directed ZSU-23/4P and larger AAA calibres such as the Soviet 37 mm and 57 mm guns. In the latter phase of the war, the Strela 2 / SA-7 MANPADS (Man Portable Air Defence System) became a cause of significant losses in helicopters.

During that period ad hoc survivability measures involved primarily the development of tactics intended to deny opponents clear line of sight to fire at rotary wing aircraft, thus reducing opportunities, and the installation of armour to protect crews and vital systems. Some helicopters were fitted with flare dispensers to seduce MANPADS.

The Soviet experience following the 1979 invasion of Afghanistan followed a similar pattern to the US Vietnam experience, with US supplied Stinger MANPADS taking a heavy toll of the Mil-24 Hind gunships and Mil-8 Hip assault helicopters which were the backbone of the Soviet fleet. Soviet countermeasures such as carbon dioxide injection into engine exhaust ducts proved effective against the early single colour Stinger seeker, but useless against the later two-colour seeker.

The next major evolution in threat capabilities and defensive technique emerged during the latter decades of the Cold War, as Western nations deployed a wide range of attack helicopters intended to kill tanks, initially using wire guided missiles and later, to increase standoff ranges, laser guided missiles. The AH-64A Apache was the most potent of this generation. Tactics involved primarily 'nap of the earth' very low altitude flight to stay out of the envelope of the ZSU-23/4P, ZU-57 SPAAGs, the 9K33 / SA-8 Gecko and Strela 10 / SA-13 Gecko SAM systems, and 'pop-up' engagement manoeuvres from behind concealment to shoot against advancing armoured formations. The helicopter would hover behind terrain, rising to acquire the target with a thermal imaging sight, fire its missiles, and once the engagement was complete, drop back behind cover and move to another firing location to avoid indirect fire weapons like howitzers and heavy mortars. These tactics were generally very effective in Europe due to the preponderance of hilly and heavily forested terrain, the limited clutter rejection performance of the ZSU-23/4P, SA-8 and SA-13 radars, and the relatively slow reaction times of these air defence weapons. In the Desert Storm campaign of 1991, these tactics and weapons proved devastating against Saddam's armoured formations.

The Soviet reaction to the AH-64A Apache was to develop a new generation of battlefield air defence systems, intended to increase the effective range of defensive fire, and to react quickly enough to kill a helicopter before it could complete its anti-missile engagement cycle.

The 9K331 Tor or SA-15 Gauntlet replaced the 1960s SA-8 with a new arrangement, combining eight vertical launch missile tubes in a turret equipped with a circular scan search radar and a large target and missile tracking engagement radar on the front of the turret. The SA-15 would scan the horizon and upon detecting a helicopter rotor, would slew its turret, lock on with the engagement radar, and rapidly fire a pair of missiles to kill the helicopter before its Hellfire missiles reached their intended target.

The venerable ZSU-23/4P was replaced by the 2K22 Treugolnik / Tunguska or SA-19 Grison, a combined 30 mm SPAAG and missile system using a similar radar package to the SA-15 but armed with very high speed two stage tube launched missiles.

The US Army responded to this threat by developing the AH-64D Longbow Apache, which combined a mast mounted millimetric wave band search and engagement radar with the 'fire-and-forget' millimetric band active radar seekered equipped Hellfire variant. A passive precision radio-frequency interferometer was added to permit the system to sniff out the emissions of the SA-8, SA-13, SA-15 and SA-19 search radars. The Longbow Apache could remain behind cover, raising only the mast mounted sensor package to search for targets, only popping up for a few seconds to fire a salvo of Hellfires at a detected target. This author flew this weapon system from the gunner's seat in 1999, and the effectiveness of the Longbow radar was very good, it could detect and identify moving targets in a single sweep.

Flares are effective against older MANPADS, but ineffective against newer seeker technologies, and radar directed SAMs and SPAAGs.

The European Tiger was modelled very much along the Apache model, but using later airframe technology, and with different role optimisations.

In conclusion, survivability will remain an ongoing problem for rotary wing aircraft, and we will see further evolution in survivability measures, and weapons used against rotary wing aircraft.