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László Szilvássy

Why Does the Attack Helicopter Have More Survival Ability than the Armed Utility Helicopter?

The author highlights the difference between attack and armed utility helicopters and supports this with professional arguments. He also presents the most common weapon systems of combat helicopters. Points out that an armed transport helicopter or multipurpose helicopter cannot substitute attack helicopters at all.

Keywords: *attack, utility, helicopter, multipurpose helicopter, weapon systems, active, passive defence*

1. Introduction

I have been following the modernisation of combat helicopters for years [12], [18], [20]. I have been and will be dealing with onboard weapons in several of my writings [13], [15], [16], [31]. I have expressed my opinion, my research results, and I have even written my doctoral dissertation [1], [2] on this topic. In my previous studies and articles, I examined several combat helicopters, including the Mi-24 [3], [4], the AH-64 [5], the Mi-28 [7], the Ka-50/52 [17] and A129 [14]. I wrote about their development [8], their applicability [6]. I ranked their efficiency requirements [10], evaluated their weapons on board [13], [15], [16], [19], [21].


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Figure 1.
An armed transport helicopter [40] *is not an attack helicopter* [11]

In my doctoral dissertation [1], I developed a parameterised comparative procedure with which I compared the combat helicopters objectively in terms of onboard weapons. I have also published this outside my dissertation [9], [11]. I have not stopped my research on aircraft weapons since then. I regularly follow published writings in this regard, among which, combat helicopters will always be my first priority.

2. Helicopters

With the helicopters, the function dictates capability. Helicopters in the armed forces perform a variety of roles, for example:

- attack;
- search and rescue;
- transport;
- observation;
- utility.

In this very paper, I intend to introduce and highlight the differences between utility and attack helicopters.

3. Attack helicopter

To understand the differences, we need to define the two helicopter versions.

Definition from Wikipedia: "An attack helicopter is an armed helicopter with the primary role of an attack aircraft, with the capability of engaging targets on the ground, such as enemy infantry and armoured fighting vehicles. Due to their heavy armament, they are sometimes called helicopter gunships" [41].

Lt. Col. János Juhász – who was Head of Operations and Training of the Hungarian Defence Forces 87th Bakony Helicopter Regiment (Szentkirályszabadja) – said:

> A high-speed, highly manoeuvrable, versatile, highly-destructive, weapon-carrying (anti-tank) device, or "aerial artillery" [9] (translation of the author).

The way I stated in my thesis:

> Attack helicopter: is an aerodynamic, rotary-wing, highly manoeuvrable aircraft equipped with guided and unguided missiles to break up enemy armoured formations. With its development, its tasks can include the escort of unarmed transport and search and rescue helicopter, direct attacks against ground-based forces, air combat, primarily against low-speed air targets but occasionally against fighter jets. It has adequate fire, missile and bombing armament, active and passive defence systems, armour, and a high degree of survival capability reserve to perform all of these tasks [1], [41] (translation of the author).

Through the research, I found the following evidence for the ability to fight air combat: in 1968, the Americans conducted a pilot exercise to execute the air combat mentioned in the definition, involving an AH-1G "Cobra", an F-4 "Phantom" and an F-8 "Crusader". Both air combats ended with "Cobra's" victory. At another practice, a combat helicopter fired a target aircraft flying at 800 km/h using a "Sidewinder" missile. We also found examples of real air combat when a Mi-24P helicopter defeated a "Phantom" in the Iraq–Iran war. The above-mentioned cases are good examples of the ability of combat helicopters fighting against air target, that does not necessarily require the construction of special fighter helicopters, only the existing weaponry is to be upgraded with modern air-to-air missiles [1]. These air-to-air missiles have already appeared on combat helicopters.

3.1. Requirements for attack helicopters

Throughout the wars and armed conflicts of the last century, weapon manufacturers gained such experience that cannot be obtained within laboratory environment without additional difficulties. The development of combat helicopters is dated to the second half of the 20th century. Based on the experience from the Korean and Vietnam war, a set of standardised requirements for combat helicopters had been developed.

Based on the experience of wars and armed conflicts, the requirements of advanced combat helicopters include:

- manoeuvrability, including air combat capability, predominantly against a combat helicopter and, if necessary, a fixed-wing combat aircraft;
- the ability to use well-variable different weapon systems to perform a wide range of tasks;
- advanced avionics features such as navigation, targeting-navigation, communication, self-defence systems):
  - complex self-defence properties;
  - passive armour protection;
  - stealth properties:
    - special painting;
    - special design:
      - concealed weapons;
      - retractable landing gear [Based on the experience of the Vietnam War, a retractable landing gear appeared as a requirement. Today, mostly fixed landing gear is used on most combat helicopters, although there is an exception here as well [27]. The RAH-66 was designed with a retractable chassis in the LHX[1] program, but it was cleared. Only Mi-24 has retractable landing gear (author's note).];
  - active protection:
    - flare (countermeasure);
    - intercept receiver;
    - radar jamming equipment.

From the listed design features one or even quite a few of them forming a complex system are not yet sufficient for a combat helicopter to fully meet the highest requirements. It is also essential that the built-in active and passive defences, armaments, and all other systems

1 Light Helicopter Experimental.

reliably serve the purpose for what the combat helicopter is designed. Even if a helicopter has high-precision weapons, if its other systems, equipment, or structural design, e.g. the impact resistance of the rotor blades or the armour protection of the equipment are not suitable, they do not allow it to remain in the air for an extended period of time.

As stated above, we can write the general efficiency criteria for a combat helicopter:

$$W = \prod_{i=1}^{n} P_i \tag{1}$$

where:

- W – efficiency indicator of a combat helicopter;
- P_i – elementary conditional probabilities, which determine the reliability of individual equipment, systems, task execution, target detection.

If we replace the elementary conditional probability (P_i) in the above context with the most critical indicators for the successful task execution, we get the following relation:

$$W = P_{im} \cdot P_s \cdot P_{tr} \tag{2}$$

where:

- P_{im} – impact ability (probability of destroying an enemy target);
- P_s – survival ability (probability of effective self-defence);
- P_{tr} – technical reliability (probability of fault-free operation).

The *impact ability* depends on the probability of target reconnaissance, eliminate surface targets and successful air combat with enemy helicopters, as well as the tactical characteristics of the onboard weapons, the effectiveness of the weapon control system, and the training and psychological–physical condition of the crew.

Survival ability (probability of effective self-defence) depends on the effectiveness of passive and active self-defence systems, stealth characteristics and aeronautical tactical procedures.

Technical reliability "the ability of the structure (system, equipment, component) or even the entire operating system of a military equipment to perform the required function while maintaining the values of specified performance characteristics during operation, maintenance, repair, storage and within the prescribed limits, in accordance with the conditions of the pre-defined modes of transport" 0 (translation of the author) depends on operability, technology, diagnostics, repairability, MTTR (Mean Time To Repair) and MTBF (Mean Time Between Failure).

The listed three probability values can be broken down further, but this does not affect the fact that the efficiency of the combat helicopter is directly proportional to the probability of technical reliability, survival and destruction of the target. By highlighting any of the features and increasing the value with a significant investment, the overall efficiency ratio will not increase to such an extent that it is decisive. It is more important to raise all three to a sufficiently high level.

Many of these features may be available to multi-task helicopters, e.g. Mi-172, MD-500/530, BO-105/108, SA-542M/L, NH-90. However, with active and passive defence features, only combat helicopters are designed and built specifically for the combat task, e.g. AH-1, Mi-24, Mi-28, A129 (T129), AH-64, Ka-50, Ka-52, Tiger, AH-2. The necessity of the complex self-defence features were highlighted by the experience of local wars in the 1970s.

Using a practical calculation, we examine how much a change in any of the above three probability values affects a helicopter's efficiency index. The following values are substituted in Equation (2) for illustration only.

Table 1.
Probability parameters of two types of helicopter (compiled by the author)

	Attack helicopter	**Utility helicopter**
P_i	0.85	0.85
P_s	**0.85**	**0.65**
P_{tr}	0.85	0.85

In our example there is no significant difference regarding the Ps – survival ability in favour of combat helicopter. In reality, there are much more significant differences. For example, according to a previous analysis, the combat potential of the AH-64 "Apache" compared to the AH-1 "Cobra" is "1.8" in troop air support and "3" in combat against tanks [34]. If I want to express this in numbers, the Pi strike capability must be quantified. Assume the following: with air defence countermeasures, assume the impact measurement capability of AH-1 to be 0.2, in which case the same parameter of AH-64 is 0.6. This difference means that at one point there is a 20% chance that the helicopter will destroy the target, in the other case there is a 60% chance.

Back to our example. There is a 85% probability that the combat helicopter will destroy the target, survive the mission and there is no malfunction. In this regard, the efficiency indicator of a combat helicopter is:

$$W_{ah} = P_i \cdot P_s \cdot P_{tr} = 0.85 \cdot 0.85 \cdot 0.85 = 0.614$$

the same for a utility helicopter:

$$W_{uh} = P_i \cdot P_s \cdot P_{tr} = 0.85 \cdot 0.65 \cdot 0.85 = 0.470$$

This is a significant difference.

The LHX program, established in 1983, was the most comprehensive and detailed research to develop the requirements for combat helicopters in the 1990s. All U.S. combat helicopter companies participated in the program. The results of the LHX program were used in the development of the Eurocopter and the A129. In addition to that, it is not difficult to discover the same segment criteria in relation with the Mi-28 and also the Kamov Ka-50 helicopters [29].

If we assume that we examine the research results and development directions of the United States and Russia, we can conclude that the combat helicopters to be commissioned after the turn of the millennium must have the characteristics listed in the following points (these properties are undergoing a significant reassessment today, especially in terms of flight speed) 0.

3.2. Manoeuvre features

Flight in the very low altitude:

- $v_{y,max}$ ≈ 10 m/s vertical speed ability;
- v_{cs} = 260–280 km/h cruising speed;
- v_{max} = 300–310 km/h maximum speed;
- $v_{h,max}$ = 40–60 km/h backward speed;
- $v_{s,\,max}$ = 30–50 km/h sideway speed.

The maximum altitude available should be around 4,500–6,000 m. The helicopter must be capable of performing all aerobatic elements in the overload range ny = (+3) – (–0.5) and for intensive pedal turns. Reach 700 to 800 km with regular refuelling, 1,200 to 1,500 km with the spare tank(s), with a flight time of 2.5 to 3.5 hours. Mid-air refuelling capability is desirable but not yet a general requirement [26].

3.3. Weapon characteristics

The helicopter must have a permanent, turret-mounted cannon. The use of a machine gun against today's modern armoured devices is not effective enough. (The comparative calculation of the armour penetration of machine guns and aircraft cannon can be found in [15].) The rotation of the weapon turret should be between ±90° horizontally and between +10 and –40° vertically. The ammunition of the machine gun or cannon is at least 500 pieces, but it is more desirable to have 1,000 rounds, for machine guns this amount is to be doubled.

Regarding the unguided missiles against the various ground targets, a relatively large amount of 70–80 mm rockets are required for appropriate suppression, which can usually be fired from 20–30 pieces blocks [30], [32].

Against ground targets the use of guided missiles (AGM), varying a wide range of passive and active systems (such as: passive infrared, semi-active laser, semi-active radio, and active self-guidance) is also recommended. It is important because, depending on the task and the particular combat circumstances, it should be possible to select the most appropriate weapon. For example, when using camouflage smoke, a semi-active radio, or an active radio self-guided missile is best suited to destroy the target. However, it cannot be used in case of broadband, active radio interference. With regard of guided-missile weapons, the application of air combat missiles is necessary. In this case, just "Fire and Forget!" instruments should be taken into consideration. It is an essential feature because the detection and identification time of enemy helicopters is approximately 56 s at a 6 km (Figure 2) distance. The flight time of a near-air combat missile is 6–12 s at this distance, which means that in the case of a semi-active approach, the detection probability of the carrier/launch helicopter is close to one. The probability of destruction is close to the probability of the destruction capability of the used device [18], [31].

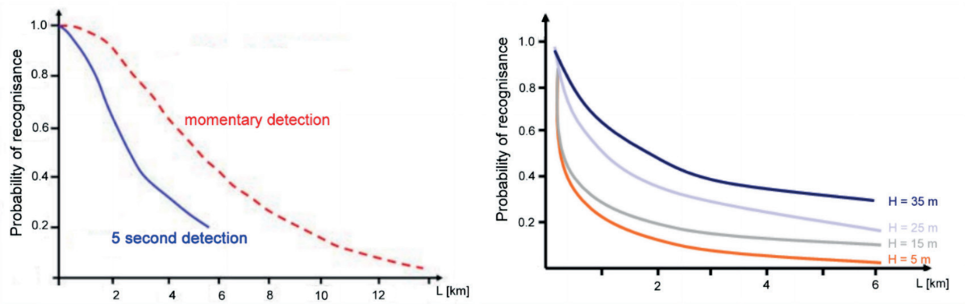

Figure 2.
Probability of visual detection as a function of distance [14], [18]

It is vital, that the helicopter's onboard aiming-navigation complex ensures the usability of the helicopter itself and the applicability of the onboard weapons within all weather conditions and 24 hours per day. For this reason, it is required to have such a radar which operates in a millimetre waveband, of course with a mapping mode, a passive sensor in the infrared range – a thermal retractor and/or a thermal imaging camera – and a laser rangefinder target marker. It is not necessary to have a TV camera operating in the visible EMH range. The location of the optical systems is most expedient on the top of the cockpit or rotor mast because this way the helicopter can perform reconnaissance and guidance from the cover. The helicopter has to cooperate with other helicopters in bond. It means that in case of efficient target distribution or the use of semi-active missiles, the helicopters in the same formation must communicate with each other via an automatic radio channel to achieve mutual targeting. It should not be ignored that regularisation of one so-called air control point per combat helicopter section can significantly increase the efficiency of helicopters. It is not closely related to the modernisation of combat helicopters, but air-to-ground integration and interoperability – for example with a ground laser marker – requires the aircraft's compatibility with other instruments. As it was previously stated, it is useful if the helicopter is suitable for bombing as well.

3.4. Passive and active self-defence

Combat helicopters perform their flight during combat operations at low altitudes, depending on the task, usually at the highest possible speed. It is necessary for several reasons. On the one hand, the higher the horizontal velocity of the helicopter is, the more accurately the unguided weapons can be used, as they are not affected to such an extent by the vibration of the helicopter. On the other hand, a helicopter is more difficult to detect when flying at low altitudes and high speed. Radars detect low flying helicopters only with difficulties. In addition to that, enemy air defence could spot and target swift moving, pop-up and disappearing helicopters only with low success rates.

Practical experience shows that 2 km to 3 km is the distance at which the probability of detecting a helicopter is sufficiently low. However, onboard unguided weapons and machine guns are used effectively from a distance between 1.5 km to 2 km. Therefore, the existence of guided armament is essential; due to their launching distance, it is usually about 6–7 km, and in some cases it can be up to 8 km to 10 km. The helicopter shall be detected by visual, acoustic, infrared and radio wave reconnaissance means. That is why, while designing a modern combat helicopter, efforts must be made to reduce detectability and to increase the so-called stealth properties. It can be achieved with the following design and structural solutions, thus reducing the detectability of the helicopter:

- the exhaust gases of the engines must be effectively mixed with the surrounding colder air, thereby reducing the infrared radiation of the helicopter, which dramatically affects the detection distance;
- the helicopter airframe must comply with the stealth technology requirements, using a lot of composite materials, coatings and special paint that absorbs and scatters radio waves. To improve the overall stealth performance, the engine air intakes also need special design, the rotor blades should be made of composite, the rotor head should have a special coating or casing. Electromagnetic radiation of electrical equipment must be minimised;
- to reduce acoustic detectability, it would be very practical to use a design with a larger number of blades and a low-speed rotor, in case of the tail rotor a larger number of blades – often four blades, X arrangement – or "fenestron" (NOTAR cannot be considered in this case due to its operation, because in the event of a projectile hit, its efficiency may significantly be reduced, which may even lead to loss of controllability).
- targeting-navigation and communication equipment should emit electromagnetic waves only for the required period and with necessary energy;
- to minimise visual visibility, the use of camouflage paint appropriate to the geographical area and the season should be the most suitable, as well as cockpit glazing, minimal reflectivity and matt colouring; the silhouette of the machine must have the smallest geometric size and less sharp contours 0.

The survival of a helicopter – primarily combat survival – depends mainly on the design of the entire aircraft structure, mainly the airframe. It requires the duplication or shielding of vital elements as well as adequate armour protection. The location of the different built-in equipment should be well-planned and taken into a careful consideration. It is advisable that sensitive items and vital mechanical and avionics equipment should be placed toward the centre of the fuselage, and all the rest should be implemented, creating layers, starting with the important ones in the inner layer and the less important or duplicated ones in the outer layer. It is necessary, because it is impossible to armour the entire helicopter due to mass and efficiency reasons. However, in areas where armour protection is provided, the level of protection must meet the following general requirements:

- in protected zones, the armour must withstand the direct impact of a 23 mm aircraft cannon ammunition;
- cockpit armour glazing must withstand handguns, the direct impact of a 12.7 mm to 14.5 mm projectiles and shreds of 23 mm aircraft cannon projectiles;
- the positioning (mutual position) of the engines must be such that they cannot be rendered inoperable by a single hit;

- the rotor blades should also have high impact resistance (see Figure 3), which is best matched by fibre-reinforced composite materials (it is also beneficial regarding the reflection of radio waves, reducing the effective reflecting surface of the helicopter).

The active and passive self-defence of today's state-of-the-art helicopters – not just combat helicopters – ensures the jamming immunity of avionics devices, especially those belonging to the communication and aiming-navigation complex. It requires various irradiation signalling devices, the more advanced ones can alert the helicopter to the level of danger of the device, depending on the wavelength and nature of the EMF emitted by the enemy's devices. For example, a locator in a reconnaissance mode is a less dangerous level than the same locator in a target tracking or rocket launch mode. If necessary, it must be possible to carry out some countermeasures, e.g. infrared traps or dipoles.

Survival ability also includes fire and explosion prevention. The helicopter must have an automatic fire extinguisher installed in the engine bay. It is advisable if the overpressure system of the fuel tanks is operated with inert gas (CO2) to avoid an explosion, or if the tanks made of some flexible, possibly "sel-sealing" material, which minimises fuel leakage in case of a hit.

Figure 3.
The two titanium-headed rotor blades of the AH-64 remained operational for five hours after the hit [14]

Both the engine and the avionics equipment of the helicopter shall be prepared structurally for operation in different geographical locations and in all weather conditions. Accordingly, its engine must have dust protection and capability to provide enough power to continue flying and land safely if one of the engines becomes inoperable. It follows that, from a safety point of view, the two-engine version is preferred. For the survival of both the helicopter and the crew, the helicopter cabin must be pressurised to protect against ABC (Atom, Biological and Chemical weapons) weapons, which of course goes hand in hand with the design and air conditioning of the pressurised cockpit, which increases staff comfort and thus significantly affects combat effectiveness.

Passive protection of a combat helicopter also includes enduring forced landings. Although in many cases, we cannot talk about landing, but rather about reducing the consequences of an impact. The helicopter landing gear shall be designed to withstand a collision at a speed of 5 m/s to 6 m/s without destruction. The long-stroke, levered, non-retractable chassis is best suited for this. In addition to the special design of the chassis, it is also important for the staff to have special energy-absorbing seats and to provide the lower part of the fuselage with energy-absorbing zones, ensuring the survival of the crew in the event of a helicopter impact at speeds up to 12 m/s.

Passive protection defends the helicopter in case of a hit and ensures survival of the crew. It also reduces helicopter detectability. Moreover, it influences the geometry and other design elements of the helicopter. Figure 4 shows the detectability of certain types of helicopters with different reconnaissance devices, including human senses 0.

Figure 4 demonstrates the objective of the American LHX program. The creation of a modern, hard-to-detect helicopter that surpasses the previous ones in terms of parameters and thus gaining a potential advantage over them. In the overall comparison, the RAH-66 "Comanche" helicopter represents the detectability base unit regarding the types of reconnaissance listed below:

- radar: 10 GHz frequency range, the helicopter approaches directly;
- infrared radar: based on the infrared target coordinator of the Stinger missile, examining the side view silhouette of the helicopter and neglecting the radiation of the Sun;
- acoustic: with moderate ambient noise, the helicopter approaches directly;
- visual: with the naked eye, terrain background, the helicopter approaches directly.

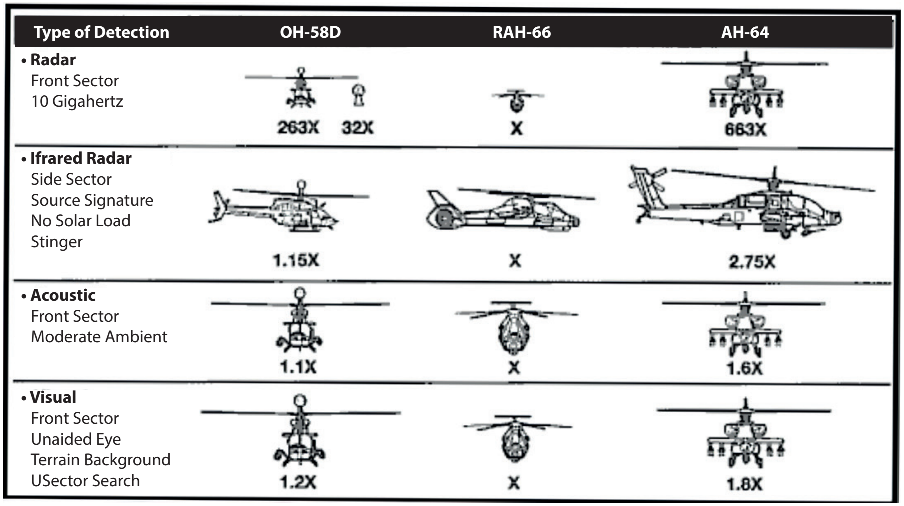

Figure 4.
The capability of RAH-66 [7], [18]

According to Figure 4, the RAH-66 helicopter far surpassed the types currently in operation. No similar comparison can be found for other types of helicopters. There may be several reasons for this. On the one hand, it is a closely guarded secret of the manufacturers, because, for example, they would not want to reveal the potentially worse values, on the other hand, they have not performed similar experiments and thus have no information. Knowing the geometric size of the Mi-28 and Mi-24 combat helicopters and the camouflage paints used during manufacture, it is likely that the reference numbers would be similar or even higher than e.g. of the AH-64 [1].

4. Conclusion

Based on the performed analyses, my conclusion is that the presence of onboard weapon system of combat helicopters is essential because it can effectively attack both ground and air targets and can be used throughout self-defence as well. It can also be stated that their armour-piercing capability is limited, so it is necessary to use unguided or guided missiles with higher armour-piercing capabilities.

Given the requirements of the age, a combat helicopter must be able to defend itself effectively, and for this, the availability of close range, air-to-air missiles are essential. Besides, a combat helicopter can have the benefit of being able to use an air-to-ground missile against medium or long-range surface targets.

The analyses also highlight that armed utility helicopters cannot replace attack helicopters, due to the fact that they do not have the necessary armour protection and they are not able to effectively fight air combat against other aircraft.

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Miért rendelkezik a támadó helikopter nagyobb túlélési képességgel, mint a felfegyverzett szállító/többfeladatú helikopter?

A szerző kiemeli a különbséget a harci és a felfegyverzett segédhelikopterek között, és ezt szakmai érvekkel támasztja alá. Bemutatja a harci helikopterek leggyakoribb fegyverrendszerét is. Rámutat, hogy egy felfegyverzett szállítóhelikopter vagy többcélú helikopter egyáltalán nem helyettesítheti a harci helikoptereket.

Kulcsszavak: *harci, támadó-, szállító-, többfeladatú helikopter, fegyverrendszer, aktív, passzív védelem*

Dr. Szilvássy László
ezredes, egyetemi docens
Nemzeti Közszolgálati Egyetem
Hadtudományi és Honvédtisztképző Kar
Repülőfedélzeti Rendszerek Tanszék

szilvassy.laszlo@uni-nke.hu
orcid.org/0000-0002-0455-4559

László Szilvássy, PhD
Colonel, Associate Professor
University of Public Service
Faculty of Military Science and Officer Training
Department of Aircraft Onboard Systems
szilvassy.laszlo@uni-nke.hu
orcid.org/0000-0002-0455-4559