

D I G I T A L   C O M B A T   S I M U L A T O R

# DCS: **BLACK SHARK 3**

*pilot's manual*



**DCS: Black Shark 3 is a simulator of Russian attack helicopter Ka-50.**

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1

**Ka-50  
HISTORY**

# 1 Ka-50 HISTORY

By the mid-1970s, the Soviet Defense Ministry leadership determined that the Mi-24 "Hind" attack helicopter (then the backbone of the Soviet Army Aviation) was not meeting Army requirements. The attempt to develop a multi-role helicopter resulted in deficiencies in the aircraft's weight and dimension as well as its flight performance. This in turn led to decreased combat efficiency. Additionally, in late 1972 the U.S. commenced the AAH program that resulted in the development of Bell's YAH-63 and Hughes' YAH-64. The latter, designated "Apache", was approved for mass-production and now serves as the U.S. Army's primary attack helicopter.

Following these developments, the Central Committee of the Communist Party and the Council of Ministers of the Soviet Union passed a resolution on the development of a new-generation combat helicopter that could be fielded with the Soviet Army Aviation in the 1980s. The prospective helicopter's primary purpose was to destroy the armored forces close to the forward edge of battle area (FEBA). This resolution pitted competing programs run by N.I. Kamov and M.I. Mil's design bureaus against each other such that only one of them would be selected for series production. At that time, both developers had already gained valuable experience in designing and producing rotary-wing aircraft.



**1-1: Ka-25F mock-up**

Based on the results of past Soviet Army helicopter operations and those of other armies, the Mil design bureau commenced work on designing a two-seat attack helicopter with both pilot and weapon operator positions. Mil adopted the same design findings as Hughes and Bell when competing for the AAH program contract. In fact, Mil's design of what would become the Mi-28 was influenced by that of the Apache AAH winner.

By the time Kamov joined the competition to develop the new Soviet Army helicopter it had a wealth of experience in designing sophisticated anti-submarine helicopters that featured an ingenious and reliable coaxial-rotor configuration. This proved to be a well-developed and promising technology that had advantages over a single rotor system. The company also had prior experience in developing Army helicopters. In 1966, in a competition to develop a transport/combat helicopter, Kamov modified its navalized Ka-25 to the Ka-25F (F – "frontovoy", i.e. frontline) version. The Ka-25F was armed with a built-in 23mm rotating automatic cannon, six "Falanga" anti-tank guided missiles (ATGM), six rocket pods, and unguided-bombs. The Ka-25F had a flight crew of two and could carry up to eight assault troops in the cargo cabin. However, preference was given then to the Mil-designed Mi-24 design based on its use of advanced engines, new target sighting system, and the then new ATGM designated "Shturm".





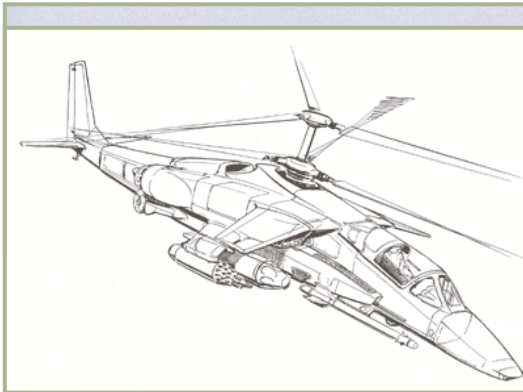
**1-2: V-50 mock-up**

By the final stages of the competition in 1969, the Kamov team offered a radically new design designated the V-50 combat helicopter. The aircraft was to have two rotors positioned longitudinally along the fuselage. The two rotors were to rotate counterclockwise in the same plane of motion with the blade synchronization preventing the blades from

colliding. The estimated speed was 400 km/h.

In 1975-1976, the V-100 helicopter project was proposed. This aircraft was to feature laterally positioned rotors with a push-type propeller. Both the V-50 and V-100 projects were very daring for that time but both were rejected in the end.

The design of the new Army combat helicopter, designated V-80 (later, Ka-50), began at the Kamov Helicopter Plant in January 1977. The program was run by the head of the design bureau, Chief Designer Sergei Mikheyev, who was later to become Designer General.



**1-4: First version of design for the single seat combat helicopter V-80**

Various aerodynamic configurations were considered for the future helicopter; however, the choice was made to use the Kamov's coaxial configuration due to its unique advantages. The substantial reduction in the power loss provided a hefty increase in main rotor thrust compared to a single-rotor configuration. This resulted in a higher static ceiling when the same power-level was used to power a coaxial-rotor versus a single-rotor configuration. The aerodynamic symmetry and the lack of cross-linkages

within the flight control system helped simplify flying the helicopter. A coaxial helicopter has fewer restrictions on side-slipping angles, angular speeds, and acceleration within the entire speed range. Additionally, there are relatively low moments of inertia due to the coaxial-rotor helicopters' compact size.

Another unique feature of the V-80 design was it being a single seat aircraft with no provision for a dedicated weapons operator. This was compensated for by incorporating a highly automated targeting/navigation suite. The feasibility of building a single-seat combat helicopter was validated by the experience drawn from the operation of fixed-

wing attack aircraft and fighter-bombers whose pilots were tasked with piloting, navigation, and weapon employment.



**1-5: ATGM "Vikhr" with APU-6 launcher**

modes, automatic data exchange among the helicopters operating in the same flight, etc. A single-person crew would provide the benefits of weight reduction, better flight performance, reduce training costs and reduce the number of possible combat casualties.



**1-6: 2A42 gun on Ka-50**

and Rapier anti-aircraft missile systems. The combination of impact and proximity fuzes with a powerful shaped charge/fragmentation warhead enables the Vikhr to be used to kill both armored ground vehicles and aerial targets.

In designing the V-80, special attention was paid to the choice of a cannon. The designers chose the 2A42 30mm single-barrel cannon, developed by the Tula design bureau, headed by V.P. Gryazev. The cannon was initially intended for infantry fighting vehicles like the BMP-2. The V-80 designers faced the challenge of mounting the cannon on the helicopter in such a manner that it would retain its high accuracy. This also had to be balanced with the cannon's primary deficiency – its heavy weight as compared to other aircraft-cannons. The decision was made to mount the cannon close to the

Kamov designers believed that combining the duties of flying, navigation, target detection, and tracking could be automated to a degree that a single crew member could perform all functions. Further, it was not expected that this would cause an excessive psychological and physical strain on the pilot. By the late seventies, the sophistication level of the Soviet helicopter industry ensured the building of such automatic systems was possible; even the Ka-25 and Ka-27 featured an automatic submarine search capability, automatic navigation and flight

The Vikhr Anti-tank Guided Missile (ATGM) system, developed by the Tula design bureau (headed by Designer General Arkady Shipunov), was chosen to be the main weapons system for the V-80. The Vikhr ATGM system's distinctive feature is its laser guidance system that is coupled with an automatic target tracking system. This ensures high-accuracy irrespective of target range. The missile's range exceeds that of the Chaparral, Roland,



helicopter's center of gravity on the right side of the airframe between the frames supporting the main gearbox - the strongest area of the airframe. Such a configuration reduced the recoil impact on the airframe and it provided the maximum level of accuracy. The restriction on the cannon's angle of rotation in the horizontal plane was compensated for by the coaxial-rotor's ability to turn at any speed with its angular speed matching that of modern-day aircraft cannons. Thus, the coarse horizontal aiming of the cannon can be accomplished by yawing the helicopter's airframe.

In addition to the ATGM and cannon systems, the Soviet military also wanted to equip the new helicopter with a large array of other weapons. As a result, the V-80's weapons suite was bolstered with rocket pods, UPK-23-250 cannon pods, bombs, KMGU canisters, and the possibility to mount air-to-surface and air-to-air missiles in the future.



**1-7: I-251V "Shkval" Automatic TV sight**

A launch-and-leave (fire and forget) targeting system was developed by the Zenith mechanical optics plant in Krasnogorsk. The Shkval automatic TV sight was developed in two variants – one for the Su-25T attack aircraft and one for the V-80 attack helicopter. The Leningrad-based Electroavtomatika scientific production association was tasked with the development of the Rubicon unified sight/navigation/flight system for the single-seat helicopter.

One of the program priorities was to enhance the helicopter's survivability. With this goal in mind, the configuration and systems' arrangement were chosen, assemblies designed, and structural materials tested. The helicopter lacked a very vulnerable tail rotor as well as an intermediate and tail reduction gearbox and control rods. A single crewman allowed the designers to increase cockpit protection. The following measures to enhance pilot survivability were taken:

- The engines were placed on both sides of the airframe to prevent a single hit from destroying both engines
- The helicopter could fly on a single engine in various modes
- The cockpit was armored and screened with combined steel/aluminum armor and armored Plexiglas
- The hydraulic steering system compartment was armored and screened
- Vital units were screened by less important ones
- Self-sealing fuel tanks were filled with polyurethane

- Composites were used to preserve the helicopter's efficiency when its load-carrying elements are damaged
- A two-contour rotor-blade spar was developed
- Control rod diameter was increased by positioning most of them inside the armored cockpit
- The powerplant and compartments adjacent to the fuel tanks were fire-protected
- The transmission is capable of operating for 30 minutes if the oil system is damaged
- The power supply systems, control circuits, etc. were made redundant and placed on opposite sides of the airframe



- Individual protection is provided to the pilot

The pilot, instrumentation, portions of the control wiring, and the targeting and navigation system are accommodated for in an all-armored cockpit. The armor consisted of spaced-aluminum plates with a total weight of more than 300kg. The armor is fitted into the fuselage load-bearing structure, which reduces the total weight of the helicopter. GosNIIAS tests confirmed the pilot's protection up to 20mm caliber cannon rounds and shell fragments.

A unique feature of this helicopter is the use of a rocket-parachute ejection system in case of an emergency. The helicopter emergency-escape system uses the K-37-800 ejection seat that was developed by the Zvezda Scientific Production Association (Chief Designer Guy Severin). The

### 1-8: K-37-800 Ejection seat in Ka-50 cockpit

pilot's safety was also ensured by the undercarriage design. The undercarriage is capable of absorbing large loads in an emergency landing, and the cockpit has a crunch zone of up to 10-15% upon impact. Additionally, the fuel system is designed to remove the possibility of fire after a rough landing.

The combat effectiveness of helicopters largely depends on the helicopter's characteristics and associated ground maintenance facilities. This issue was brought into focus at an early design stage of V-80 development, and experts from the Defense Ministry NIIRAT Aircraft Operation and Maintenance Scientific and Research Institute actively participated in the work. While developing the helicopter's maintenance systems, consideration was given to a self-sustained deployment option on unpaved airfields. Thus, by the late 1970s, the Kamov Design Bureau had finalized the concept of a new, single-seat attack helicopter that was coaxial, with a wide variety of powerful weapons capable of engaging enemy air defense systems while staying outside air defense system engagement ranges. It was expected to be fitted with a functionally-integrated, highly-automated equipment suite that would assist in high combat survivability for aircraft and pilot, and be capable of long-term deployment to unprepared sites. The helicopter was to operate as part of a reconnaissance and attack unit comprised of aerial and ground reconnaissance, surveillance, and target designation capability. It should be mentioned that the American AH-64A Apache, which was being closely monitored, was determined to be the main rival of the new helicopter. It was a rather difficult task to compete against the Apache, and it was necessary to tackle it within the framework of the contest.

In August 1980, the "to be or not to be" question for the Kamov single-seat helicopter was finally settled. The USSR Council of Ministers Presidium Commission on Military Industrial Issues decided to build two V-80 and two Mi-28 prototype aircraft. That same year, the Ministry of Defense issued a common performance specification for the experimental helicopters of both types.

The first V-80 prototype (side Number 010) left the Kamov Helicopter Plant in June 1982. On 17 June, for the first time, test pilot Nikolay Bezdetnov performed a hover in the V-80 and on 23 July the V-80 made its maiden forward flight.



**1-9: V-80 (side number 012) with the Mercury low-level TV sighting system (on the foreground)**

V-80 No. 1 was designed to assess its flight characteristics and evaluate the helicopter's systems. In particular, it flew with various tail assemblies, without stub-wings, etc.

In August 1983, the second prototype (side number 011) was built as a test-bed for the on-board equipment, avionics, and armament. The helicopter was powered by upgraded TV3-117VMA engines. For the first time, it was also fitted with the Rubicon targeting/navigation system and the NPPU-80 rotating cannon. The second aircraft flew for the first time on August 16, 1983.

In late 1984, the initial results of the contest were reviewed and the first stage of the State Comparative Right Tests to evaluate the flight characteristics of both contending helicopters had started.

In December 1985, the third V-80 (side number 012) with a Mercury low-level TV sighting system mock-up was built to assist in the flight performance evaluation program.

In September 1985, flights tests of the two contending helicopters were held at the Main Missile Artillery Department testing ground. These tests were part of the State Comparative Flight Tests to estimate combat effectiveness.

These tests finished in August 1986, and the results showed that the V-80 outperformed the Mi-28 in combat effectiveness due to its higher survivability, better flight



characteristics (especially at high altitudes and temperatures), and its wider weapons capabilities. These tests also proved that the level of pilot psychophysical strain was close to that of a fighter-bomber pilot. This demonstrated the possibility to combine the pilot and navigator functions in principle. The Defense Ministry institutes came to the conclusion that the Kamov entry showed more promise than the Mil entry.

#### 1-10: V-80 testing

Despite this success, there were a number of shortcomings stressed. The most serious one being that the helicopter was not capable of night operations due to the drawbacks of the Mercury TV night-vision system. As a result of the comparative tests, the customer recommended that Kamov improve the night-vision system, equip the V-80 with an airborne defense system, reduce the number of operations performed by the pilot while searching and attacking the target, and ensure the integration of on-board equipment with ground and air reconnaissance systems. With the contest nearly over, the Kamov helicopter was sent into mass production in accordance with a 14 December 1987 directive issued by the USSR Council of Ministers.

Preparation for mass production began at the Arsenyev-based Progress Aircraft-Building Plant in the Far East. In accordance with the above-mentioned directive, in March 1989, the Kamov Design Bureau helicopter plant built a fourth V-80 prototype (side number 014), and in April 1990 – the fifth helicopter (side number 015) was built. No. 015 would become the standard for mass production.

From 1988 to 1990, four helicopters participated in flight design tests. In 1990, the USSR Council of Ministers Commission on Military Industrial Issues decided to build an initial batch of the helicopters, soon designated Ka-50, at the Arsenyev-based plant. The lead serial helicopter was constructed there that same year. On 22 May 1991, test pilot N. Dovgan took the helicopter (side number 018) to the air.

The first stage of the Ka-50 state tests (the assessment of flight characteristics) was started in mid-1991. By January 1992, the lead serial Ka-50 was sent to the GUTs State



**1-11: Ka-50Sh at the MAKS '99 airshow**

(Moscow Region), and in September 1992, a serial Ka-50 was displayed at the Farnborough Air Show in Britain for the first time where it topped the bill. The fifth prototype (painted black) had managed to star in a film entitled "Black Shark", and it has been that name that has since been associated with the Ka-50. Since 1992, the Ka-50 has participated in all major world air shows.



**1-12: Ka-50Sh nose with "Shkval" system  
above and Samshit-50 optoelectronic system  
below**

Kamov felt their duty was to enable the Ka-50 to fight around the clock. The nighttime version of the Ka-50, designated Ka-50Sh, was developed in 1997. Its avionics suite was

Right and Testing Centre for the second stage of the state tests (the assessment of combat effectiveness), which started in February.

Soon thereafter, the Ka-50 entered the world stage. In March 1992, Designer General Sergei Mikheyev delivered a speech about the new helicopter at an international symposium in Great Britain. It was there that the new designation of the helicopter, Ka-50, was mentioned for the first time. In August 1992, the third Ka-50 prototype participated in the Mosaeroshow-92 exhibition in Zhukovsky

In mid-1993, the service tests of series-built Ka-50 helicopters were initiated at the Torzhok-based Army Aviation Combat Application Centre. The centre pilots and engineers that included Major General B.Vorobyov, Colonel V.Khanykov, Lieutenant Colonel S. Zolotov and others, greatly contributed to the Ka-50 tests and development of its combat application tactics. On 28 August 1995, the Ka-50 entered the inventory of the Russian Army in accordance with a decree by the Russian President.

The Ka-50 single-seat combat helicopter became the forerunner of a whole family of Army helicopters. The first generation of Ka-50 could only operate in daytime. However,



comprised of a new opto-electronic system designated Samsheet-50, which was designed by the Urals Optical Mechanics Plant (Russian abbreviation - UOMZ). This system included an array of surveillance/sighting subsystems (thermal imager, laser rangefinder/target designator, ATGM laser control system) mounted on a gyro-stabilized platform within a rotating spherical container. This container was in turn housed in the nose of the airframe. To retain the Ka-50Sh's daytime combat operations capability, the helicopter was still equipped with the Shkval automatic TV sight.

The Ka-50Sh made its maiden flight on 4 March 1997, with test pilot Oleg Krivoshein at the controls. That same year, the helicopter was displayed at the Abu Dhabi arms exhibition. The aircraft was then modified, which resulted in the change in the relative position of the Shkval and Samsheet systems in the nose of the aircraft. The modified Ka-50Sh was completed in June 1999, and exhibited at the Nizhny Tagil arms exhibition and MAKS '99 air show. A further derivative of the Ka-50 nighttime version was represented by a helicopter boasting a newly integrated avionics suite being developed by the Ramenskoye Instrument-making Design Bureau (RPKB). This helicopter was also shown at MAKS '99. Unlike the initial variants of the Ka-50Sh, this version featured two nose-mounted, gyro-stabilized optoelectronic sight systems housed in rotating spherical casings - the flight one (upper) and the sighting one (lower). Both were developed by the UOMZ plant.

To provide greater flight safety for all Ka-50 versions flying at night, Kamov and the Orion Scientific Production Association offered to provide crews with OVN-1 night-vision goggles that had undergone testing with the Ka-50 over the summer of 1999, and were shown at MAKS '99.



**1-13: Ka-50 assembling at the "Progress" Aircraft-Building Plant**

The Ka-50's modular design led to several additional versions derived from the base variant. The success of a helicopter unit's combat record depends on the coherency of their actions as well as on the commander's efficiency. The commander's helicopter has to be outfitted with a more capable avionics suite than that featured by the rest of the

unit. This command helicopter provides better detection of targets on the battlefield, target designation, target distribution, continuous control of the other helicopters' actions, and communications with ground command posts. This is the role that the Ka-52 Alligator was designed to fill. The Ka-52 is a variant of the Ka-50 but is a multipurpose all-weather combat helicopter with side-by-side seats for the two crew members.



#### 1-14: Ka-52

The Ka-52 retains its predecessor's combat capabilities, including the ability to use the Ka-50's full spectrum of weapons. Its surveillance/sighting system can search for targets and attack them in both day and night and in any weather. The Ka-52's development does not imply the Ka-50 will be replaced. On the contrary, the most effective tactic the Army will use is to use the Ka-50 and Ka-52 as a team, sharing vital information. The Ka-52's prototype was built in November 1996, with its maiden flight being made by test pilot A. Smirnov on 25 June 1997.

Since 1997, the two-seat version of the Ka-50 has been taking part in a tender for a new, Turkish combat helicopter. In line with the requirements of the Turkish military, the new helicopter, designated Ka-50-2, will seat its crew in tandem. This aircraft will boast several foreign-made avionics components and weapons that meet standards set by the Turkish armed forces.



**1-15: Export Ka-50-2**

Kamov is ready to develop other Ka-50 versions that meet the specific needs of the most demanding customer. Kamov guarantees that the primary capabilities of the Ka-50 will be retained - unrivalled maneuverability, high reliability, flight safety and survivability, and excellent combat efficiency. These qualities are grounded in the helicopter's unique coaxial-rotor configuration, the Ka-50's ingenious and reliable design, top-notch avionics, and a weapons suite whose superiority has been proven by theoretical research, comparative trials, and field operation results.



**1-16: A combat flight of the Ka-50 in Chechnya**





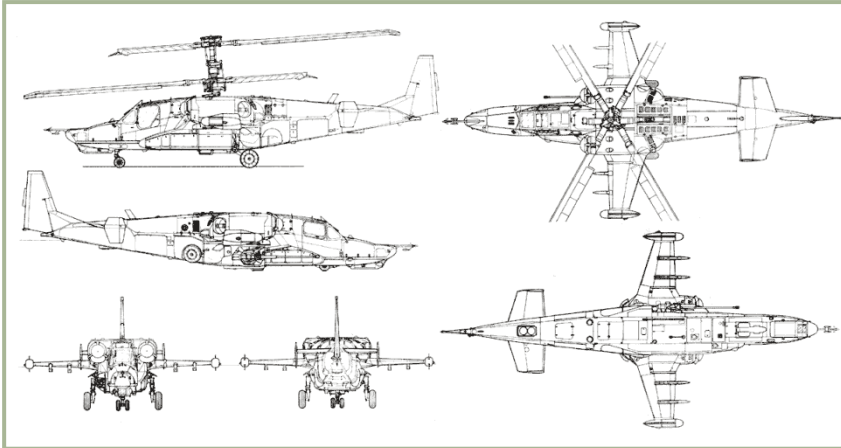
2

**GENERAL  
DESIGN**

## 2 GENERAL DESIGN

### General Design and Layout

The Ka-50 is a single-seat, two-rotor (coaxial) attack helicopter powered by two turbo shaft engines and supported by tricycle landing gear.



**1-1: Ka-50 Drawings**

The Ka-50 fuselage is designed as a non-pressurized, semi-monocoque structure that is divided into several sub-compartments - rectangular in midsection. Two joints sub-divide the airframe into front / rear parts and a tail unit. The fuselage is built mostly of aluminum alloys and polymer composite materials (organic plastic, carbon – fiber plastic, and honeycomb filler). The Ka-50 airframe is composed of frames, spars, ribs, heavy-duty and light-load panels, as well as door and hatch reinforcements, beams, and a stress-resistant skin. The airframe uses "hanging" panels to streamline the fuselage.

The helicopter's fixed stub-wings provide additional lift and serve as weapon attachment points. Each stub-wing is equipped with two hardpoints for carrying weapons, fuel tanks, and pods.

The tail unit includes a vertical stabilizer, rudder, horizontal stabilizer, and widely-spaced additional vertical fins at the end of the horizontal stabilizer.



**1-2: Helicopter with open access covers and disassembled wing**

The retractable, wheeled tricycle landing gear consists of a forward strut and two main heavy-duty struts with a 2,600mm track and a 4,911mm base. The front strut tires are pressurized to  $8 \pm 0.5$  kgf/sq.cm, and the main strut tires are pressurized to  $6.5 \pm 0.5$  kgf/sq.cm.. In flight, the struts are retracted rearwards into the fuselage bays, the main struts being covered by shutters.

## Power Plant and Rotor System

The Ka-50 power plant incorporates two TV3-117VMA turbo shaft engines, transmission gear boxes, power plant systems, and devices. The engines include a free-running



**1-3: The exhaust nozzle of auxiliary power unit (in operate) and screen-type exhaust devices of main engine**

turbine and a pneumatic turbo-drive starting system. The torque from the turbines is transmitted through the intermediate and main reducing gears. Each engine measures 2055x650x728mm and develops 2,200 hp at take off with a fuel consumption of 137 g/(hp • hr).

The main engine compartments and the Auxiliary Power Unit (APU) housing are separated by fire-proof partitions. Both engines are equipped with centrifugal dust filters and screen-type exhaust devices that mix

external air with exhaust gas to suppress the helicopter's emissions in the infrared band. The transmission system includes one main and two intermediate gears that serve to transmit power output from the main engines to the rotors and adjust their rate of rotation. The engines are designed to be started independently by means of a free-wheeling clutch that disengages one or both engines from the main reducing gear and supports helicopter flight with a single running engine or in autorotation descent mode. The main reducing gear is equipped with the front and rear drive boxes that incorporate the helicopter's system units and the main rotor braking mechanism. The auxiliary power plant incorporates the AI-9V gas-turbine engine and a pneumatic drive to feed compressed air to the turbo drive and main engines' start-up system.



**1-4: Assembly of main rotor**

The Ka-50's main rotor system is made up of two triple-blade coaxial rotors and blade control units. The upper rotor (top view) rotates clockwise and the lower rotates counterclockwise. The main rotor heads are unhinged, and the blades are attached to them through the torsion bars installed in self-lubricating bearings. The blade spars are designed as hollow beams of variable section with glass-carbon plastic partitions. The helicopter tail unit is glued to the spar's butt section. Its skin and rib facings are made of organic plastic with a polymer, honeycomb plastic filler. The blades' swept ends are fixed to the spars at an angle of 33°.

The helicopter's fuel system is comprised of two primary tanks and up to four external fuel tanks. The front tank serves to feed fuel to the port side engine, and the rear tank provides fuel to the starboard engine and to the auxiliary power unit (APU). Both primary tanks are made of kerosene-resistant rubber-fiber material. The tanks' bottoms and two-thirds of their walls are protected by layers of natural rubber. Additionally, the tanks contain polyurethane foam with an elastic, porous filler to prevent a fuel explosion if it is hit by enemy fire.

## General Purpose Equipment

The Ka-50's hydraulic system drives the hydraulic actuating mechanisms of the helicopter. Mechanisms served by hydraulics power include the control surface drives, the braking mechanisms of the landing gear main struts, the landing gear extension and retraction cylinders, and the cannon control units. The flight control system of the Ka-50 incorporates pitch, roll, and yaw inputs and the general pitch control unit. The flight control hydraulic inputs are then combined in the control drive unit that ensures reliable operation in both the irreversible manual control system mode and the combined control



mode (i.e., the mode combining manual control and auto-piloted flight stabilization). The Electrical Power System uses three-phase 115 V 400 Hz AC power that is supplied by two generators with an output of 80 kW and a 500 W inverter. The 27 V DC supply is supplied through rectifiers. On the ground, the helicopter can also be connected to a 115 V 400 Hz external power supply unit.

The Ka-50's Warning System includes the SAS emergency warning system and the EKRAN built-in warning and control system. A Series 3 Tester U3 flight data recorder serves to record and store helicopter flight parameter data and system performance data from the last three hours of flight in case of emergency. The unit is capable of recording 38 analog and 63 digital signals. Safety of the magnetic tape is ensured by the "black box", which is sealed to be heat and impact-proof.



**1-5: Ekran built-in warning and control system (left) and auxiliary flight indicator (right) in Ka-50 cockpit**

The KKO-VK-LP oxygen supply system feeds oxygen to the pilot when at altitudes up to 6,000 m. The pilot's oxygen supply set consists of an oxygen bottle, an oxygen mask with a hose, and a gas mask. The 2-litre oxygen bottle is capable of supplying the pilot 90 minutes of air.

The deicing system prevents icing of the helicopter's most vital systems, such as the engine air intakes and dust-filtering devices, the main rotor blades, the windshield, the air pressure sensors, the

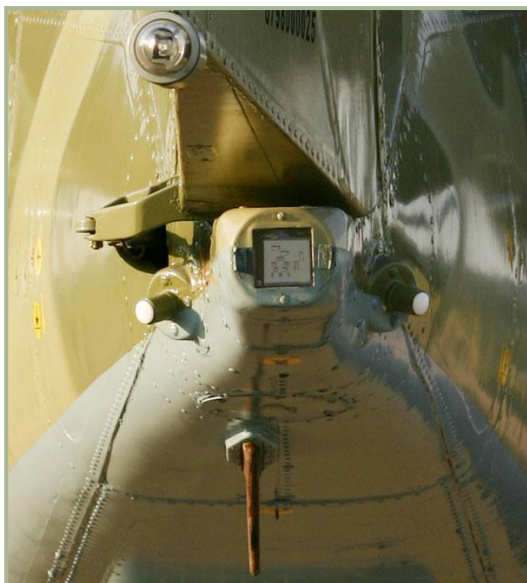
angle of attack and yaw sensors, the clock, and the icing visual indicator. Additionally, the cockpit windshield and the Shkval-V protective glass cover are equipped with defrosting liquid sprinklers and wipers.

The helicopter emergency escape system includes the K-37-800 pilot ejection system, the main rotor blade cut-off system, the cockpit escape hatch system, the ejection system attachments, and the control system.

## Radio Equipment

The Ka-50 radio communications suite includes two R-800L1 and one R-868 VHF transceivers; an automatic data transmission system that updates ground controllers of the helicopter's position and performance; the SPU-9 intercom system; the P-503B device that records any signals coming through the pilot's headphones; and the Almaz-UP-48 voice message unit (VMU) system that is capable of providing voice warning reports to the pilot of eleven types of flight emergency situations.

The Ka-50 is also equipped with an IFF transponder, the ARK-22 radio compass, and the A-036A radio altimeter.



**1-6: The tail of the Ka-50. The white navigation light is located at the top of the image. The L-140 laser sensor system is in the center and various IFF antennas are located to each side and below**

The PrPNK "Rubikon" (K-041) piloting, navigation, and targeting system combines digital and analog information systems with digital combat-flight information processors. The Rubikon is based on an integrated computer system that includes five sub-units: four BCVM 20-751 computers (combat, navigational, data display, and target designation), one BCVM 80-30201 computer (weapons control systems), and one UVV 20M-800 data input/output device.

The I-251V Shkval-V targeting system incorporates TV components, a laser range finder and target designator, and a laser beam-rider system for the Vikhr ATGM system. The Shkval also provides image stabilization, variable field of views, and an automatic target-tracking system once a target is designated. The electro-optical television

sensor has either a wide or narrow field of view, with line-of-sight deflection angles of +35° in azimuth and from +15° to -80° in elevation. The IT-23MV indicator displays a monochrome image produced by the Shkval television system.

The RANET indication system displays targeting, piloting, and navigational information on the ILS-31 head-up display (HUD). Its other purpose is to create the shapes and symbols that are displayed on the IT-23MV indicator. RANET provides a 24-degree field-of-view against the backdrop of the ILS-31 screen.

Advanced Map Moving System (AMMS):

- Flight preparation and planning
- Cartographic support for all stages of mission
- Processing of information from the linked systems
- Output of information to linked systems
- Navigation calculations for mission

The AMMS enables:

- Programming, editing and saving of waypoints, runways, radio beacons, target locations and the ability to study terrain along the flight route, etc.

- Ability to alter flight plan during mission
- Real-time determination of helicopter position coordinates by using built in navigational satellite system sensor (NAVSTAR/GLONASS); display of the helicopter position on the electronic moving map display; ability to cycle map scale and check cross-track error, and other necessary navigation information
- Display of aeronautical information and flight plan required for navigation during all stages of a mission
- Reception of information from the autonomous pressure altitude sensors and necessary processing of pressure altitude for the needs of the built-in satellite navigation system sensor
- Reception and processing of information from the other avionics systems such as the "Rubicon" targeting-navigation system and data link equipment.
- Indicating the position of wingmen using data link as well as targeting line of sight vector from the "Shkval" targeting system
- Annotate moving map with text and symbols



#### 1-7: "ABRIS" AMMS system

The Obzor-800 target designation system is mounted on the pilot's helmet and generates control signals for the Shkval-V weapons system. Target designation is accomplished by the pilot turning his or her head within  $+60^\circ$  (azimuth) and  $-20^\circ$  to  $+45^\circ$  (elevation).

The PNK-800 Radian piloting and navigation system functions as a subsystem to the Rubikon system and it affects the automated piloting and navigation systems in

combination with the other system components. The Radian incorporates the C-061K pitch-and-heading data system and the IK-VSP-V1-2 speed-and-altitude data system.

## Countermeasures Systems



**1-8: UV-26 flares dispenser, left (red) navigation light and the signal flare cartridge dispenser**

The Ka-50 is equipped with the L-140 Otklik laser detection system that is capable of detecting and identifying laser guidance systems and range finders. The UV-26 system is used to dispense infrared flare decoys are carried in two 26mm cartridge pods that are fixed to the wing tips. Each pod contains 64 cartridges.



## Performance Characteristics

First flight, year	1982
Crew	1
Powerplant	
Type	TV3-117VMA
Takeoff power, hp	2x2,200
Dimensions, m	
Length overall, rotors turning	15.6
Wing span	7.34
Height	4.9
Main rotors diameter	14.45
Weights, kg	
Normal takeoff weight	9,800
Max takeoff weight	10,800
Fuel, l	
Internal fuel	1,870
External fuel	4x550
Speed, km/h	
Max speed at S/L	350
Cruising speed	255
Ceiling, m	
Hovering ceiling	4,000
Service ceiling	5,500
Max rate of climb m/s / altitude, m	10 / 2,500
Design G limit	3.5
Range, km	
Operational range	450
Ferry range	1,100
Armament	
ATGM, number / type	12 / Vikhr
Launching range, km	8
Cannon	
Type	2A42
Caliber, mm	30
Ammunition, rounds	220 API, 240 HE
Weight of projectile, kg	0.39
Initial speed of projectile, m/s	980



Rockets	
Type / caliber, mm / number	S-8 / 80 / 122
Type / caliber, mm / number	S-13 / 122 / 20



**3**

**ARMAMENT**

## 3 ARMAMENT

The Ka-50's armament is comprised of a cannon, gun pods, aerial bombs, unguided rockets, and laser-guided missiles. The cannon system includes a NPPU-80 mount with a 30mm 2A42 automatic cannon that is capable of engaging air, land, and sea targets.

### Cannons

The cannon is supported by the helicopter's hydraulic drive system. The mount allows the cannon to be deflected from  $-2^{\circ}30'$  to  $+9^{\circ}$  in azimuth and from  $+3^{\circ}30'$  to  $-37^{\circ}$  in elevation. The cannon ammunition is contained in two cartridge boxes. The front cartridge box contains 240 armor-piercing tracer / rounds, and the rear box contains 230 high-explosive, incendiary rounds. This allows the pilot to easily select the type of ammunition that will be fed to the cannon through a double-sided belt. The fire control system enables the cannon rate of fire to be set to rapid (550-600 rpm) or slow (350 rpm), and it allows the burst length to be set to either 20 or 10 rounds. Additionally, the externally mounted UPK-23-250 gun pods, each containing a GSh-23L 23mm cannon with 250 rounds, can be attached to the inner under-wing hardpoints.

### 2A42 Cannon History

In the early 70s, Russian weapon designers were commissioned to increase the combat effectiveness of the BMP infantry fighting vehicle armament with a small-caliber autocannon. The gun was developed by the Tula Design Bureau, headed by V. Gryazev. The



**3-1: 2A42 Gun**

cannon is chambered for the 30mm AO-18 cartridge and the cannon's long barrel and short automatic receiver facilitates its arrangement inside an armored vehicle turret. The cannon also provides excellent elevation range. To reduce recoil, the barrel and muzzle brake are shifted rearward during firing. The electronic trigger mechanism ensures an automatic fire mode at both low and high rates and a single-shot fire mode. All of these factors increase the cannon's combat effectiveness.

Intensive combat effectiveness tests were conducted with the new cannon mounted on a BMP infantry fighting vehicle. The cannon proved to have considerable range and fire accuracy (at 1,500 m). Its large ammunition load included 500 cartridges compared to 38 cartridges of the older "Zarnitsa" cannon. The new 30mm cannon was proven to be very effective against a wide array of target types.

In 1980, a new infantry fighting vehicle, termed the BMP-2, came into service. The BMP-2 received the new index 2A42 30mm cannon.

The BMP-2 showed high combat-effectiveness in Afghanistan while fighting on flat and mountainous terrain. Some drawbacks of the 2A42 were uncovered during this combat however. This was manifested in excessive exhaust smoke during firing, especially at high rates of fire; smoke would fill the crew compartment of the vehicle. Additionally, the cannon was fairly ineffective against entrenched enemy forces. However, combat also revealed that low rates of 2A42 fire remained effective in all firing modes.

The 2A42 is effective against light armor out to 1,500 m and unarmored targets out to 2,000 m. The cannon is also effective against air targets flying at altitudes up to 2,000 m.

The 2A42 is gas-operated. The bolt is closed after its rotation, and the cannon is belt-fed. Two metallic cartridge belts are comprised of separate "Crab" type 9H-623 links. These links are locked together by the cartridges. The belts are fed into the cannon in succession by a switch located on the back-plate of the cannon and then the cartridge is rammed from the belt into the chamber. The cartridge cases are then ejected forwards along the barrel.

The cannon has a blocking mechanism that prevents it from firing when the last cartridge of one of the two cartridge-belts enters the firing chamber. The bolt is then stopped at the sear. When the pilot presses the firing button after switching to another belt, the firing continues without any reloading.

The high-quality and combat effectiveness of this cannon, developed by the BMP designers, attracted the attention of the attack helicopter design bureaus. As a result, the powerful automatic cannon employed by the BMP-2 was chosen to arm the Ka-50. Such a move dramatically increased the fire power of the Ka-50 and gave it another tool to combat enemy ground and air units.

#### 2A42 Cannon Specifications

Caliber, mm:	30
Rate of fire, rds/min:	600-800 / 200-300
Cannon weight, kg:	115
Initial shell velocity:	
HE-T, m/s:	950
AP-T, m/s:	980
Number of grooves:	16
Ammunition load, rds:	220 AP-T; 240 HE-T)

#### 2A42 Cartridge Specifications

Specification	AP-T	HE-T
Projectile caliber, mm:	30	30
Weight of cartridge, kg:	0.853	0.837
Length of cartridge, mm:	291	291

Explosive charge weight, kg:	0.127	0.123
Weight of projectile, kg:	0.400	0.389
Initial velocity of projectile, m/s:	960 - 980	950 - 970
Initial projectile velocity probable deviation, m/s:	5	5
Time of burning, s:	More than 3.5	

## Bombs

The Ka-50 is capable of mounting free-fall bombs on the four BD3-UV weapon racks that can be located on the stub-wings. KMGU small-caliber bomb containers may also be carried here. Bombs and containers that may be carried on these stations include:

### FAB-250 General Purpose Bombs

This is a family of high-explosive bombs of varying caliber. The number in the designation refers to the bomb's approximate weight (in kilograms). These bombs are effective against ground structures, equipment, defensive installations, bridges, and fortifications.



**3-2: The FAB-250 High-Explosive Bomb**

### KMGU-2 Sub-Munition Dispenser

The KMGU-2 ("General Container for Small-Sized sub-munitions") is designed to dispense small caliber bomblets and air-deployed mines. The sub-munitions are placed in the dispenser in cartridges (BKF – "container blocks for frontal aviation"). The KMGU-2 consists of a cylindrical body with front and rear cowlings and contains 8 BKF cartridges filled with bomblets or mines, carried in specialized slots. The dispenser doors are pneumatically actuated to dispense the sub-munitions.



### 3-3: The KMGU-2 Sub-munitions Dispenser

The KMGU-2 electrical system ensures a regular time interval of 0.005, 0.2, 1.0 or 1.5 seconds between each cartridge release. BKF cartridges carried by the Ka-50 are usually equipped with 12 AO-2.5RT fragmentation bombs of 2.5 kg, 12 PTM-1 1.6 kg anti-tank mines, or 156 PFM-1C 80 g high explosive mines. KMGU-2 dispensers are suspended singly on universal BDZ-U beam bomb racks. Cartridges are released from altitudes of 50-150 m.

## ATGM Weapons

The Ka-50 anti-tank guided missile (ATGM) equipment includes up to twelve laser beam-riding 9A4172 Vikhr ATGMs. Vikhr missiles are launched from UPP-800 movable mounts that are attached to the outside stations of the stub-wings. Each UPP-800 is capable of suspending up to six ATGMs. To facilitate launching ATGMs at ground targets while in horizontal flight, and make sure that the missile guidance system locks on to the laser beam, the UPP-800 mount can be deflected downward up to 10°.

## 9K121 "Vikhr" (AT-9) Anti-tank Weapon System

The Vikhr anti-tank weapon system is designed for use against armored vehicles, including those equipped with reactive armor, and air targets flying at speeds of up to 800 km/h. The system began development in 1980, at the "Tochnost" Design Office for Instrument-making (Scientific and Production Combine) under the direction of chief designer A.G. Shipunof. It entered service in 1992. By the beginning of 2000, the weapon system was carried on the Su-25T close support aircraft (up to 16 missiles can be carried on two APU-8 launchers) and the Ka-50 attack helicopter (up to 12 missiles carried on two APU-6 launchers). The NATO missile designation is AT-9. The Ka-50 Vikhr missile system includes:

- Supersonic laser beam-riding 9A4172 missiles
- The I-251V "Shkval" electro-optical fire control system
- APU-6 launchers





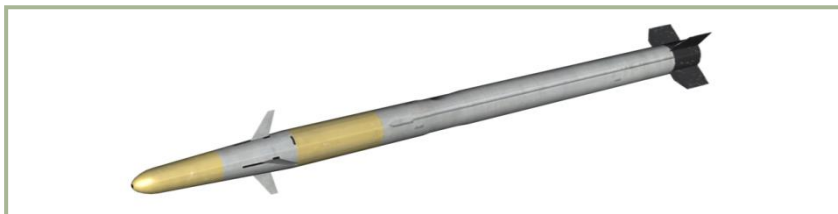
### 3-4: The APU-6 "Vikhr" (AT-9) Launcher

The system allows missiles to be fired singly or in pairs. The missile's supersonic speed (up to 610 m/s) decreases the shooting aircraft's vulnerability during the attack, and it can allow quick sequential attacks against multiple targets. The missile covers its 4 km effective range with a flight time of nine seconds.

The missile was designed according to a canard aerodynamic layout and features folding fins. Aiming is done with the help of the "Shkval" automated targeting system. Upon identifying the target image in the TV display, the pilot places a cursor over the target and commands a lock by pressing a button. The display provides target data when it is locked and authorizes the pilot to shoot when the target is within valid launch parameters.

The missile is tube-launched with the help of an ejection charge before rocket motor ignition.

The laser beam-riding guidance together with the electro-optical target lock ensures high accuracy regardless of target range. In addition, laser beam-riding guidance provides more reliable performance in the presence of environmental clutter (e.g. dust, smoke) and/or enemy countermeasures (e.g. smokescreens).



### 3-5: The 9A4172 Vikhr (AT-9) Missile

In the Ka-50 and Su-25T aircraft, the Prichal laser designator/rangefinder is integrated with the on-board Shkval fire control system. The Shkval system automatically tracks a locked target and illuminates it with the laser designator. The missile detects the laser beam and attempts to keep it centered between two receiving sensors in the tail while flying towards the target. The missile has only one servo motor for steering, so it rolls around its longitudinal axis in flight (corkscrew), continuously correcting pitch and yaw in turn. This rotating motion gives the missile a distinctive spiral trajectory.



The missile storage, transportation, and launch are all performed with the same tubular transport-launch container, ensuring reliable missile performance for up to 10 years without any maintenance.

### 9K121 "Vikhr" Specification

Range, km:	
Day	0.5-8 (10)
Night	5 (6)
Launch altitudes, m:	5-4000
Flight time, s:	
At maximum range:	28
At 8.000 meters:	23
At 6.000 meters:	14
Average speed at 8.000m range, m/s:	350
Warhead	
Type	Tandem conical shaped charge
Weight, kg:	8
Weight of explosive, kg:	4
Fuze type:	Impact and proximity
Proximity fuse range, m:	2.5-3.5
9A4172 missile	
Stage number:	2
Length, mm:	2,750
Diameter of body, mm:	125
Wing span, mm:	240
Stabs span, mm:	380
Weight, kg:	40-45
Launching tube length, mm:	2,870
Launching tube diameter, mm:	140
Temperature conditions, C°:	-50 up to +50
Automatic sight I-251V Shkval:	
Day channel	TV
Track system	Automatic
Air launcher APU-6	
Missiles number:	6
Launcher weight, kg:	60
Launcher length, mm:	1,524
Launcher width, mm:	720

Launcher height, mm:	436
Pointing angle in vertical, degree:	10

## Rocket Weapons

The unguided rocket system of the Ka-50 consists of four B-8V20A or B-13L5 pods. Each B-8V20A pod contains twenty 80mm S-8 rockets of different modifications (hollow-charge, armor-piercing, fragmentation, high-explosive, and other warheads containing flares, darts, and various kinds of projectiles). The B-13L5 pods contain five S-13 122mm rockets that can be equipped with armor-piercing, hollow-charge, or high-explosive warheads.

### S-8 Rocket

In the late 1960s, the Tochmash design bureau was commissioned to develop an 80mm unguided air-to-ground rocket system to increase the firepower of fighter-bombers and ground attack aircraft. The requirements were based on the assessment that existing 57mm unguided rockets were not adequate. The new weapon requirements included aerodynamic heat resistance, reduced adverse effects of missile motor burn on launching aircraft, increased rate-of-fire, increased maximum engagement range, and decreased minimum launch altitude.



**3-6: S-8KOM rocket**

With combinations of different warheads and rocket motors, a wide variety of 80mm unguided rockets were developed. Today there are over 25 models in series production and an additional 10 experimental prototypes.

The S-8M and S-8KOM variants have a solid-propellant motor with an increased burn time and a shaped-charge warhead with improved fragmentation effect. The S-8KOM can penetrate up to 400mm of armor.

S-8M (S-8OFP) - modernized. HE warhead has an increased fragments action and increased action time of engine.



**3-7: S-80FP1 (S-8M) rocket**

The S-80 and S-80M are used for illumination of the target area. On impact they emit 2 million candles of visible light for 35 seconds.



**3-8: S-80M rocket**

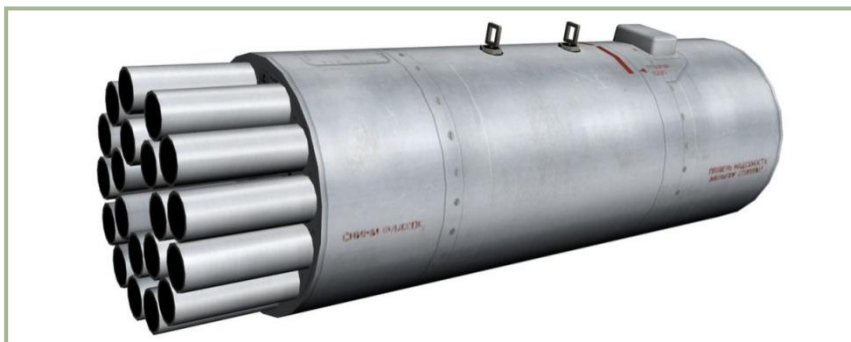
The S-8TsM are intended to improve the efficiency of the ground attack aircraft by targeting (marking) ground objects. When the rocket hits the ground it forms a well seen smoke cloud which marks the target or any point of the ground surface.



**3-9: S-8TsM rocket**

Implementation of these rockets is the same as for high-explosive rockets and it's possible either from automatic ranging or manual mode.

Twenty rockets per weapon station can be carried in a B-8 launcher and its modified versions: B-8M, B-8M1 and B-8-0 with improved heat resistance. The helicopter variant of the B-8 launcher, designated B-8V20A, has longer launch tubes and a less-sophisticated aerodynamic shape because the kinematical air resistance is negligible at helicopter speeds.



**3-10: B-8V20A launcher**

S-8 firepower and effectiveness are superior to that of older S-5 rockets. One 20 rocket salvo from a single B-8 launcher is equivalent to three 32-rocket salvos of S-5. S-8 also has greater precision and an increased maximum engagement range over the S-5 system. As a result, the S-8 rocket system has been replacing the S-5 on both fixed-wing and rotary-wing aircraft.

### S-8KOM Reference

Caliber, mm	80
Length, mm	1570
Weight,	11.3
Warhead, kg	3,6
Weight of explosive, kg	0,9
Effective launch range, m	1,300-4,000
Maximum speed, m/s	610

## S-13 Rocket

Conflicts in Middle East in the 1970s demonstrated the severe vulnerabilities of stationary aircraft at airfields. Multiple aircraft parked in the open could be destroyed by a single enemy aircraft that penetrates air defenses. Even surrounding each aircraft with a protective berm became inefficient due to the increased firepower and accuracy of modern air-to-ground weapons.

Based on these observations, NATO High Command promptly instituted the dispersion of aircraft around an airfield and enclosing them in hardened aircraft bunkers (HAB). These bunkers were built from reinforced concrete and had a corrugated 5mm inner metal shell to protect from weapon spalling. A thick layer of soil was then placed over the concrete bunker, thus making it quite a strong fortification capable of withstanding several direct hits of fragmentation and blast-fragmentation bombs.



**3-11: S-130F unguided rocket**

Soviet High Command placed top priority on developing unguided rocket systems capable of penetrating these bunkers and destroying their contents. This task could already be accomplished with large-caliber rockets like the S-250F; however, because all the enemy aircraft were placed inside HABs (some HABs were also built as decoys), the presence of enemy air defenses, and the low hit probabilities of a single rocket, one would need an enormous strike package to destroy such an airfield. Modifying existing rockets for these tasks was considered impractical.

Also, in 1969, an analysis of existing rocket systems led to the task of developing a 127mm unguided rocket (analogous to US HAP Zuni) that would fill the niche between 57mm and 240mm rockets. This task would later be carried out at the Novosibirsk Institute of Applied Physics in the development of the 122mm unguided rocket, designated S-13.



**3-12: UB-13 launcher**

Work on a prototype began in 1973, and by 1979, the S-13 rocket was ready for tests from UB-13 launchers that each contained six rockets. The tests included a number of specially built HABs. A typical test HAB had 1 m thick reinforced concrete walls and was covered by 5 m of soil. In the tests, S-13 rockets penetrated these structures and



exploded under the floor. Concrete walls had holes 0.2-0.4 m in diameter. The inside walls of the HAB showed spalling craters 1.5 m in diameter and 0.4 m deep. The S-13 was then accepted into series production.

However, the S-13 still had one drawback when HABs were penetrated; the concrete flakes were held in place by anti-spalling shields that greatly reduced the fragmentation effect. Rockets were often penetrating the walls and concrete floor and exploding deep underground, sometimes without any damage to the target aircraft. Changing the fuze delay was useless because HABs have varying wall thickness, and depending on which part of the bunker was hit, various fuze delays would be needed.

Before S-13 trials were even completed, Novosibirsk Institute of Applied Physics started working on an enhanced concrete-piercing variant (the S-13T) with two warheads positioned in tandem, and each warhead having its own fuze. Once the rocket hit the target, both fuzes detonated. Hence, each warhead was a back-up of the other one. If the first one detonated under the floor, the second detonated within the bunker. And if the first warhead detonated within the bunker, the second one detonated outside. The ideal outcome would be when both detonated above the floor.

In 1984, the Soviet Air Force Research Institute conducted field tests of the S-13T aboard an Su-17M4 fighter - bomber. Lieutenant colonel A. Shestuk was lead engineer and lieutenant colonel A. Borodai was lead test pilot. 31 flights were made with a total of 99 S-13T rockets fired. 31 rockets penetrated bunkers (1 m thick concrete and 2-6 m thick soil cover) and exploded inside and above the floor.

The new rocket was also tested against runways. The S-13T did not ricochet and was destroying 15-17.2 sq. meters of reinforced concrete 0.25 m thick. Launched in a salvo, rocket impact deviation did not exceed 10 m. It was also guaranteed to perform properly after up to twenty takeoffs and landings of the aircraft.

Considering the caliber of this new rocket, designers soon decided to develop a new blast-fragmentation variant, designated S-13OF (HE). This version was to be used against lightly-armored vehicles. It was to be more efficient than the S-8, and built out of highly standardized modules.

### **S-13OF Reference**

Caliber, mm:	122
Length, mm:	2,898
Weight, kg:	69
Warhead weight, kg:	33
Warhead charge weight, kg:	7
Maximum range, m:	1,600-3,000
Maximum speed, m/s:	530



## Air-to-Air Missiles

For combat against airborne targets, the Ka-50 can carry Strelets launcher modules fitted with "Igla" infrared homing air-to-air missiles, for up to two missiles per module mounted on the aircraft's extension hardpoints.

### 9S846 "Strelets"

The 9S846 Strelets is a set of control equipment and launch modules designed to facilitate automated remote single launch of Igla-type missiles from various ground, air, and sea-based platforms.

The Strelets system is comprised of the following components:

- A universal launch module that facilitates the preparation and launch of up to two missiles;
- Control and communication equipment linked to the carrier platform's fire control system;
- A set of connectors to provide mechanical and electrical connection between the launch system and the carrier platform;
- Test equipment for periodic monitoring of the launch system's electric parameters.

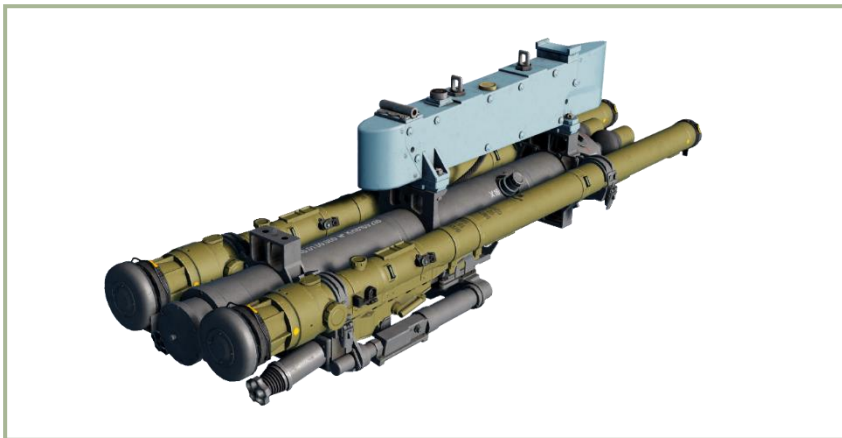


**3-13: Control and Launch Module, 9S846 "Strelets"**

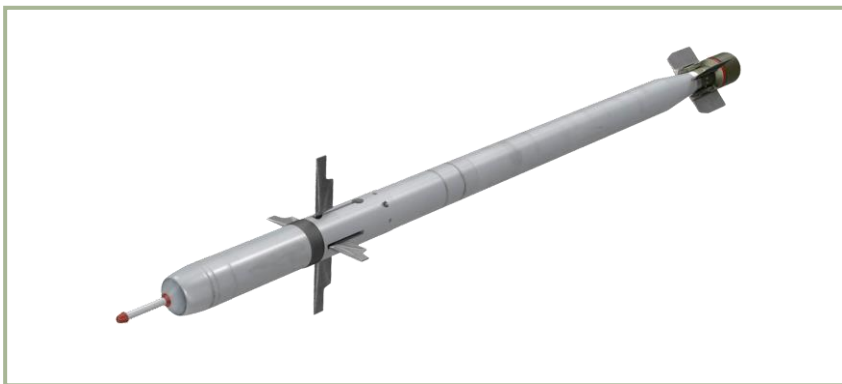
The 9M342 "Igla" infrared guided missile is a short-range light air-to-air missile that was based off of the 9K338 "Igla" MANPADS (NATO classification – SA-18 Grouse). This

variant is a modification designed for use with launch platforms such as helicopters and ground-based air defense vehicles.

The missile is designed to destroy subsonic airborne targets. Developed by the Kolomna-based NPK "KB Mashinostroeniya", one of Russia's leading R&D centers for the production of military technology. The missile has folding wings and fins, and weighs 11.3 kg, with the warhead proper weighing 1.25kg. The missile's flight speed can reach up to 570-600 meters per second and has an effective range of 6 kilometers. The "Igla" has high G-load and average resistance to aircraft countermeasures.



**3-14: 9S846 Strelets launcher with two "Igla" missiles**



**3-15: 9M342 Igla missile**

## 9M342 "Igla" Specification

<b>Launch distance, km:</b>	
Effective altitude, m	10-3500
Effective range, m	500-6000
Target velocity, m/s	
- Head-on	Up to 400
- Pursuit	Up to 320
<b>Warhead</b>	
Type	High-explosive
Weight, kg	1.25
Fuse type	Impact and proximity
<b>9M342 "Igla"</b>	
Main propulsion system	Solid propellant
Length, mm	1690
Maximum diameter, mm	72.2
In-flight maneuvering	Aerodynamic surfaces
Initial weight, kg	11.3
Deployed weight, kg	19
Arming time, s	55
Guidance type	Optical, dual-spectrum, servo
Control system	Single-channel
Operating temperature, C°	-50 ~ +50
<b>9S846 "Strelets"</b>	
Ammunition count, rockets	2
Ammunition per module	2
Firing mode	Single
Empty weight, kg	41
Control equipment weight, kg	4.5

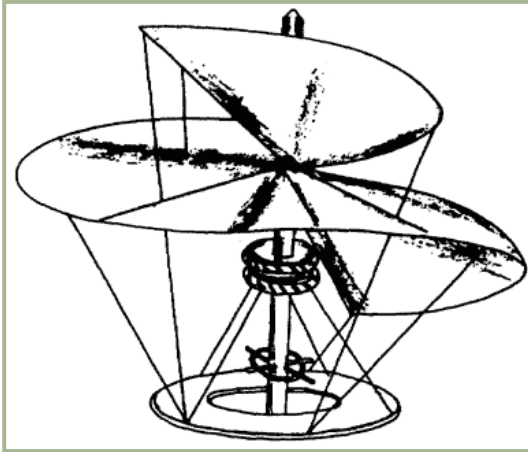


**4**

# HELICOPTER FUNDAMENTALS

## 4 HELICOPTER FUNDAMENTALS

If developing vertical flight had been as simple as the idea itself, the helicopter would have undoubtedly been the first practical aircraft. In its earliest form, the helicopter was conceived by Leonardo da Vinci in the early 1500's. In his notes, da Vinci used the Greek word "helix", meaning a spiral, and combined this word with the Greek word "pteron", meaning wing. It is from this combination of Greek words that our word helicopter is derived.



**4-1: Da Vinci Sketch of the Helixpteron**

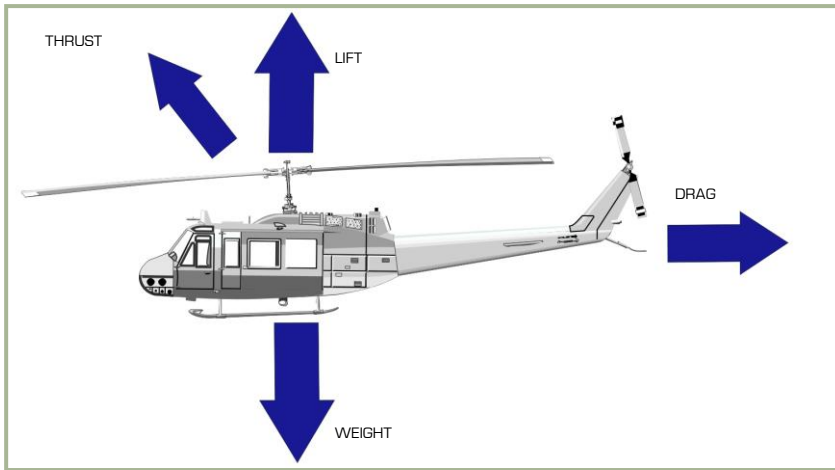
Development proved too difficult and complicated for the early experimenters because they did not have an engine of sufficient power to ensure flight. When larger, lighter, and more reliable engines were developed hundreds of years later, the dream of a helicopter became a reality.

The same laws of force and motion that apply to fixed wing aircraft also apply to the helicopters. Controls for the helicopter are complex; torque, gyroscopic precession, and dissymmetry of lift must be dealt with. Retreating blade stall also limits the helicopter's forward airspeed.

This chapter provides a basic explanation of helicopter controls, velocity, torque, gyroscopic precession, dissymmetry of lift, retreating blade stall, settling with power, pendular action, hovering, ground effect, translational lift, and autorotation.

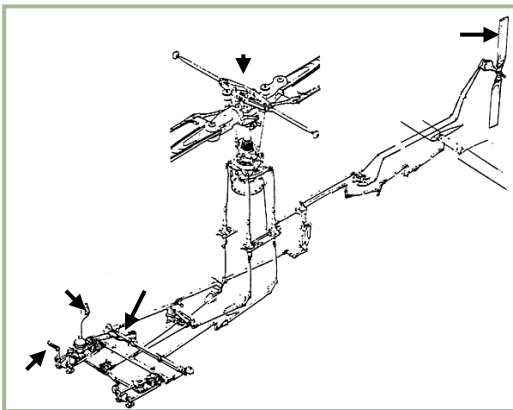
### The Four Forces That Act On a Helicopter

Weight and drag act on a helicopter as they do on any aircraft; however, lift and thrust for a helicopter are obtained from the main rotor. In a very basic sense, the helicopter's main rotor does what wings and a propeller do for a fixed-wing aircraft. Moreover, by tilting the main rotor, the pilot can make the helicopter fly to either side, forward, or backwards.



**4-2: Forces Acting on a Helicopter**

## Controls



**4-3: Helicopter Controls**

The sketch in **figure 4-3** shows the main rotor, cyclic and collectives, anti-torque pedals, and anti-torque rotor. Basically, the cyclic control is a mechanical linkage used to change the pitch of the main rotor blades. Pitch change is accomplished at a specific point in the plane of rotation to tilt the main rotor disc. Most current military helicopters now have hydraulic assistance in addition to the mechanical linkages. The collective changes the pitch of all the main rotor blades equally and simultaneously. The anti-torque pedals are used to adjust the pitch in the anti-torque rotor blades to compensate for main rotor torque.



## Velocity

A helicopter's main rotor blades must move through the air at a relatively high speed in order to produce enough lift to raise the helicopter and keep it in the air. When the main rotor reaches required takeoff speed and generates a great deal of torque, the anti-torque rotor can negate fuselage rotation.

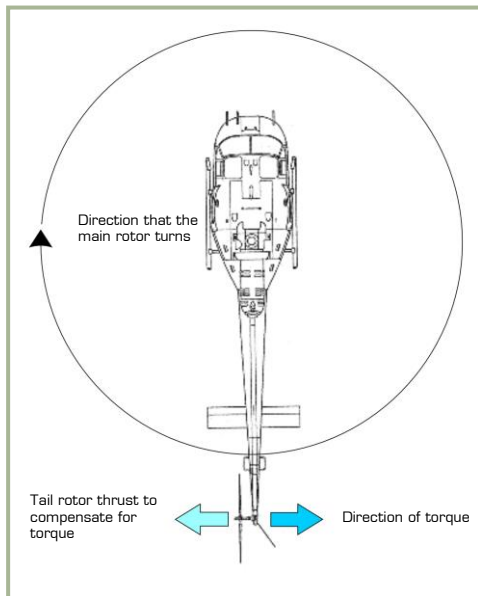
The helicopter can fly forward, backward, and sideways according to pilot control inputs. It can also remain stationary in the air (hover) with the main rotor blades developing enough lift to hover the helicopter.

## Torque

The torque problem is related to a helicopter's single-main-rotor design. The reason for this is that the helicopter's main rotor turns in one direction while the fuselage wants to turn in the opposite direction. This effect is based on Newton's third law that states "To every action there is an opposite and equal reaction." The torque problem on single-rotor helicopters is counteracted and controlled by an anti-torque (tail) rotor.

On coaxial helicopters, the main rotors turn in opposite directions and thereby eliminate the torque effect.

## Anti-torque Rotor



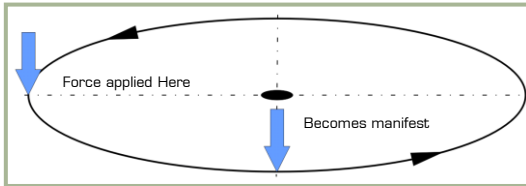
**Figure 4-4** shows the direction of travel of the main rotor, the direction of torque of the fuselage, and the location of the anti-torque (tail) rotor.

An anti-torque rotor located on the end of a tail boom provides torque compensation for single-main-rotor helicopters. The tail rotor, driven by the engine at a constant speed, produces thrust in a horizontal plane opposite to the torque reaction developed by the main rotor.

**4-4: Tail Rotor Thrust to Compensate for Torque**

## Gyroscopic Precession

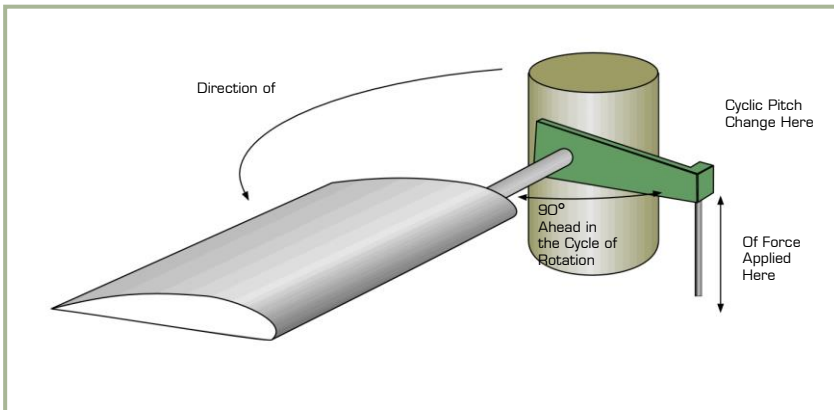
The result of applying force against a rotating body occurs at  $90^\circ$  in the direction of rotation from where the force is applied. This effect is called gyroscopic precession and it is illustrated in **figure 4-5**. For example: if a downward force is applied at the 9 o'clock position in the diagram, then the result appears at the 6 o'clock position as shown. This will result in the 12 o'clock position tilting up an equal amount in the opposite direction.



**4-5: Gyroscopic Precession**

direction of rotation from the main rotor blade.

**Figure 4-6** illustrates the offset control linkage needed to tilt the main rotor disc in the direction the pilot inputs with the cyclic. If such a linkage were not used, the pilot would have to move the cyclic  $90^\circ$  to the right of the desired direction. The offset control linkage is attached to a lever extending  $90^\circ$  in the



**4-6: Offset Control Linkage**

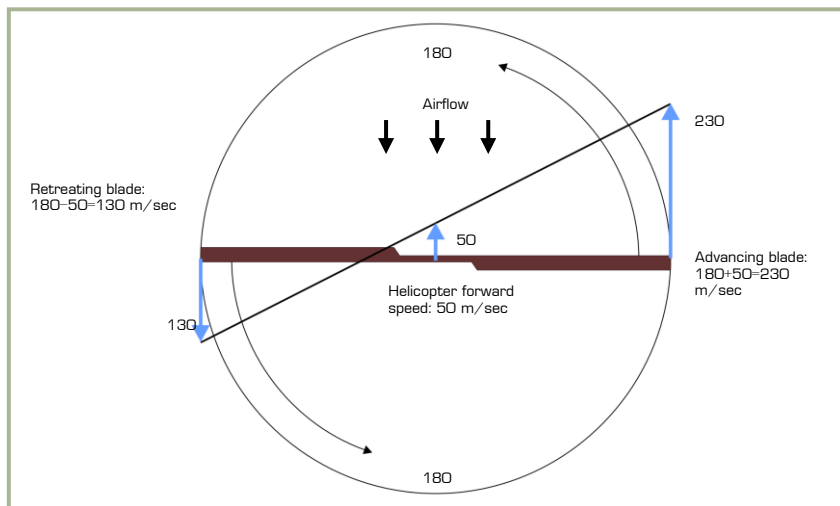
## Dissymmetry of Lift

The area within the circle made by the rotating blade tips of a helicopter is known as the disc area or rotor disc. When hovering in still air, lift generated by the rotor blades is equal within all parts of the disc. Dissymmetry of lift is the difference in lift that exists between the advancing half of the disc and the retreating half; this is created by horizontal flight and/or wind.

When a helicopter is hovering in still air, the tip speed of the advancing blade is approximately 600 feet per second and the tip speed of the retreating blade is the same.

Dissymmetry of lift is created by the movement of the helicopter in forward flight. The advancing blade has the combination of blade speed velocity and that of the helicopter's forward airspeed. The retreating blade however loses speed in proportion to the forward speed of the helicopter.

**Figure 4-7** illustrates dissymmetry of lift and shows the arithmetic involved in calculating the differences between the velocities of the advancing and retreating blades. In the figure, the helicopter is moving forward at a speed of 50 m/sec, the velocity of the rotor disc is equal to approximately 180 m/sec, and the advancing blade speed is 230 m/sec. The speed of the retreating blade is 130 m/sec. This speed is obtained by subtracting the speed of the helicopter (50 m/sec) from the tip speed of 180 m/sec. As can be seen from the difference between the advancing and retreating blade velocities, a large speed and lift variation exists.



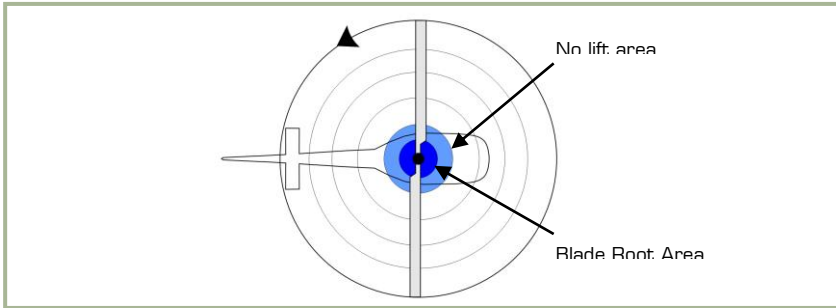
#### 4-7: Dissymmetry of Lift. $(\text{ROTATIONAL VELOCITY}) \pm (\text{HEL FORWARD SPEED}) = (\text{AIRSPEED OF BLADE})$ .

Cyclic pitch control, a design feature that permits changes in the angle of attack during each revolution of the rotor, compensates for the dissymmetry of lift. As the forward speed of the helicopter is increased, the pilot must apply more and more cyclic to hold a given rotor disc attitude. The mechanical addition of more pitch to the retreating blade and less to the advancing blade is continued throughout the helicopter's range.

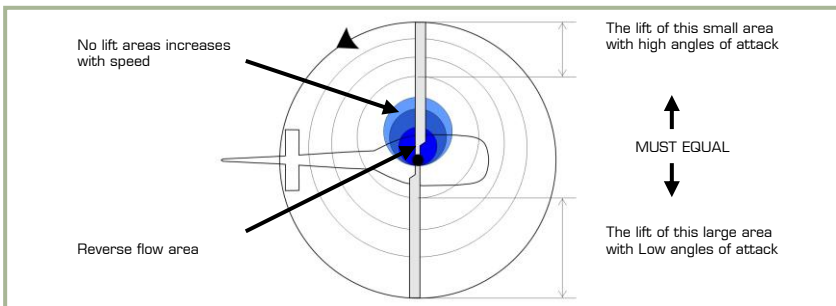
## Retreating Blade Stall

**Figure 4-8** illustrates the tendency of a helicopter's retreating blades to stall in forward flight. This is a major factor in limiting a helicopter's maximum forward airspeed. Just as the stall of a fixed wing aircraft wing limits the low-airspeed flight envelope, the stall of a rotor blade limits the high-speed potential of a helicopter. The airspeed of a retreating blade slows down as forward airspeed is increased. The retreating blade must produce an

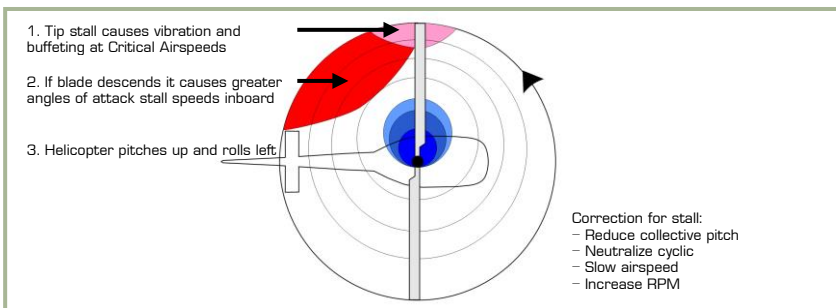
amount of lift equal to that of the advancing blade, as shown in **figure 4-9**. As the airspeed of the retreating blade is decreased with forward airspeed, the blade angle of attack must be increased to equalize lift throughout the rotor disc area. As this angle of attack is increased, the blade will eventually stall at some high, forward airspeed as shown in **figure 4-10**.



**4-8: Hovering Lift Pattern**



**4-9: Normal Cruise Lift Pattern**



**4-10: Lift Pattern at Critical Airspeed**

Upon entry into a retreating blade stall, the first noticeable effect is vibration of the

helicopter. This vibration is followed by the helicopter's nose lifting with a rolling tendency. If the cyclic is held forward and the collective is not reduced, the stall will become aggravated and the vibration will increase greatly. Soon thereafter, the helicopter may become uncontrollable.

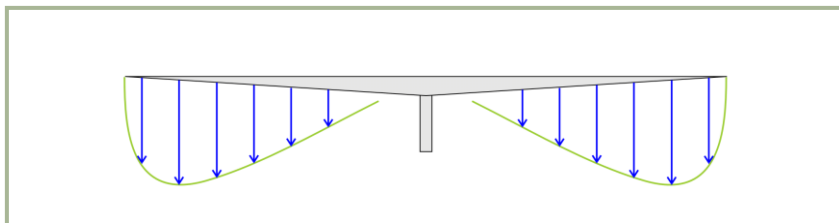
## Settling With Power (Vortex Ring State)

Settling with power is a condition of powered flight when the helicopter settles into its own main rotor downwash; this is also known as Vortex Ring State.

Conditions conducive to settling with power include a vertical, or nearly vertical, descent of at least 300 feet per minute with low forward airspeed. The rotor system must also be using some of the available engine power (from 20 to 100%) with insufficient power available to retard the sink rate. These conditions occur during approaches with a tailwind or during formation approaches when some aircraft are flying in the downwash of other aircraft.

Under the conditions described above, the helicopter may descend at a high rate that exceeds the normal downward induced flow rate of the inner blade sections. As a result, the airflow of the inner blade sections is upward relative to the disk. This produces a secondary vortex ring in addition to the normal tip vortex. The secondary vortex ring is generated at about the point on the blade where airflow changes from up to down. The result is an unsteady turbulent flow over a large area of the disk that causes loss of rotor efficiency, even though power is still applied.

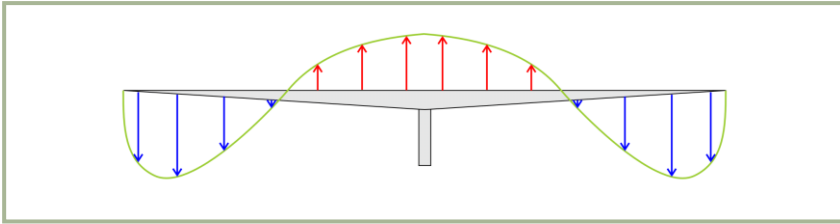
This graphic shows induced flow along the blade span during normal hovering flight:



**4-11: Induced Flow Velocity During Hovering Flight**

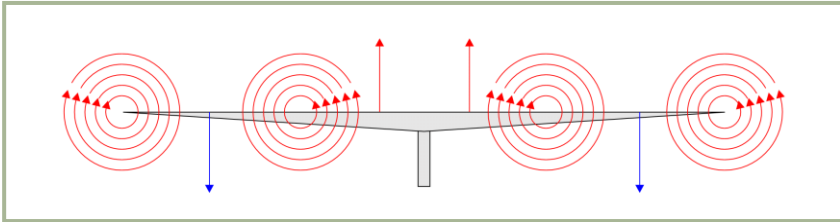
The downward velocity is highest at the blade tip where blade airspeed is highest. As blade airspeed decreases towards the center of the disk, downward velocity is less.

**Figure 4-12** shows the induced airflow velocity pattern along the blade span during a descent conducive to settling with power:



#### 4-12: Induced Flow Velocity During Vortex Ring State

The descent is so rapid that induced flow at the inner portion of the blades is upward rather than downward. The upward flow caused by the descent can overcome the downward flow produced by blade rotation. If the helicopter descends under these conditions, with insufficient power to slow or stop the descent, it will enter a vortex ring state:



#### 4-13: Vortex Ring State

During a vortex ring state, roughness and loss of control is experienced because of the turbulent rotational flow on the blades and the unsteady shifting of the flow along the blade span.

Power settling is an unstable condition, and if allowed to continue, the sink rate will reach sufficient proportions for the flow to be entirely up through the rotors. This can result in very high descent rates. Recovery may be initiated during the early stages of power settling by putting on a large amount of excess power. During the early stages of power settling, the large amount of excess power may be sufficient to overcome the upward flow near the center of the rotor disc. If the sink rate reaches a higher rate, power will not be available to break this upward flow and thus alter the vortex ring state of flow.

Normal tendency is for pilots to recover from a descent by application of collective pitch and power. If insufficient power is available for recovery, this action may aggravate power settling and result in more turbulence and a higher rate of descent. Recovery can be accomplished by lowering collective pitch and increasing forward speed (pushing the cyclic forward). Both of these methods of recovery require sufficient altitude to be successful.



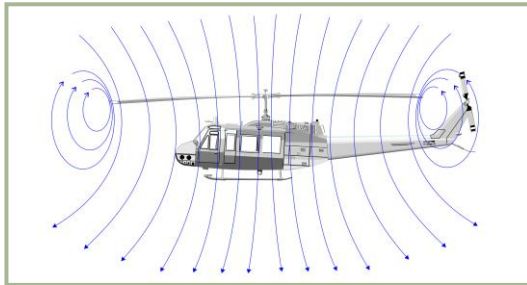
## Hovering

A helicopter hovers when it maintains a constant position over a point on the ground, usually a few feet above the ground. To hover, a helicopter's main rotor must supply lift equal to the total weight of the helicopter, including crew, fuel, and if applicable, passengers, cargo, and armaments. The necessary lift is generated by rotating the blades at high velocity and increasing the blade angle of attack.

When hovering, the rotor system requires a large volume of air upon which to work. This air must be pulled from the surrounding air mass; this is an expensive maneuver that takes a great deal of engine horsepower. The air delivered through the rotating blades is pulled from above at a relatively high velocity, forcing the rotor system to work in a descending column of air.

The main rotor vortex, and the recirculation of turbulent air, add resistance to the helicopter while hovering. Such an undesirable air supply requires higher blade angles of attack and an expenditure of more engine power and fuel. Additionally, the main rotor is often operating in air filled with abrasive materials that cause heavy wear on helicopter parts while hovering in the ground effect.

## Ground Effect

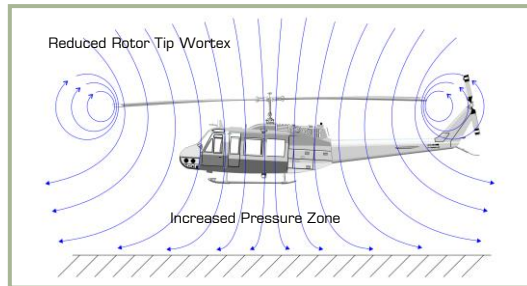


**4-14: Airflow When Out of Ground Effect**

Ground effect is a condition of improved performance found when hovering near the ground. The best height is approximately one-half the main rotor diameter. **Figure 4-14** illustrates air flow in and out of ground effect.

The improved lift and airfoil efficiency while operating in ground effect is due to the following effects:

First, and most importantly, the main rotor-tip vortex is reduced. When operating in the ground effect, the downward and outward airflow reduces the vortex. A vortex is an air flow rotating around an axis or center.



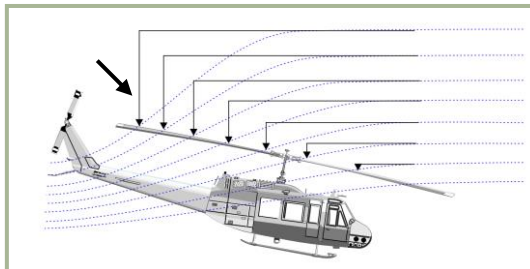
**4-15: Airflow When In Ground Effect**

This makes the outward portion of the main rotor blade more efficient. Reducing the vortex also reduces the turbulence caused by recirculation of the vortex.

Second, the air flow angle is reduced as it leaves the airfoil. When the airfoil angle is reduced, the resultant lift is rotated slightly forward; this makes the angle more vertical. Reduction of induced drag permits lower angles of attack for the same amount of lift and it reduces the power required to rotate the blades.

## Translational Lift

The efficiency of the hovering rotor system is improved by each knot of incoming wind gained by forward motion of the helicopter or by a surface headwind. As the helicopter moves forward, fresh air enters in an amount sufficient to relieve the hovering air-supply problem and improve performance. At approximately 40 km/h, the rotor system receives enough free, undisturbed air to eliminate the air supply problem. At this time, lift noticeably improves. This distinct change is referred to as translational lift. At the instant of translational lift, and as the hovering air supply pattern is broken, dissymmetry of lift is created. As airspeed increases, translational lift continues to improve up to the speed that is used for best climb.



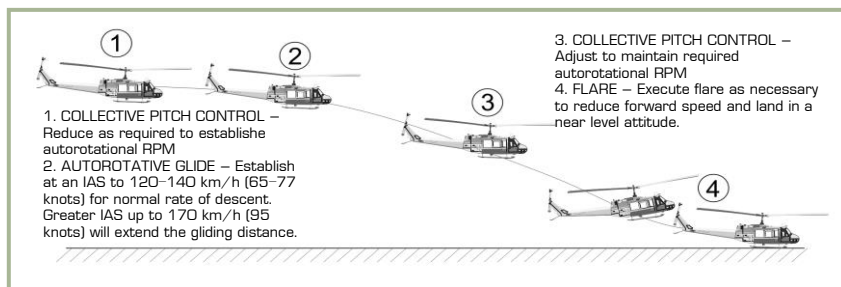
**4-16: Translational lift**

In forward flight, air passing through the rear portion of the rotor disc has a higher downwash velocity than the air passing through the forward portion. This is known as

transverse flow effect and is illustrated in **figure 4-16**. This effect, in combination with gyroscopic precession, causes the rotor to tilt sideward and results in vibration that is most noticeable on entry into effective translation.

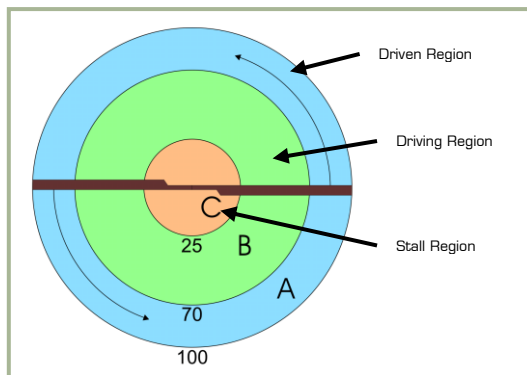
## Autorotation

If engine power fails, or other emergencies occur, autorotation is a means of safely landing a helicopter. The transmission in a helicopter is designed to allow the main rotor to turn freely in its original direction when the engine stops. **Figure 4-17** illustrates how the helicopter is allowed to glide to earth and by using the main rotor rpm, make a soft landing.



**4-17: Approach to Landing, Power Off**

The rotor blade autorotative driving region is the portion of the blade between 25 to 70 percent radius, as shown in **figure 4-18**, blade element B. Because this region operates at a comparatively high angle of attack, the result is a slight but important forward inclination of aerodynamic forces. This inclination supplies thrust slightly ahead of the rotating axis and tends to speed up this portion of the blade during autorotation.

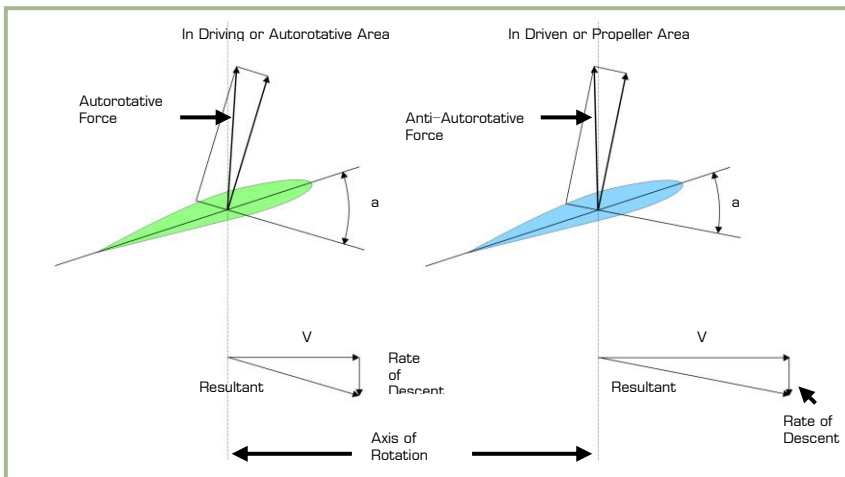


**4-18: The Rotor Blade Autorotative Regions**

The blade area outboard of the 70 percent circle is known as the propeller or driven region. Analysis of blade element A: the aerodynamic force inclines slightly behind the rotating axis. This inclination causes a small drag force that tends to slow the tip portion of the blade. Rotor rpm stabilizes, or achieves equilibrium, when autorotative force and antiautorotative force are equal.

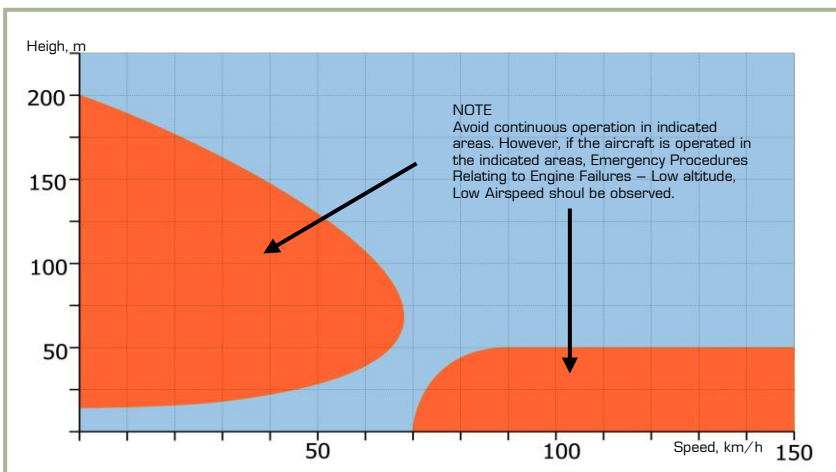
The blade area inboard of the 25% circle is known as the stall region because it

operates above its maximum angle of attack. This region contributes considerable drag that tends to slow the blade.



**4-19: Autorotation Blade Forces**

All helicopters carry an operator's manual that has an air speed versus altitude chart similar to the one shown in **figure 4-20**. The shaded areas on this chart must be avoided. This area is referred to as the "dead man's curve" and "avoid curve". The proper maneuvers for a safe landing during engine failure cannot be accomplished in these areas.



**4-20: Height-Velocity Diagram**

## Summary

Weight, lift, thrust, and drag are the four forces acting on a helicopter. The cyclic for directional control, the collective pitch for altitude control, and the anti-torque pedals to compensate for main rotor torque are the three main controls used in a helicopter.

Torque is an inherent problem with single-main-rotor helicopters. Gyroscopic precession occurs at approximately 90° in the direction of rotation from the point where the force is applied. Dissymmetry of lift is the difference in lift that exists between the advancing and retreating halves of the rotor disc.

Settling with power can occur when the main rotor system is using from 20 to 100 percent of the available engine power, and the horizontal velocity is under 10 knots. At a hover, the rotor system requires a great volume of air upon which to generate lift. This air must be pulled from the surrounding air mass. This is a costly maneuver that takes a great amount of engine power.

Ground effect provides improved performance when hovering near the ground at a height of no more than approximately one-half the main rotor diameter. Translational lift is achieved at approximately 18 knots, and the rotor system receives enough free, undisturbed air to improve performance. At the instant translational lift is in effect and the hovering air-supply pattern is broken, dissymmetry of lift is created. Autorotation is a means of safely landing a helicopter after engine failure or other emergencies. A helicopter transmission is designed to allow the main rotor to turn freely in its original direction if the engine fails.



**5**

**AERODYNAMIC FEATURES  
HELICOPTERS COAXIAL**



## 5 AERODYNAMIC FEATURES OF COAXIAL CONFIGURATION HELICOPTERS

Nowadays, the world helicopter industry employs two main rotor configurations: single-rotor and coaxial-rotor. Most helicopters feature the single-rotor configuration.

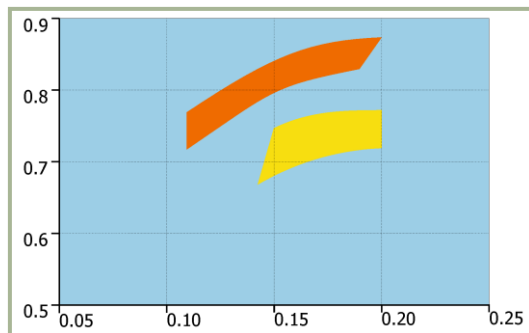
The pioneers of helicopter-development were fully aware of the fundamental advantages presented by the coaxial configuration; in fact, several projects and attempts to build coaxial helicopters at various times in history are well known. However, it was only single-rotor helicopters with a tail rotor that western designers put into extensive service. Single-rotor helicopters were developed and widely used in the Soviet Union and Russia, too. In developing the national helicopter industry, considerable funds and effort were employed to further the development of the single-rotor configuration; however, these efforts failed to resolve certain fundamental flaws inherent to this configuration.

Due to their smaller dimensions, high thrust-to-weight ratio, superb maneuverability and aerodynamic symmetry, coaxial helicopters were widely used as ship-borne helicopters operated by the Soviet Navy. Civil aviation began extensive use of the coaxial Ka-26 and Ka-32 helicopters.

Between the late 1970s and early 1980s, all necessary prerequisites were developed for the development of a combat coaxial-rotor helicopter; this was later designated the Ka-50. The stiff and fair competition between the Ka-50 (coaxial-rotor) and Mil Mi-28 (single-rotor), resulted in an impressive victory by the Ka-50, and it went into production for the Russian Army.

### The Principles of the Reactive Moment Compensation

The coaxial configuration is special because it embodies a principle of reactive moment compensation that is fundamentally different from that of the single-rotor configuration.



**5-1: Coaxial rotors and single rotor aerodynamic quality in the hover**

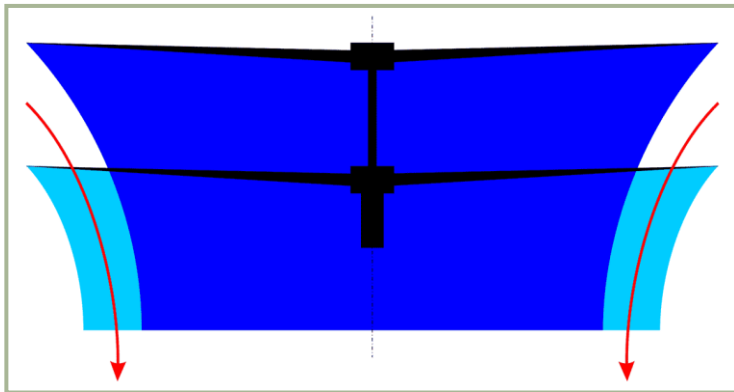
To compensate for the reactive moment of the single-rotor helicopter's main rotor, an anti-torque tail rotor is necessary. However, reactive moments of a coaxial-rotor are compensated for by the counter-rotational forces canceling out each other. This removes the need for any additional forces like a tail rotor. The coaxial-rotors' reactive moments are compensated automatically throughout the flight, thus requiring little input compensation by the pilot.

A peculiarity of a coaxial-rotor with zero reactive moment in balanced flight is that the pilot's pedal inputs create a disparity between the upper and lower reactive moments of the engines. This resulting summary reactive moment can then be used for yaw directional control.

The reactive moment compensation method employed in a single-rotor helicopter requires the pilot's constant attention. To achieve balanced flight, the pilot needs to adjust the tail rotor's side forces; this puts the helicopter to a certain disadvantage compared to a coaxial design.

## Power Efficiency

As far as power is concerned, the coaxial design has a considerable edge over its single-rotor counterpart because all available power is transferred to the rotor drive, i.e. used for developing lift. The single-rotor design however must share power between the main rotor and the tail rotor; the tail rotor can consume 10-12% of the total power.



**5-2: Diagram of air stream through coaxial rotors**

Another important feature of the coaxial configuration is illustrated when the helicopter is hovering. The upper rotor airflow grows narrower at 15-20% to the lower rotor and this allows the lower rotor to suck in additional air. This in turn increases the total rotor airflow and reduces the power used for developing the lift.

The counter-rotation of coaxial rotors leads to a significant reduction in power that is required to hover the helicopter. Flight testing as well as other experimental data shows the coaxial-rotors to be 6-10% more efficient as compared to the single-rotor helicopter.

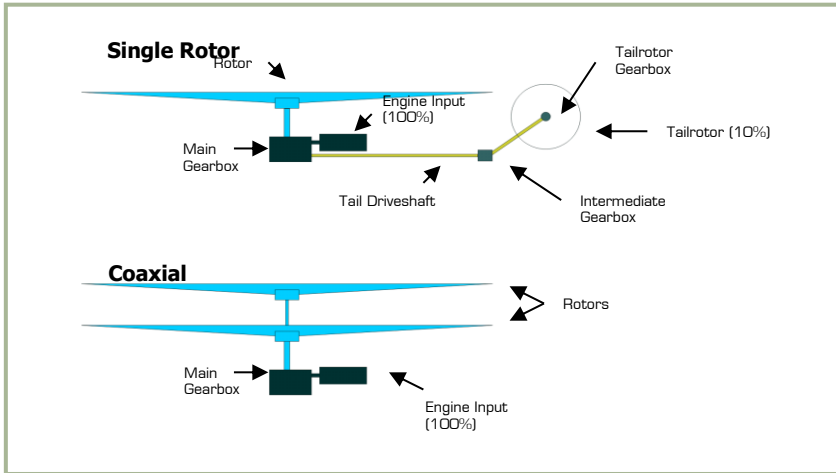
Given that coaxial-rotor helicopters do not have to use power to compensate the reactive moment, coaxial helicopters are generally 16-22% more effective than single-rotor helicopters. This additional power provides an impressive hover ceiling (500-1,000 m) and vertical rate of climb (by 4-5 m/sec).

Despite the apparent fact that a coaxial system rotor mast would create greater drag than a single-rotor system mast, flight testing of coaxial-rotor and single-rotor helicopters of the same type displayed no obvious increase in drag. This is due to the following reasons:

- The beneficial and mutual effect of coaxial rotors in forward flight. This is similar to the biplane effect and it provides a substantial reduction in power that is needed to create lift
- The lack of the tail rotor and need for powering it
- The lack of tail rotor drag and the interference of the tail rotor and the tail boom
- The inefficiency of single-rotor helicopters having to fly with the forced slip at zero banking
- Measures taken when designing coaxial-rotor helicopter like the Ka-50 to reduce drag (i.e. by retracting the landing gear in flight)

## Dimensions

The coaxial configuration allows a helicopter to be smaller and lighter than the single-rotor one; this can provide an important tactical advantage.



### 5-3: Coaxial and single rotor helicopters drive train

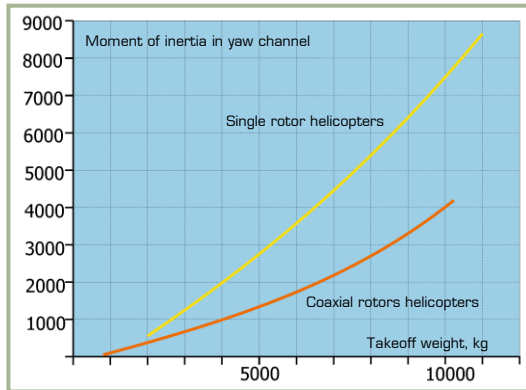
To appreciate the changes in dimension and weight between single-rotor and coaxial-rotor helicopters, it can best be illustrated in the following cases:

- Coaxial-rotor and single-rotor helicopters have the same airborne weight and available power developed by their engines (Ka-50 and Mi-28)
- Coaxial-rotor and single-rotor helicopters have the rotor blades of the same diameter (Ka-50 and AH-64).

In example a, the coaxial configuration results in reducing the coaxial-rotor helicopter size by 35-40% as compared with the single-rotor one.

This is mainly due to the reduction in the rotor's diameter due to greater lifting power in hover, lack of power loss due to the absence of a tail rotor, and the requirement to mount the single-rotor helicopter's tail rotor at the rear of the airframe to avoid the main rotor blade sweep disc.

Example b features reduced aerodynamic efficiency and additional power loss to drive the tail rotor of a single-rotor helicopter, and it has a reduced available flight weight. In this example, the presence of the tail rotor leads to the helicopter's dimension being 20% larger than that of the coaxial one.



**5-4: Coaxial-rotor and single-rotor helicopters' moment of inertia**

The coaxial-rotor helicopter's reduction in size and different weight distribution along the airframe results in a considerable reduction in longitudinal and directional moments of inertia. This is vital for providing the required controllability when flying a helicopter.

## Controllability and Stability

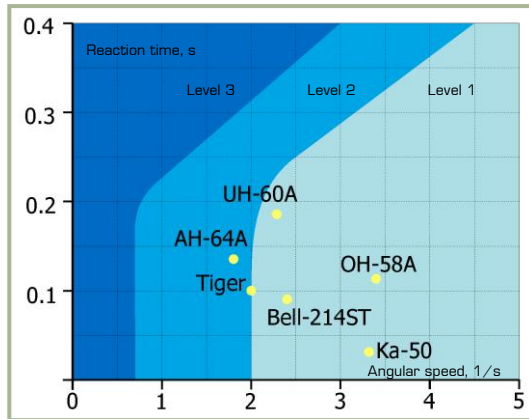
Aerodynamic symmetry is the most important feature of a coaxial helicopter; it enhances controllability and stability substantially.

With advances in helicopter design and manufacture, designers have repeatedly turned to symmetric aerodynamic configurations. They clearly understand the importance of aerodynamic symmetry for achieving ease of control when flying a helicopter.

Fixed-wing aircraft development is a good example of this; only symmetric fixed wing aircraft are built, with the exception of a few non-commercial examples. It is hard to imagine an aircraft with two engines set at various points of their respective wings and developing different thrust whose disparity would change depending on the flight mode.

Helicopter developers however have to design with asymmetry in regards to a single-rotor configuration – an unavoidable evil that is balanced with the perceived simplicity of this technological solution. At the same time, developing an efficient tail rotor and its transmission proved to be a tall order.

Aerodynamic symmetry of the coaxial configuration is provided by the lack of reactive moment on the airframe and the relatively close upper and lower rotors and their beneficial mutual effect. This results in little thrust difference when balanced. Balance is provided by the rotors' side forces directed in different directions as they balance each other with their lateral movement. This emerges due to their separation being insignificant.



**5-5: Helicopter controllability levels (hover and low-speed flight / banking)**

Thanks to the lack of the tail rotor, the coaxial-rotor helicopter is not subject to the constant effect of the alternate side force. The coaxial design ensures a smooth combination of efficient control and aerodynamic damping, which provides good controllability.

For example, the Ka-50's lateral controllability characteristics have been evaluated under the ADS-33C standard (Manual Control Requirements to Military Helicopters) of the U.S. Army Aviation Department. **Figure 5-5** shows the results of the evaluation for hovering and low-speed flying. It is apparent that the Ka-50 controllability characteristics match Level 1 (excellent controllability) of the ADS-33C standard with the Ka-50 having significant edge in lag value and frequency compared to the other helicopters in the study.

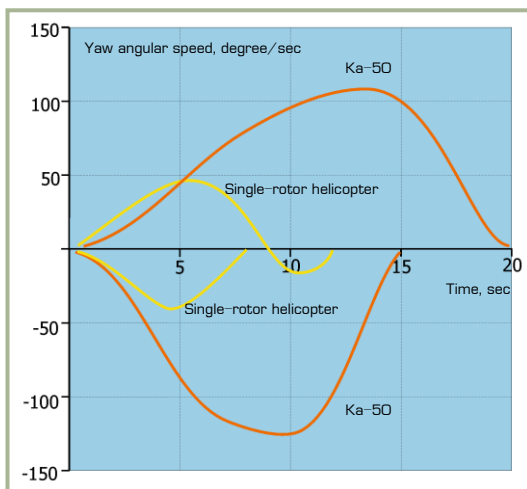
Owing to aerodynamic symmetry, a coaxial-rotor helicopter has literally no correlation between longitudinal and lateral movement. For example: in a single rotor helicopter, changing collective results in changing directional trim by the tail rotor; this affect is absent with a coaxial system. However, it has independent control and is easy to master by any pilot irrespective of their flying skills. The lack of flight mode variables and yaw movement and side forces on the airframe, combined with the lack of a relation between the power changes (collective pitch) and directional and lateral control, improves a coaxial helicopter's stability and controllability. Due to this, flight safety is enhanced and flying in extreme conditions is easier. This is especially true regarding low-altitude flying, small landing pads, broken terrain, high barometric altitudes, and system failures. Controlling a coaxial-rotor helicopter is as simple as flying a docile training aircraft. At the same time, stability, controllability and maneuverability are equal to, if not better, than single-rotor helicopters.

## Maneuverability

The fast-changing environment of modern combat and the need to gain tactical advantage places the necessity for expanded speeds and modes suitable for 'flat' maneuvers, (i.e. a maneuvers intended to change the direction of flight without the use of regular g-loading) as a top priority for a combat helicopter.

The unrestricted efficiency that a coaxial helicopter can perform flat maneuvers is rooted in its design. The coaxial configuration concentrates all important functions in the coaxial rotor: development of lift, propulsive force, longitudinal and directional control, and collective pitch control.

The unique design of a coaxial-rotor system and its inherent availability of rotor directional control, by means of the lack in force moments, provide coaxial-rotor helicopters another important feature - the control system becomes nearly independent of the angle of sideslip. It is this and the lack of the tail rotor that provides limitless opportunities to perform flat maneuvers at high angles of sideslip.



### 5-6: Yaw angular speed in the hover

A coaxial-rotor helicopter's empennages place no restrictions on the angle of sideslip because it is designed to handle changing sideslip angles of 180 degrees.

A radical, new maneuver, termed a 'flat turn', has been tested with the Ka-50 and has been cleared for operational use. At a speed of up to 90-100 km/h, this maneuver can be performed to 180 degrees to both left and right within the horizontal plane with banking being close to zero.

The flat turn is purely a combat maneuver that can be used to direct fixed weapons towards a target in the shortest time. This makes a traversing ring mount for a gun unnecessary and it gains valuable time when turning at high angles. The lack of a tail



rotor enables a coaxial helicopter to use all the advantages of its directional control and develop high yawing rates with no restrictions while maneuvering. Though single-rotor helicopters boast a greater directional control movement, that movement cannot be employed at all times; this is especially true for a quick and dramatic control input. This is due to the restrictions on the yaw rate caused by tail rotor and transmission strength considerations, the insufficient strength of the tail boom, and considerations given to maintaining controllability should the tail rotor be caught in the vortex ring. Given this, the lack of a tail rotor allows the helicopter to be controlled in the horizontal plane by quickly pushing the pedals; this can result in a much faster yawing maneuver. This flat turn capability, combined with an impressive hovering capability, can prove to be a significant tactical advantage in winning a duel with another helicopter or bringing weapons to bear against a ground target. Employing the flat maneuver, made possible by a coaxial-rotor, ensures that taking off and landing is easier and safer regardless of wind conditions. When landing on small helicopter pads, or when obstacles are present, this method of taking off and landing provides a significant operational and tactical advantage.

Maneuvering in the horizontal plane in a coaxial-rotor and single-rotor helicopter has some peculiarities. This includes a dramatic loss of airspeed, which in turn influences helicopter maneuverability.

Changing the required vertical g-load is performed by increasing the pitch angle and the rotor's angle of attack; the g-load rate will then depend on the pitch angle and rate, i.e. depending on the longitudinal control system's capabilities - its efficiency and power. The more effective the longitudinal control, the faster the pitch angle change will be. The g-load change with an increasing g-load rate has no time to diminish and this makes the maneuver more efficient. Should the maneuver not be efficient, then speed will drop faster than the g-load increases and this can result in difficulties in achieving the required g-loading.

Coaxial-rotor helicopters feature better effectiveness and longitudinal power control than single-rotor helicopters. This is due to reduced movements of inertia and the greater available control movements inherent to the greater values of the arms of force applied to the hubs of the upper and lower rotors because of their separation. This is confirmed by statistic dependencies of the maximum available acceleration and longitudinal acceleration of the coaxial-rotor and single-rotor helicopters.

Boasting greater control efficiency and power, a coaxial-rotor helicopter enters a dive with better efficiency and greater safety. The point at which the helicopter enters a dive, the cyclic is pushed forward with a resulting drop in vertical g-load, curving of the trajectory, and an increase in the airframe's angular speed. When negating this angular speed by pulling back on the cyclic to enter a steady dive, the rotor blades' flapping motion increases faster than the airframe angular speed changes. If this is accompanied by insufficient change to the angular speed, due to inefficiency of the longitudinal control (like that of single-rotor helicopters), the collision of the tail boom and rotor blades is possible as a result of their conflicting movements. Thus, the efficiency and power of the coaxial helicopter's longitudinal control system ensures more efficient and safe maneuvering accompanied by a reduction in vertical g-loading.

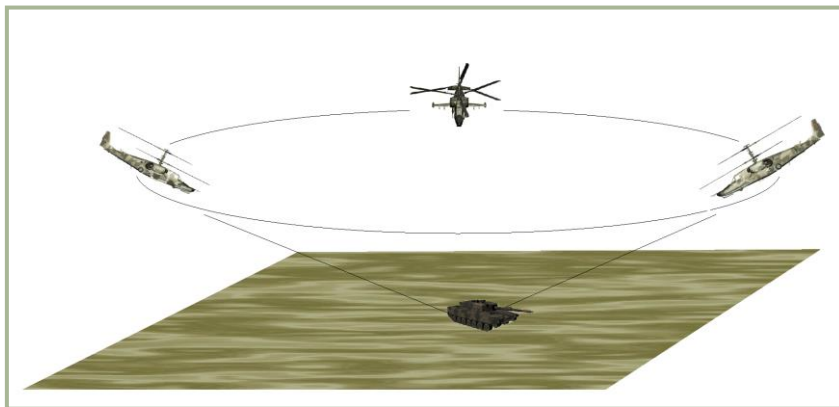
Coaxial helicopters have a substantial advantage in low-speed horizontal maneuvering that enhances both combat efficiency and survivability. These advantages are produced by redundant power due to the lack of a tail rotor and the better efficiency of the coaxial-rotor as compared to a single-rotor at a low speed. Hence, the coaxial-rotor helicopter

has a greater acceleration rate from hover in comparison with its single-rotor counterpart and this will result in a reduced acceleration time to achieve the required speed.

The presence of a tail rotor places stringent limitations on the acceleration from a hover due to the threat of the tail rotor getting caught in the vortex ring. Coaxial-rotor helicopter aerodynamics make it easier for the pilot to fly in any direction in all ranges of operating airspeed from zero to maximum allowed by the control system. Low-speed maneuvering is much safer when flying a coaxial-rotor helicopter.

If the helicopter accelerates backwards and reaches the flight control system maximum speed, the only thing the pilot can do is to push one of the pedals and turn the coaxial helicopter 180 degrees.

When examining horizontal maneuvers, one should note two important maneuvers: the funnel and accelerated turn. The accelerated turn is performed nearly identically by both single-rotor and coaxial-rotor helicopters. Also, a radical new maneuver called the 'funnel' allows the helicopter to keep a ground target engaged for an extended period of time while maintaining a negative pitch angle. However, maintaining a negative pitch angle leads to forward acceleration. This in turns leads to a loss of the target and the subsequent need for multiple passes. This degrades hit probability and increases the helicopter's vulnerability. The funnel maneuver gives a vital advantage in combat and can only be performed by coaxial-rotor helicopter.



#### 5-7: "Funnel" maneuver

The funnel is performed at a speed between 100 and 180 km/h with a negative pitch angle of between 30 and 35 degrees. This maneuver is in fact a sideslip turn in which the pitch and banking angles trade places. When the funnel is performed, the rotor thrust is near-parallel to the horizontal plane and is directed to the center of the notional cone. The forces of inertia are balanced while the helicopter rotates along the near-circular trajectory at a sideslip angle of 90%. Thus, the funnel is based on the ability of the coaxial-rotor to perform an extended sideslip and lateral movement at a high speed.

The accelerated turn is a combat maneuver that is used to quickly alter the direction of flight. It can be effective in attacking ground targets and in aerial combat. The unique

aspect of performing accelerated turns with a coaxial-rotor helicopter is the use of significant side-slipping, which considerably increases the maneuver's efficiency.

This is due to the lack of the restrictions on angular speed of rotation and the ability to perform accelerated turns with deep (60 deg.) sideslip, which increases the efficiency of the turn. The coaxial-rotor helicopter has this capability owing to the lack of a tail rotor.

Coaxial-rotor helicopters have advantages in performing many other types of maneuvers. These advantages become evident when such a helicopter performs maneuvers like making a turn while performing a zoom. Great angular speed and excellent sideslip performance are prerequisites for this though.

To review, coaxial-rotor helicopters can perform aerobatics: 'slant loop', ascending roll, etc. While performing aerobatics, the helicopter can develop pitch angles of up to 90 degrees with banking angle reaching 130-140 degrees.

## Autorotation

Coaxial-rotor helicopters can operate in extreme flight modes that are worth discussing, including their minimum vertical descent rate in autorotation that is 1 sq. m less than single-rotor helicopters with the same loading. This is due to the biplane cell effect of the coaxial-rotor system that reduces the induced loss of power as described earlier. Despite low thrust requirements in autorotation, a single-rotor of a single-rotor helicopter still draws power, thus adding to the increase in the vertical descent rate of single-rotor helicopters.

A coaxial-helicopter can perform a minimum vertical descent with 57.3 kg per sq.m loaded. This is compared to a single-rotor helicopter of the same class with a loading of 43.4 sq.m; this is 8-10% difference. This difference has no impact on landing a coaxial-helicopter due to the following:

- The aerodynamic symmetry of the coaxial configuration, the control simplicity, the lack of cross-coupling (e.g. 'collective pitch - pedals') and the efficient longitudinal control provides the coaxial helicopters an easy autorotation transition
- The autorotation landing speed of a coaxial-rotor helicopter is approximately 15 km/h less than that of single-rotor helicopter; this is due to the lower (by 20-30 m) leveling with a greater (by 10 degrees) pitch angle, which is made possible by powerful longitudinal control and the smaller size of a coaxial-rotor helicopter. Lower landing speeds enhance landing safety, especially when flying over uneven terrain.

The lack of a coaxial-rotor helicopters' directional stability in autorotation has been addressed. Autorotation landing methods have been developed and adopted that employ a rotor rotation frequency that is 3-4% less than normal. This reduces the vertical descent rate substantially (by 2-3 m/sec), enhances directional control efficiency, and improves landing characteristics.

## Vortex Ring Flight

In cooperation with defense industry research institutes and the Ministry of Defense, Kamov took part in extensive flight tests and research dedicated to the study of vortex ring states with coaxial-rotor helicopters. The test results confirm the following:

- The vortex ring's top boundary for both the upper and lower rotors is the same; the right and lower boundaries of the vortex ring (where the characteristics of this mode are minimal) are somewhat more extensive in coaxial-rotor helicopters
- When a coaxial-rotor helicopter enters a vortex ring state, it is best to use available altitude to gain forward airspeed and exit the state. Adding power may only exacerbate the problem. The same is true for the single-rotor helicopters.

## Flight Safety

The human-factor is fundamental for flight safety; however, coaxial-rotor helicopters are easier to fly and boast better controllability and maneuverability than single-rotor systems. They are also more efficient and this helps make them safer in comparison.

A helicopter's dimensions are an important aspect of flight safety. A coaxial-rotor helicopter's smaller size enhances its flight safety regarding the avoidance of obstacles during low altitude flight, which is vital for any combat helicopter. Because a coaxial-rotor helicopter's dimensions match that of the main rotor, there is no chance of its empennage being damaged while flying close to obstacles. However, if an empennage were to be damaged or lost (e.g. during a rough autorotation landing), this would be irrelevant for the flight safety.

Comparing the flight safety of coaxial-rotor to single-rotor helicopters, proponents of single-rotor systems often cite the issue of rotor-blade overlapping with coaxial-rotor helicopters. It should be mentioned that the issue of blade collision with the airframe is relevant to all rotary-wing aircraft. Based on lab tests, experimental research, and flight test data analysis, it has been proved that coaxial-rotor helicopters provide flight safety in all flight modes (including in aerobatics) in regards to rotor-blade minimum distance.

Coaxial-rotor helicopters have no restrictions on pedal deflection, even including a maximum deflection of 180 degrees left or right. The impossibility of using the pedal to their full capacity with typical single-rotor helicopters can cause flight safety concerns to tail rotor operation.

In summary, coaxial-rotor helicopters are generally safer to fly than the single-rotor helicopters.



6

COCKPIT  
CONTROLS



## 6 COCKPIT CONTROLS

### Instrument Panels Overview



**6-1: Ka-50 instrument panels**

The cockpit of the Ka-50 contains several instrument panels that include gauges and indicators that display flight parameters, aircraft system states, engine state, control positions, and system warnings. Owing to the single-pilot operation of the Ka-50 cockpit, all flight and weapon system controls must be accessible to the pilot, whereas they are often divided between two cockpits in a traditional, tandem seat attack helicopter. This has led to a rather crowded cockpit that at first can seem quite intimidating! However, with practice and a study of this manual, the cockpit will soon feel like home.

Many of the controls in the cockpit have pop-up tool tips displayed when the mouse is placed over them. This can be a useful tool when trying to remember the many control functions within the cockpit. These tool tips can be toggled off and on from the options menu.

Using your mouse, you may manipulate many of the controls. This can include:

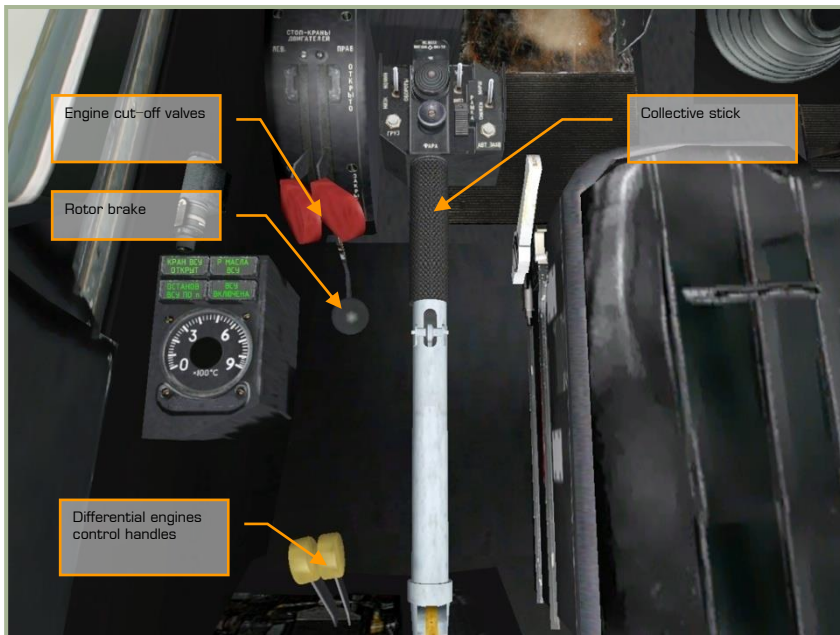
- Left mouse click to toggle a switch
- Left or right mouse click to rotate a rotary dial

- Rotate the mouse wheel to spin a knob
- Left click and drag to spin a knob

When the mouse is placed over a control that can be manipulated, the cursor will turn green and provide you an icon to indicate the type of possible action. All of the mouse click functions also have keyboard press equivalents; these can be reviewed in your keyboard input control list. These keyboard commands are listed in blue within this manual.

Let's do a walk-around of the primary areas of the cockpit:

The primary flight instruments are located on the forward panels, beneath the dashboard anti-glare shield.



## 6-2: Power plant controls

The collective is your primary means of controlling how much lift is being generated by the rotors. When you want to generate more lift, pull back on the collective; when you wish to reduce lifting power, push the collective forward. The other controls are used during the engine start procedure and you will often not need them during the course of a mission.

- Collective up [Numpad + +]
- Collective down [Numpad + -]

The two engine cutoff valve levers open and close fuel injection into the engines. These two red levers are moved independently:



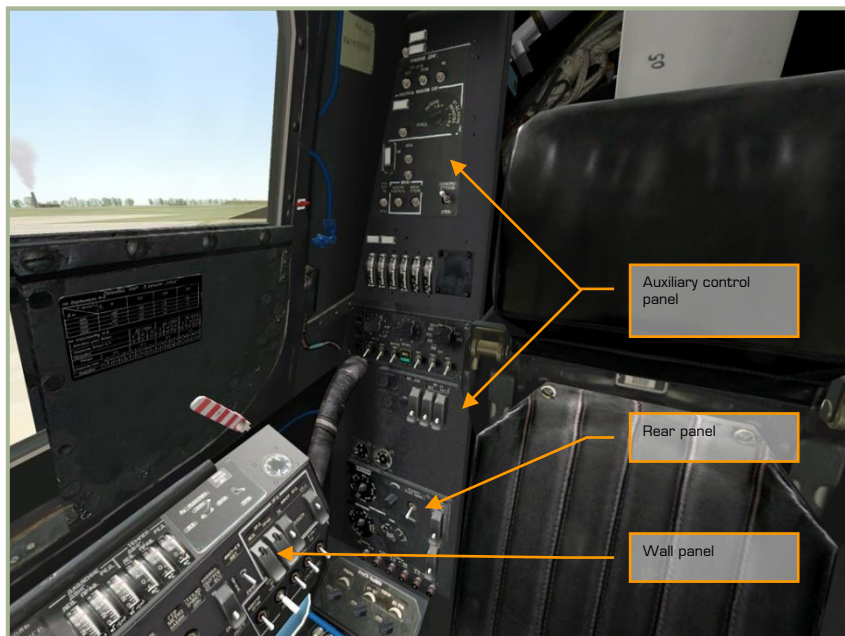
- Left engine cutoff valve [RCtrl + Page Up]
- Right engine cutoff valve [RCtrl + Page Down]

Behind the engine cutoff valve levers is the rotor brake:

- Rotor brake [LShift + R]

The two throttles at the base of the collective are used to set the RPM of the engines and each engine can be set independently or linked:

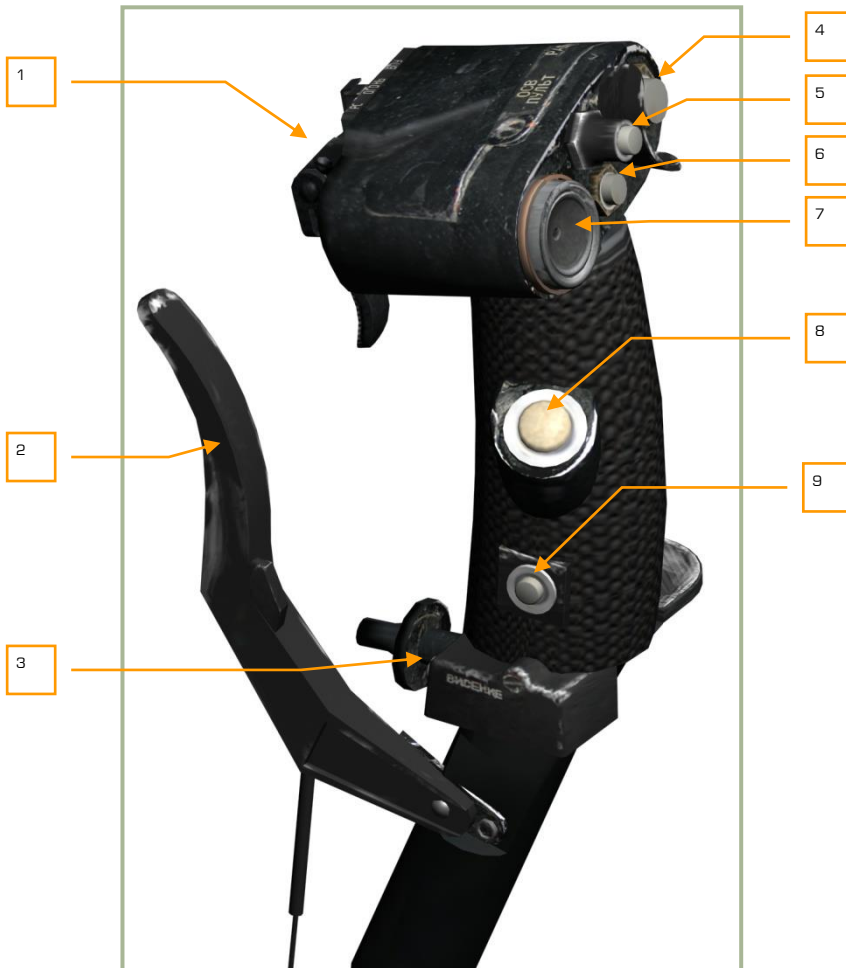
- Linked throttles up [Page Up]
- Linked throttles down [Page Down]
- Left throttle up [RAlt + Page Up]
- Left throttle down [RAlt + Page Down]
- Right throttle up [RShift + Page Up]
- Right throttle down [RShift + Page Down]



### 6-3: Side and rear panels

This portion of the cockpit has a wide array of controls that include built in tests (BIT), video recorder, countermeasures dispenser controls, weapon controls, cockpit lighting, engine governors, and engine monitoring systems to name a few.

## Cyclic Control Stick



**6-4: Cyclic pitch control stick**

The cyclic is your primary means of controlling helicopter attitude. Just like a fixed-wing aircraft, pushing and pulling the stick affects aircraft pitch and moving the stick side to side inputs roll. Unlike a fixed-wing aircraft though, you will generally pitch the helicopter forward to initiate forward flight and pull the stick back to slow down or even fly backwards.

The cyclic has a number of buttons and hats that allow you to manipulate the various systems of the helicopter without having to take your hands off the cyclic. These include:

1. **"ОГОНЬ РС – ВПУ"** (Fire weapon – cannon) triggers.
2. Wheel brake paddle [W].
3. **"ВИСЕНИЕ"** (Hover) button – Toggles the hover autopilot mode on and off [LAlt + T].
4. **"РАДИО"** (Radio) button – Activates radio in transmit mode. No function.
5. **"ОСВ ПУЛЬТ"** (Gauge lighting) button – Toggles cockpit and gauges lighting on and off.
6. **"ЦЕЛЬ УКАЗ"** (Uncage Shkval – confirmation) button – uncage the "Shkval" EO targeting system for target designation and confirmation of data entry (i.e. during navigation system INS fix-taking procedure) [O].
7. **"МЕТКА"** (Marker) hat switch – Slew control for "Shkval" line of sight [;], [.,], [.] and [/].
8. **"ТРИММЕР"** (Trimmer) button – Cancels all force on cyclic with the trimming mechanisms. When released, the autopilot will stabilize current angles of pitch, bank and yaw [T]. Note that this is a different method of trimming the aircraft compared to fixed wing aircraft.
9. **"ОТКЛ АП"** (Autopilot disengage) – autopilot emergency disengage [LAlt + A].

If you have a programmable control stick at home, you may wish to program it to match these settings. You can do so using the input control manger in the options screen.

## Release Weapon – Cannon Triggers

The triggers block is located on the opposite side of the stick from the pilot. Triggers are intended for generating "fire" signals for weapon system and selected weapons.

By default the **"ВПУ"** (Onboard cannon) small trigger is guarded by the larger **"РС"** (release weapon) trigger. The larger weapon trigger is intended for shooting or launching external weapons of the selected type (ATGMs, rockets, bombs, canisters and gun pods).

Note that when firing an anti-tank guided missile like the Vikhr, you will need to hold down the weapon trigger for up to a full second
---



**6-5: Weapon (large) and Cannon (small) triggers in default position – Release Weapon trigger operates**



**6-6: Weapon (large) and Cannon (small) triggers in default position – Release Weapon trigger operates**

1. "ОГОНЬ ВПУ" – Onboard cannon (small) trigger [\[SPACE\]](#). Trigger is inoperative.
2. "ОГОНЬ РС" – Weapon (large) trigger [\[RAlt + SPACE\]](#). Trigger is operative.

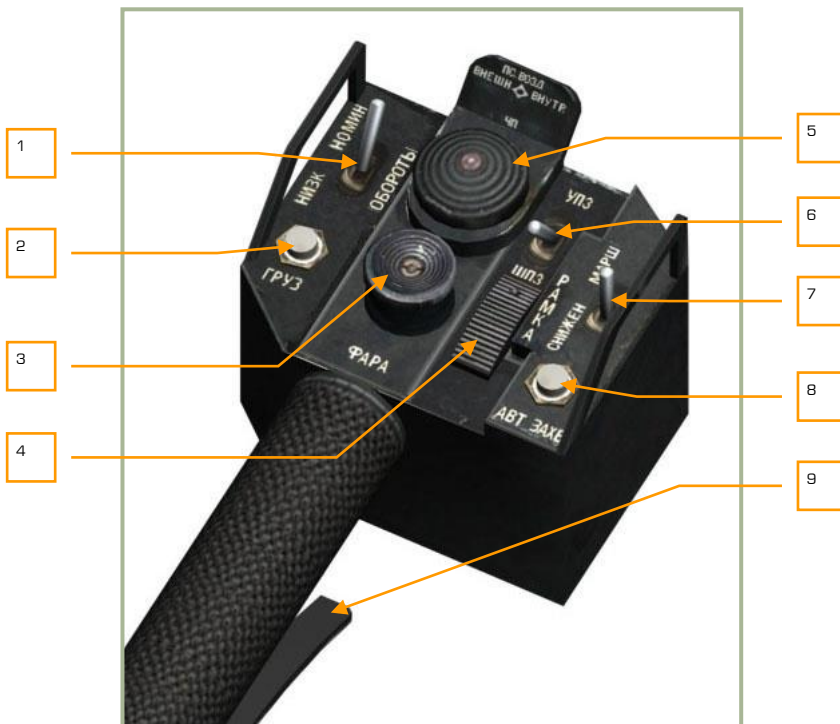
For cannon employment it is necessary to flip up [\[C\]](#) the "PC" weapon (large) trigger. When that is done, the weapon system transmits the signal for cannon operation and the "ВПУ" cannon (small) trigger may operate.



**6-7: Weapon (large) and Cannon (small) triggers in Cannon operate position  
(Release Weapon (large) trigger is flipped up)**

1. "ОГОНЬ ВПУ" – Onboard cannon (small) trigger [\[SPACE\]](#) is operative.
2. "ОГОНЬ РС" – Weapon (large) trigger is inoperative.

## Collective Control stick



**6-8: Collective control stick**

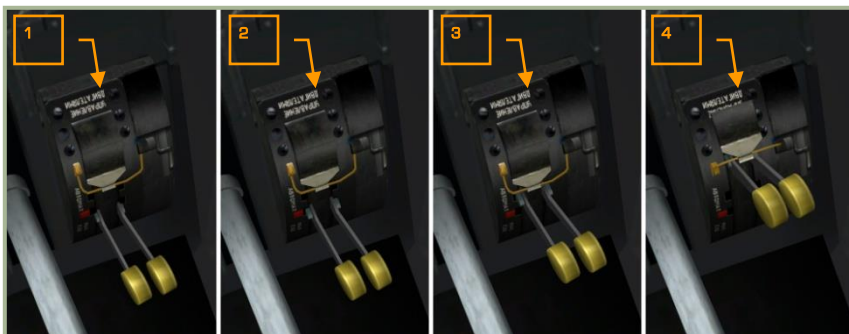
In addition to adjusting the pitch of the rotor blades and thereby affecting main rotor lift, the collective also has a number of buttons, hats, and switches that allow you to manipulate certain functions. These include:

1. **"ОБОРОТЫ"** Control selector for re-adjustment of the free-turbine (rotors) RPM governor. To low [RAlt + Numpad -] and to nominal [RAlt + Numpad +].
2. **"ГРУЗ"** Sling load button - No function.
3. **"ФАРА"** Hat switch. Slew search/landing lights. [RCtrl + ;], [RCtrl + .], [RCtrl + ,] and [RCtrl + /].
4. **"ПАМКА"** selector – Adjust "Shkval" tracking gate size [I] and [J].
5. This four position hat allows the selection of external hardpoints.
  - **"ВНЕШН"** – Outboard hardpoints [Y].
  - **"ВНУТР"** – Inboard hardpoints [I].
  - **"4П"** – All hardpoints [U].

- “ПС ВОЗД” – Air-to-Air missiles hardpoints [LCtrl + U].
- 6. “УПЗ-ШПЗ” switch. Adjust Shkval field of view (FOV) between 23x and 7x: wide [-] and narrow [=].
- 7. “СНИЖЕН – МАРШ” switch. Three position switch between Off, Descent, and Route autopilot modes [D] and [R].
- 8. “АВТ ЗАХВ” button. Toggles target acquisition and lock when using Shkval [Enter].
- 9. Collective brake - Assign altitude lever [F]. This lever serves two functions:
  - Press this lever to disengage the collective stick brake before moving the stick. The brake is needed to prevent the stick from moving due to vibration or casual touch.
  - Once the brake has been released and a signal is sent to the navigation system, the lever can be used to assign a new altitude when using the altitude hold flight mode.

## Separate engines throttle levers

The separate engine throttle levers are located on the engines control panel under pilot's left hand. They have common axis of rotation and move upward – downward.



The throttle levers have four fixed positions:

1. Idle.
2. Governor fail.
3. Auto.
4. Max.

In game, the control of the throttle levers is implemented in two manners:

1. Buttons [Page Up], [Page Down] for both engines simultaneously.  
Right engine [RShift + Page Up], [RShift + Page Down].  
Left engine [RAlt + Page Up], [RAlt + Page Down].  
Each buttons press moves the levers one position up or down.





2. Analogue axis assigned in the INPUT options.

At IDLE mode are usually performed startup procedures and most of the systems functional tests.

GOVERNOR FAIL is needed in case of failure of power turbine's RPM governor to avoid engine (power turbine) overspeed.

AUTO is the main mode during normal operation of the powerplant. All flights must be performed at this mode, except for specific emergencies.

MAX mode is intended to ensure maximum power of one engine in case of failure of the other engine.

## Left and Right Forward Panels

### Left Forward Panel



**6-9: Left forward panel**

The left forward panel is primarily dedicated to various flight control gauges and warning systems. While most of the primary flight information will be displayed on the heads up display (HUD), the analog gauges can provide a valuable backup and provide additional information not present on the HUD.

1. Master caution push-light – Resets the light to off when pressed [M]. The master caution light will turn on anytime a warning or caution light is activated

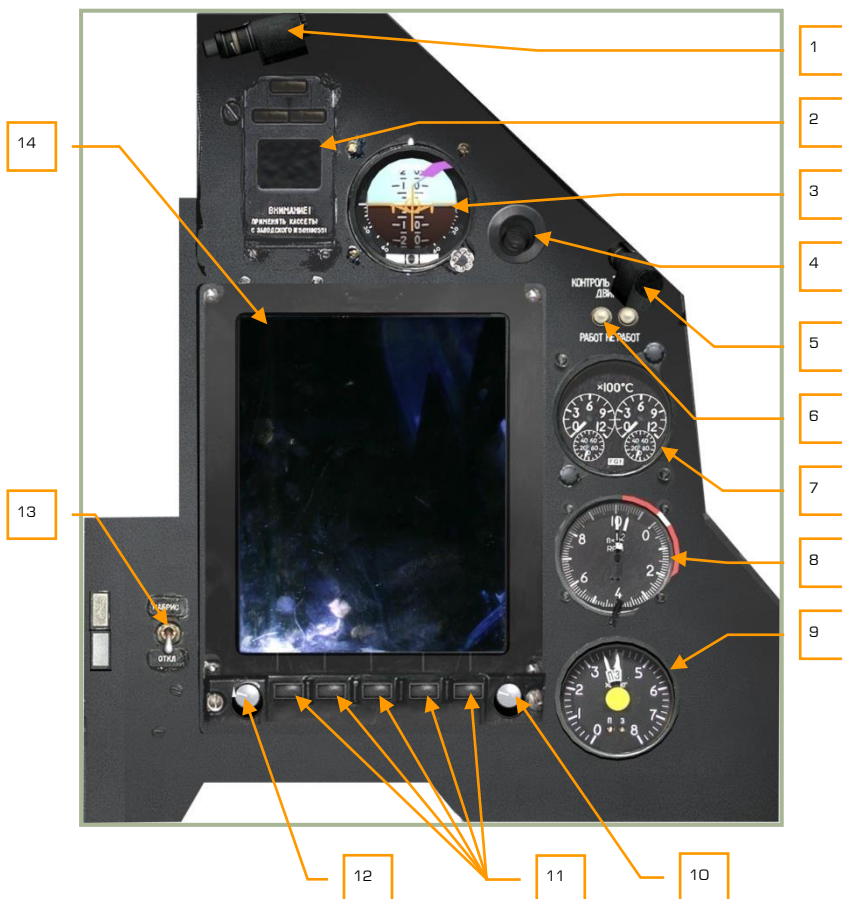


2. Caution lights panel
3. Vertical Velocity Indicator (VVI)
4. Attitude Director Indicator (ADI)
5. Barometric altimeter
6. Horizontal Situation Indicator (HSI)
7. Automatic/Manual course and heading source switch
8. Laser rangefinder/designator mode switch
9. Laser designator reset button
10. Rotor pitch indicator
11. Mechanical Clock
12. Gear position indicator
13. Rotor RPM indicator
14. Radar altimeter
15. Indicated airspeed indicator
16. Rotor RPM warning push-light [\[B\]](#)
17. Missile warning system with laser jammer, self protection system mode of operation select, No function
18. Warning, Cautions, and Advisory lamps test button [\[LShift + L\]](#)
19. Accelerometer

Details of the above gauges and indicators are described below.

Note that the example gauge and indicator readings shown in figures may not be indicative.
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## Right Forward Panel



**6-10: Right forward panel**

The right forward panel is dominated by the ABRIS display, but also includes gauges for flight control, test devices, engine management, and fuel management.

1. Cockpit light
2. EKRAN Warning System display
3. Standby Attitude Indicator (SAI)
4. Cockpit air conditioner vent
5. Night light
6. Exhaust gas temperature indicator test buttons



7. Exhaust gas temperature indicator
8. Dual engine RPM indicator
9. Fuel quantity indicator
10. ABRIS cursor control
11. Multi-function ABRIS buttons
12. ABRIS brightness display knob
13. ABRIS On/Off switch
14. ABRIS display

Please see the ABRIS section of this manual for a detailed explanation of this sub-system.

## Attitude Director Indicator (ADI)

The Attitude Director Indicator (ADI), also referred to as the "artificial horizon," indicates the helicopter's orientation relative to the horizon.

To operate the ADI, electrical power will need to be active after the Inertial Navigation Unit (INU) power-up sequence is complete.

The ADI includes the following indications:

- Pitch (fore and aft tilt) and bank (side to side tilt) angles
- Desired pitch and bank (to reach the next waypoint)
- Assigned airspeed
- Assigned altitude
- Lateral deviation from assigned flight path or hover position
- Yaw angle
- ADI malfunction



**6-11: Attitude and Direction Indicator (ADI)**

1. **Lateral deviation from assigned flight path.** Located at the top of the ADI, this line indicates the degree to which the aircraft is flying along the assigned heading along the route leg. If the aircraft is flying along the correct heading, the vertical line will be centered in the window. If, however, the line is on the right side, you are flying to the left of the desired flight path and vice versa if the line is to the left.
2. **Assigned pitch and bank steering not available flag.** If no steering information is available, this red flag will be visible in the top left corner of the ADI.
3. **Deviation from assigned airspeed.** Along the left side of the ADI is a vertical scale that represents the aircraft's current speed in relation to the set airspeed for the current leg of the route. If the indicator is below center, it indicates that the aircraft is traveling too fast and vice versa if the line is above center.
4. **Aircraft symbol.** Appearing like a fixed-wing aircraft, this symbol indicates current aircraft pitch and roll in relation to the artificial horizon. Note that it is different from western ADI instruments that have a static aircraft symbol. With the Russian-style ADI, the aircraft will move according to bank angle.
5. **ADI malfunction flag.** If the INU is not providing attitude information or the ADI is not receiving power, this flag will be visible.
6. **Self-test button.** The first press of this button will open the cover [LCtrl + LAlt + LShift + A] and a second press will run a self-test [LAlt + LShift + A].
7. **Pitch scale.** Displayed in large 10 degree increments with 5 degree hash marks between, these lines are inscribed on the ADI artificial horizon ball and indicate aircraft pitch angle in relation to the aircraft symbol.
8. **Bank steering bar.** This vertical, gray bar can move to the left and right and indicates the level of bank needed to align the aircraft on the correct steering



course. If the aircraft is on course or no steering information is available, the bar will be centered.

9. **Deviation from assigned altitude.** This vertical scale and yellow caret on the right side of the ADI indicates the aircraft's current altitude in relation to the assigned altitude for the current leg of the route. If the aircraft is too high or too low, the caret will be below or above the center mark. The caret being above the center point would indicate that the aircraft was below the assigned route leg altitude.
10. **Pitch steering bar.** This horizontal, gray bar can move up and down and indicates the pitch angle needed to align the aircraft on the correct steering course altitude. If the aircraft is on course at the correct altitude or no steering information is available, the bar will be centered.
11. **Aircraft symbol setting knob.** This knob can be rotated left [LAlt + LShift + ,] and right [LAlt + LShift + .] to move the horizon line on the ADI ball vertically. You can use this function to fix any misalignment before flight. This control can also be used to "zeroise" the horizon indication for the given angle-of-attack. This can be useful in simplifying the level flight control at a given airspeed.
12. **Yaw indicator.** Indicating the yaw of the aircraft, this indicator displays a ball in a liquid filled tube. If there is no yaw in the flight path, the ball will be centered. If there is yaw, the ball will be displayed in the opposite direction of yaw. The sideslip indication ball moves by local acceleration so it will not always display the actual sideslip. This depends much on the type of maneuver you are flying.

## Horizontal Situation Indicator (HSI)

The Horizontal Situation Indicator (HSI) is located in the left forward panel and it displays aircraft heading, offset from the assigned flight path, and position relative to a selected navigation reference that may be a steerpoint, fixed point, radio beacon, or airfield.

Although primary navigation data may be displayed on the HUD, the HSI provides additional information for precise navigation.

To operate the HSI, electrical power will need to be enabled and the either the "K-041" or "Navigation System" switch must be set to ON. The HSI will operate after INU alignment is complete.

### Waypoint vs. Steerpoint

Often incorrectly used interchangeably, the two terms are in fact different. A waypoint is a list of navigation points that have unique coordinates and names. A steerpoint on the other hand is the current waypoint that is selected for navigation. As such, there can be many waypoints but there can only be one steerpoint at a time.

The HSI includes the following indications:

1. Current heading (demarcated in 5° increments).
2. Desired flight path heading, according to flight plan or entered manually.



3. Desired course (shown both with analog needle and digital counter), according to flight plan or entered manually.
4. Distance to steerpoint.
5. Bearing to a radio station, as measured by the ARK-22 radio-compass.
6. Lateral deviation from the assigned flight path or hover position.
7. Longitudinal deviation from an assigned hover position.



6-12: HSI Indicator

1. **Heading unreliable, "KC" flag.** If the INU fails to provide current heading, or the HSI is not receiving power, this flag at the top of the instrument will be visible.
2. **Distance steerpoint.** Shown as a numeric, this number indicates the direct range to the steerpoint in kilometers.
3. **Desired heading (DH) index.** This thick yellow line indicator on the outside of the compass card indicates either the desired heading to steerpoint or a manually set heading.
4. **Navigational computer failure "K" flag.** If navigational computer BIT continually fails, this flag on the left side of the instrument will be visible.
5. **Desired Track Angle (DTA) pointer.** This arrow is according to flight plan or entered manually. This indicator appears as two white lines with an arrow at the end. A corresponding "tail" exists 180 degrees on the opposite side of the compass.

6. **Longitudinal deviation from an assigned hover position.** This horizontal, gray line in the center of the instrument indicates the helicopter's relative longitudinal hover position compared to when hover mode was initiated. If the line is below the center point it indicates that the helicopter is hovering too far forward of the initial hover point. Conversely, if the line is above the center point it indicates that the helicopter has moved too far backwards. Ideally, you want the horizontal and vertical lines to form a cross in the center.
7. **Self-test button.** Press this button to run a self-test of the instrument. [LCtrl + LAlt + H]
8. **Desired Heading set knob.** If the "DH/DTA source" switch is set to the Manual position, this knob may be rotated left [LCtrl + LShift + ,] and right [LCtrl + LShift + .] to manually set the desired heading index to steerpoint.
9. **Current heading reference arrow.** At the top of the compass card is a downward pointing arrow that indicates the current heading of the aircraft when matched with the compass heading below.
10. **Desired Track Angle digital counter.** Shown as a numeric, this number indicates either desired track angle to the steerpoint or a manually selected number in degrees.
11. **Compass card.** This circular gauge rotates according to current aircraft heading. The current heading is shown at the very top of the card underneath the heading reference arrow.
12. **Lateral deviation from the assigned flight path or hover position.** This vertical, gray line in the center of the instrument indicates the helicopter's relative lateral position compared to when hover mode was initiated, or to the assigned flight path between previous and current steerpoints. If the line is to the left of the center point it indicates that the helicopter is hovering too far to the right. Conversely, if the line is to the right it indicates that the helicopter has moved too far to the left. Ideally, you want the horizontal and vertical lines to form a cross in the center. Note that if Hover mode is inactive and the "Heading/Course flight path mode" on the Autopilot panel is set to the Heading position, that the deviation indicator will become inactive (will be centered). In the Heading mode, direct flight to the steerpoint method is used.
13. **"ЗПУ-ЗК РУЧН – АБТ" (DH/DTA source) switch.**  
This switch is used to select between automatic and manual desired heading and desired track angle setting of the HSI. When in the default down position, automatic "АБТ" mode is selected. When in automatic mode, the heading and course pointers will be updated by the navigation system and automatically change according to the current waypoint. When in the up position, manual "РУЧН" mode is selected and the DH and DTA knob is used to adjust the pointers. [LCtrl + H]
14. **Navigational computer failure "Г" flag** (same as item 4). If the navigational computer has a continuous BIT failure, this flag will appear on the right side of the instrument.
15. **RMI bearing to radio station.** This small yellow arrow points to the bearing of the selected radio station. This bearing is read from the OUTER, non-moving

scale and the radio station is selected via the ARK-22 Automatic Direction Finder control panel.

16. **Outer scale.** This static scale has markings for 6, 12, 24, and 30, and is used to read bearing to the radio station indicated by the yellow arrow.
17. **Desired Track Angle knob.** If "DH/DTA source" switch is in the Manual position, this knob may be rotated left [LCtrl + LAlt + ,] and right [LCtrl + LAlt + .] to set a DTA manually to steerpoint pointer.

## Laser Designator Panel

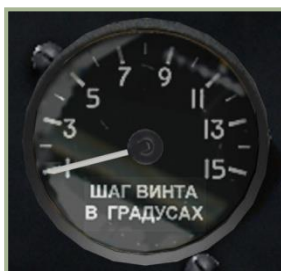


6-13: Laser designator panel

1. The small "СБРОС ЛДП" laser designator reset button is used to cease laser illumination, if it has not already timed out after 20 sec. [LCtrl + LAlt + O]
2. The laser range finder / laser designator mode toggle "ЛД-ЛДП" switch is located directly below the HSI and is set to the "ЛД" laser range finder position by default. [LShift + O] When set to the "ЛДП" laser designator position, the laser can be used to designate targets for weapons such as the Kh-25ML, Kh-29L or laser bombs. The Ka-50 can search for a target and illuminate it for 20 seconds by a second press of the Enter key. This switch does not affect "Vikhr" employment.

## Rotor Pitch Indicator

The rotor blade pitch indicator is used to monitor the pitch angle of the rotor blades. The collective pitch control can be used to increase rotor pitch up to 15°.



6-14: Rotor blade pitch indicator