Helicopters

In Search and Rescue

Basic Level

Charley Shimanski
Dr. Charlie Mize
Mountain Rescue Association
www.mra.org

MOUNTAIN RESCUE ASSOCIATION

HELICOPTERS IN SEARCH AND RESCUE

Basic Level

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Lesson 1

Objective

The Mountain Rescue Association (MRA), a volunteer organization dedicated to saving lives through rescue and mountain safety education, has developed this program to assist search and rescue (SAR) organizations in their helicopter operations.

This material is designed for search and rescue professionals that work occasionally with helicopters in their search and/or rescue operations.

At the conclusion of this program, students should be able to:

- Understand the basic functions and operation of helicopters,
- Identify key elements of aerodynamics, helicopter design and controls,
- Implement helicopter management and safety precautions, and
- Recognize key issues that contribute to effective use of helicopters in search and rescue.

About the Authors

Charley Shimanski

Charley Shimanski is President of the Air Rescue Commission for the International Commission for Alpine Rescue. He is a 30-year member of Alpine Rescue Team and Mountain Rescue Program Coordinator, Flight For Life Colorado. *He is also* Past President and Education Director for the Mountain Rescue Association, a national organization of rescue mountaineers. Charley has participated in hundreds of rescues among Colorado's highest peaks, and has consulted rescue mountaineers, mountain guides, and climbers throughout the world, from Israel to China, from Mt. Kilimanjaro to Aconcagua.

Dr. Charlie Mize

Charles Haviland Mize, BA MD, is a specialist in emergency medicine and resuscitation and is a leading expert on the retrieval of critically-ill and injured patients from austere environments at high-altitude. He has led numerous helicopter rescue operations throughout the Himalaya. He is a co-founding member of BearBadger, a physician-led team that undertakes high-risk patient retrieval, and is the founder of Bhutan Emergency Aeromedical Retrieval, the Kingdom of Bhutan's pre-hospital helicopter critical care and mountain rescue team.

Introduction

The introduction of helicopter aviation dramatically changed the reach and power of search and rescue work. Search and rescue (SAR) operations that were once limited by rescuers' ability to traverse difficult terrain, terrain sufficiently dangerous to create a need for rescue, can be brought quickly into action from the sky. Capable of search and reconnaissance as well as rescue and extrication, the helicopter brings unparalleled versatility in its ability to support emergency and disaster response. But with this versatility come the dangers inherent to helicopter flight and operations. As local SAR teams gain improved access to air support, it becomes essential that those who work in search and rescue learn the basics of helicopter aviation and receive a thorough orientation to helicopter safety.

The past several decades have seen helicopters play an increasing role in search and rescue. The Alpine Rescue Team employed seven helicopters throughout its 1988 Colorado search for a lost hiker: two U.S. Army Chinooks, three news helicopters and two charter helicopters. In a typical demonstration of helicopter versatility, the news helicopters conducted aerial searches for the victim while the Chinooks carried rescuers to be deployed in the field. Helicopter aviation enabled NBC affiliate KCNC-TV pilot Mike Silva to spot the crash site of a Civil Air Patrol plane and to then guide field teams and an Army Chinook to the site. Thanks to his work, these SAR teams were able to rescue a survivor from the crash. Silva later brought helicopter support to the aid of several rescuers suffering from Acute Mountain Sickness, extracting them from the top of Pendleton Mountain during a SAR operation. That operation also employed a charter helicopter to fly infrared scanning equipment while KCNC's Silva together with CBS-affiliate KMGH pilots Peter Peelgrane and Lyle Gurley flew countless hours assisting in the search.

Helicopters bring unique value - and unique danger. Helicopter crashes are devastating and often lethal events that threaten even the most prepared and careful rescue operations. Even on the ground, helicopters pose significant danger: rotor blades spinning faster than 150 M.P.H. can inflict deadly wounds to the careless or inattentive. The safety of helicopters in search and rescue is in direct proportion to the knowledge and skill of those who manage their use.

In the United States, there have been several recent accidents involving rescue helicopters;

- 2008 – A rescue paramedic was fatally injured when he was struck in the head by a main rotor blade during a rescue of two hikers.
- 2009 – A New Mexico State Police helicopter crashed into a mountainside. The pilot and the search subject he rescued died in the crash, but the spotter survived.
- 2012 – Mount Rainier National Park Ranger Nick Hall died from a 2,400 foot fall when he lost his balance on the mountain during a helicopter rescue of injured climbers.
- 2013 – An Alaska State Police helicopter crashed during a rescue of a snowmobiler. The pilot, his spotter, and the subject they rescued died in the crash.

Despite the fact that helicopters are uniquely valuable, they can be extremely dangerous. Photo: Office of Aircraft Services (OAS)

Pilot error and machine failure can both lead to crash. A helicopter is only as skilled as its pilot; its pilot, only as strong as the machine he or she flies. There are three major killers of helicopter pilots: 'Wind, Weather, and Wires.'

These tragedies are cause for caution but not alarm. Helicopter crashes kill fewer people than any other form of transportation, representing, for example, just 0.1 percent of the 56,000 transportation fatalities that occurred in 1979. Moreover, when a helicopter crashes, its pilot and occupants are far more likely to survive than those aboard a crashing plane. Contrary to popular conception, it is not impact with the ground that usually kills passengers, but rather the forward momentum at time of landing. This speed carries the aircraft into trees and other hazards. In general, helicopters have a lower forward speed than do planes because helicopters require less air speed to avoid stalling. In addition to reducing the likelihood of impact with obstacles on the terrain, this lower forward speed also allows a helicopter pilot to negotiate an emergency landing with less room. It is important to note that, in addition to trauma, cabin fire is another significant cause of death after helicopter crash.

We close this introduction with a note on terminology. Aviation often refers to helicopters as *rotary-wing aircraft*, a name that comes from the rotating 'wings' of the helicopter's rotor blades. By contrast, *fixed-wing* refers to planes and other aircraft whose lift arises from the air movement that forward thrust generates on stationary wings. This course and those that follow it use term helicopter and rotary-wing aircraft interchangeably.

Part

1

Part 1 – Helicopter Basics

Rescue leadership must perform a thorough risk-benefit analysis in order to assure safe utilization of helicopter resources. Photo: Rocky Mountain House SAR and Ahlstrom Air; Canada

Use of Helicopters

When a search and rescue team employs a helicopter, it puts a powerful instrument to work. Modern helicopters are capable of a variety of missions, to include:

- The search for a lost or injured person or persons
- Their subsequent evacuation
- The insertion or extrication of rescuers
- An aerial survey of topography by search and rescue leadership

While SAR teams will often engage planes to search large open areas for prominent clues (e.g. ski tracks, tents, downed aircraft, etc.), they turn to helicopters to search with closer detail or to explore areas more difficult to examine from fixed- wing aircraft (such as cliffs, gullies, cliff bottoms, etc.).

In search operations, the noise from a helicopter may attract the victim of a search who, in turn, may attempt to attract the attention of those on board the helicopter. In addition, helicopters can transport searchers and other equipment to remote search and rescue assignments.

Helicopters are often used not only to evacuate an injured subject from the field but to transport that injured party to a local hospital. Helicopter rescue teams employ a number of methods to evacuate injured subjects. In addition to carrying victims into the helicopter cabin, helicopter teams can also perform extrications where victims and rescuers are carried outside of the helicopter. These methods referred to "external loads," and include the use of hoist systems and slings. SAR teams also employ helicopters to support operation logistics through the transport of rescuers and/or their gear. The speed afforded by helicopter transport can reduce time and rescuer fatigue, both vital considerations in many rescue operations.

A thorough analysis of the benefit and the risk of helicopter deployment in any given search and rescue operation is vital to safe helicopter use. The Incident Commander and other leadership must undertake this analysis and decide if the benefits brought by helicopter aviation outweigh its attendant risks. Is it worth the risk, for example, to deploy a helicopter to evacuate a healthy search subject simply to avoid a two- or three-mile walkout? Few would say it is. Conversely, who would question the need for an air ambulance when the victim of a plane crash lies unconscious and bleeding at the scene of the crash? Between these two examples fall the majority of search and rescue operations and the more difficult decision to call for air support or to decline it.

Helicopter Limitations

To accurately weight the advantages brought by helicopter use against its risks and expense, search and rescue teams must be aware of the many factors that limit helicopter aviation. Altitude, weather and terrain will all affect a helicopter's performance and will thus in turn alter its usefulness in search and rescue operations. All aircraft have a limited working altitude (called service ceiling), which changes with air temperature and humidity.

Visibility Minimums

Safe flight requires pilots to know where they are, where they are going and what possible obstacles might endanger their journey. Absent this knowledge, flying is exceeding dangerous. Depending on the capability of the aircraft and the training of the pilot, flights are governed through either one of two sets of rules to ensure that pilots are in contact with their environment: Visual Flight Rules (VFR) and Instrument Flight Rules. VFR requires that a pilot maintain visual contact with the environment and must avoid clouds. IFR allows flight through the use of instruments, flight plans and coordination with air traffic control teams when imperfect weather compromises a pilot's ability to see with a naked eye.

In general, smaller helicopters do not have IFR capability, and must fly in what the aviation community refers to as *visual meteorological conditions* – they cannot fly through clouds and must keep a safe distance from other aircraft.

Although visual flight rules are used by both fixed-wing and rotary-wing aircraft, VFR for helicopters is different from that employed by planes due to the slower speeds helicopters are able to fly.

VFR rules dictate that there must be a minimum one-half mile visibility and a 500-foot ceiling (distance between ground and bottom of lowest clouds). For National Guard helicopters, the visibility for VFR is increased to 1 mile. A pilot flying under VFR must have sight of the ground at all times.

The standards for night flying are more conservative. During night flying, VFR require a minimum three-mile visibility. The rules further demand that the pilot keep a 500-foot minimum below clouds, a 1000-foot minimum above clouds, and a 2,000-foot horizontal distance from clouds.

Larger helicopters, such as most of those used in search and rescue operations, generally possess instrument flight capability and can thus fly under instrument flight rules.

Weather Conditions

Turbulence is the rough air that causes sudden and undesired movement in flight. Heavy turbulence can make helicopter flight difficult or even unsafe and can render the careful control required for many rescue operations challenging or impossible. There are several causes of turbulence: storm wind, rising air and the air currents around mountains are common examples. Pilots often desire the calm air of morning flights before the sun has warmed the earth and set the air to rise. Cumulus clouds indicate turbulence with strong updrafts and downdrafts. Downdrafts often flow in the middle of a valley and can challenge a helicopter's lift, especially at high altitudes with their consequent reduction in engine power. By contrast, updrafts often exist over ridges or on the sunny side of a rising hill or mountain. The leeward side of a ridge (that side sheltered from the predominant wind) may have severe downdrafts.

Even if a helicopter is on its way to evacuate a victim, ground personnel should still move to the scene with all equipment necessary to transport the victim. Never assume a helicopter en route will become a helicopter on scene. Should weather, mechanical failure or crash arrest the helicopter's progress, the ground team must be prepared to continue to mission.

Fuel

As noted in the "Helicopter Types" section (below), each type of helicopter has flight range dictated by engine type, weight and fuel supply. Helicopters are often based some distance from the search and rescue mission, and the journey from this base to the point of action costs time and fuel. SAR leadership might engage a mobile fuel tanker at the operation's heliport to refuel helicopters during an extended search mission, but more often than not helicopters will have to leave the scene to refuel.

Mechanical

It goes without saying that a helicopter is a machine, and machines do not always work. Moreover, their failure can be unpredictable and catastrophic. For this and other important reasons (cost, ground safety, and so on), it is imperative that SAR teams conduct a thorough risk-benefit analysis prior to each and every helicopter operation.

Classifications of Helicopters

Helicopter Emergency Medical Services (HEMS) Helicopters

Most search and rescue teams will have access to local Helicopter Emergency Medical Services (HEMS) helicopters, since many rescue missions occur within proximity of a large town with a Level I trauma center. Flight crews specially qualified in critical care medicine staff each flight. In the United States, a flight nurse and paramedic often comprise these teams. A physician may staff a flight to meet specific clinical need, although this is uncommon. These ships can usually carry anywhere from one to four supine adult patients, depending on the type of craft and the internal configuration.

Emergency medical equipment including electrocardiograph monitor, oxygen, defibrillator, suction apparatus, endotracheal intubation equipment, intravenous fluids, transport Isolettes and emergency drugs are all carried on board the helicopter. In effect, the emergency room is carried to the patient for immediate treatment and care.


Flight nurses and/or paramedics are a key element of med-evac helicopters. Photo: Charley Shimanski

These air ambulances enable an emergency medicine and critical care team to provide immediate intensive care to a patient at the site of injury and to transport that patient as rapidly as possible to the hospital for definitive care.

Whenever a Helicopter Emergency Medical Services (HEMS) helicopter responds to a mission, search and rescue team members should refrain from talking to the flight nurse or pilot. The only person who should discuss the patient with the flight nurse is the primary medical team member, who will give the flight nurse a full (and brief) update of the patient's condition, nature of injuries, etc. (For further information on this briefing, contact your team's Medical Director. If you do not have a Medical Director, contact the HEMS helicopter's medical director). The helipad director or person most familiar with helicopter operations should be the only person to speak with the pilot while the ship is on the ground.

SAR team members should be aware of how HEMS helicopters are dispatched. In most cases, this will be via the local Sheriff's dispatch, although some SAR teams may be able to request these helicopters directly.

If the SAR team believes that a victim's injury or illness may require immediate medical care, then the rescuers should notify the HEMS crew or dispatch in advance. Doing so allows the pilot and flight crew to familiarize themselves with the terrain and weather conditions before they are actually called into action.

HEMS teams and their aircraft operate under their own set of limitations. Their equipment and the regulations that govern HEMS work often limit where they are able to land. As an example, if the HEMS team works under Federal Aviation Administration (FAA) code Part 135, they may be restricted from certain landing sites, particularly at night, that public use aircraft may safely and legally use. Also, their size or configuration, set up mostly for helipads and streets, might not work well in the mountains.

Law Enforcement Helicopters

Many local county Sheriffs or city Police Departments operate helicopters for law enforcement, especially those in the vicinity of a large city. The altitude limits of these helicopters often preclude their use in the mountains, but may allow for search and rescue flights in the foothills. SAR teams should know the limitations of local law enforcement helicopters and their pilots. If either lack the ability to fly at altitude, they should not be considered a resource for high altitude missions.

On the other hand, many county governments have sophisticated aviation programs. In most of California, for example, the vast majority of search and rescue operations are conducted by county aviation units. In Los Angeles County, it can be either the Sheriff or the fire department's rescue-equipped helicopters. In other counties it may be a combined unit or a Sheriff's unit. Within the last couple of years, the California Highway Patrol has greatly expanded their program and now flying missions when county resources are not available, including missions in mountainous terrain.

Civilian Helicopters

Charter helicopters may be available to SAR teams. Although charter helicopters can be a valuable resource for SAR teams, the possible benefit they bring requires forethought and anticipatory planning if the benefit is to be fully realized. Often these helicopters and their pilots lack extensive experience in search and rescue flights and sometimes in flying at altitude. Coordination between charter helicopters and SAR teams is less likely to be rehearsed; SAR teams will often lack familiarity with the machine and its pilot. Whenever possible, safety demands that SAR team leadership develop an awareness of the altitude and performance limits of charter aircraft and pilots. There is also the matter of cost: charter helicopter services usually charge for their services. SAR teams that anticipate the engagement of charter aircraft should develop a plan with the local sheriff and the private helicopter agency before the need becomes real. In some situations, funds may be available to augment search or rescue missions, but SAR team leadership would be wise to investigate such possible funding in advance of a real need.

Media Helicopters

Search and Rescue teams close to large cities with network television stations may be fortunate to have at their disposal one or more media helicopters. In many situations, these helicopters can become an extremely valuable resource. Key to the successful implementation of media helicopters is a strong mutual relationship between the SAR team and the local television or radio station that operates the ship. Since these helicopters are an expensive tool for the station, the SAR team must be judicious in requesting these resources.

Search and Rescue overhead teams should keep in mind that the media helicopter pilot and crew have **two** important objectives. The first objective is to "bring home the news story." The second objective is to assist in the SAR mission. The overhead team must respect the media's needs while focusing on its own objectives.

Key to the successful utilization of media helicopters is a strong mutual relationship between the SAR team and the local television or radio station that operates the ship. Photo: Charley Shimanski

Small acts of collaboration between the SAR team and the news crew may seem to be insignificant when they are anything but: actions that seem trivial to SAR team members can carry significant importance for a news. Imagine that a television news helicopter, with a SAR member on board as a spotter, is responsible for a "find" during a search operation in which a safe field landing and extrication of the victim is possible. Often, the television station will have a ground crew at the command post, shooting footage of the return of the helicopter. When the SAR team allows the pilot to come to full rotor stop and to escort the victim off the helicopter himself or herself, the SAR team allows the television station to tell a great story, to present itself in a positive light, and to take appropriate recognition of the contribution of their helicopter. Remember that it is the television station that foots the bill for the expensive helicopter! And that the pilot's skills enabled the "find."

As with charter helicopters, SAR team leadership must also be aware of the operational and altitude limitations of media aircraft and their pilots. Nonetheless, these extremely valuable resources should never be overlooked.

Some state SAR teams make little use of private helicopters. For example, California rescue teams occasionally receive support from military aircraft, they seldom engage media or charter helicopters.

Military Helicopters

Because the armed services have a budget to assist civilian search and rescue efforts, SAR teams are increasingly undertaking missions that involve collaboration with military helicopters stationed at local Army or Air Force bases. The US military generally employs three types of helicopters to assist in SAR work: the double rotor Chinook and the single rotor UH-70 Lakota and Blackhawk. The UH-70 Lakotas are used less frequently for mountain activities due to their altitude limitations.

Requests for Army air support are made through the Air Force Rescue Coordination Center (AFRCC) headquarters. Since missions requiring this type of air support are generally multi-agency missions, these requests are made by the local sheriff's office or, when present, by the State Mission Coordinator for the state SAR agency.

Requests for Army air support are made through the AFRCC headquarters. Photo: Scott Darsney

National Guard resources may also be requested through the state's National Guard Joint Operations Centers.

While military helicopters are often operated by some of the best pilots in the country, they frequently fly in environments different from those found in mountain rescue. This environment includes more than just the physical geography of the flight, and may include the radio frequencies available, the types of maps used and the required crew size to fly a mission.

Part
2

Part 2 – What Makes a Helicopter Fly (Besides Money)

Aerodynamics

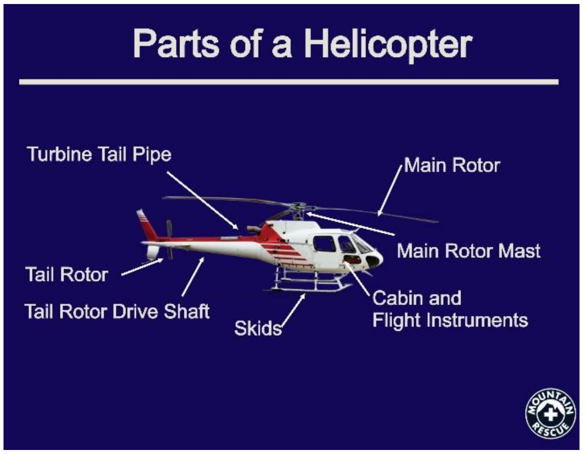
Most helicopters operate with a single main rotor coupled with a single tail rotor. If a helicopter with a single main rotor lacked a tail rotor, the torque of the main rotor would cause the fuselage of the ship to spin in the direction opposite to that of the rotor blades. The tail rotor acts to counteract the effect of this torque, allowing the helicopter to fly without spinning. Twin rotor helicopters correct the spinning effect of this torque by having the two main rotors turn in opposite directions.

The actual "lift" in a helicopter is accomplished by the main rotor blade, which has a cross-section similar to the wing of an airplane. As this "wing" moves through the air, spinning on an engine-driven shaft, lift is generated. The amount of lift generated is dependent on the "pitch," or the angle of attack of the rotor blade through the air.

If you extend your hand out the window of a speeding car and move the angle of your hand up from the horizontal position, you can feel the lift produced as the angle is increased. A rotor blade works in the same way.

Helicopter Design

The main rotor is the rotor that rotates on the horizontal plane. The main rotor turns at speeds of approximately 300 RPM. In helicopters with a single main rotor, the tail rotor is the smaller rotor in the rear or the aircraft, rotating in the vertical plane. The tail rotor generally turns between 1,500 - 1,800 RPM, making it impossible to see while in motion, **especially at night.** The dangerous speed and near-invisibility of the tail rotor have important implications for helicopter safety. The cabin is defined as the internal portion of the helicopter where pilots and passengers are seated.



Rotor Systems

There are two basic helicopter designs, the single main rotor helicopter or the dual (a.k.a. tandem or twin) main rotor helicopter. The most common design uses a single main rotor, which imparts lift and thrust, and a smaller tail rotor, which compensates for torque induced by the powered turning of the main rotor.

Some helicopters have dual main rotors, mounted in tandem, side-by-side or one above the other. The two rotors can then correct each other's torque by turning in opposite directions.

Helicopter Controls

Helicopter flight requires a pilot to master four controls and their interplay. These are:

- Collective Pitch Control
- Throttle Control
- Anti-Torque Control
- Cyclic

Collective Pitch Control

The "collective pitch control" lever is located to the left of the pilot and moves in a simple up and down motion. It is important to note that the location of the pilot in the aircraft is not standardized. In many helicopters, the pilot sits in the right hand (starboard) seat, while in others he or she sits on the left. The collective pitch control is positioned relative to the pilot's seat (to its left) and not simply on the left (port) side of the aircraft. The collective allows the pilot to vary the angle of attack, or "pitch," of the main rotor blades, increasing the corresponding lift. For turbine engine helicopters, as the collective pitch control is pulled up, the angle of attack of the main rotor blade is increased. As the pitch of the main rotor blades is increased, power must be increased to assure a constant r.p.m. A fuel governor accomplishes this by providing more fuel to the engine as the pitch is increased.

Throttle Control

The throttle increases or decreases the rate of revolution of the main rotor blade. On piston engine helicopters, the throttle is mounted to the collective pitch stick to allow for their coordinated use. Increasing the pitch of the main rotor blades requires more engine power to maintain rotor RPM when the helicopter lifts off or climbs. On turbine-powered helicopters, this power coordination is accomplished automatically through the fuel control and governor systems of the turbine engine.

Anti-torque Control

The two floor pedals provide "anti-torque" control by varying the amount of thrust generated by the helicopter's tail rotor by adjusting the pitch (angle of attack) of the tail rotor blade(s). This thrust counteracts the torque generated by the helicopter's main rotor. Anti-torque control is essential: it prevents the helicopter from spinning out of control. By maintaining tail rotor thrust equal to main rotor torque, the helicopter will hold a hover without spinning in any direction. While in a hover or at low airspeeds, the pilot can change the aircraft's heading by increasing or decreasing the anti-torque. With the initiation of forward movement, the pilot must blend pedal action with other control movements to produce a coordinated flight.

On dual rotor helicopters, the problem of torque control is solved through the counter-rotation of the main rotor blades. Manipulation of the relative torques of the two main blades affords heading and directional control in a hover.

It is important to recognize that while anti-torque control provides helicopters with substantial maneuverability, it can become an important liability as well. Sometimes wind conditions, altitude and the limitations of engine performance conspire to create a situation where the maximum thrust provided by the tail blades is insufficient to counteract the torque generated by the main rotor. When this occurs, the aircraft will enter into an uncontrollable turn, a circumstance dangerous for all on-board.

Cyclic Control

The final primary flight control is the "cyclic" control stick, which is controlled by the pilot's right hand via a lever that projects between the legs. The cyclic pitch control produces changes in pitch to each rotor blade individually. If the pilot pushes the cyclic stick forward, the pitch of each blade is increased as it sweeps toward the tail of the helicopter. As each blade swings forward, toward the nose of the helicopter, pitch is flattened. The result is that each blade produces more lift as it swings to the rear than when it swings ahead. Lift-thrust force is produced in the rear, which elevates the tail of the helicopter.

Directional movement of the helicopter (including bank during turns) and speed in forward flight are achieved by use of the "Cyclic Control." The main rotor system is tilted in the direction of the stick movement.

This principle occurs whenever the cyclic is moved, allowing the pilot lateral and roll control of the helicopter.

To hover and move to the left, pitch is changed to each blade, producing more thrust as it swings to the right. A side ward force is produced, pushing the helicopter in that direction. To move to the right, the rotor blades are unbalanced and more thrust is produced over the left side of the helicopter.

Types of Landing Gear

Several types of landing gear are found on helicopters. Each type of landing gear provides a unique function relative to others. The most common types of landing gear are detailed below:

Wheels

Wheels are primarily used on medium- and heavy-class helicopters. Helicopters with wheels are often capable of movement on the ground, an important ability when necessity requires repositioning at a heliport.

Skids

Skids are the most common type of landing gear used in light- and medium-class helicopters. Skids are permanent, non-retractable horizontal "feet" which provide a long, flat touchdown surface for the helicopter. Tundra pads and snow pads may be used for weight distribution when landings are required in areas where helicopter weight may cause the ship to settle on landing.

Floats

Floats can be used on land as well as water. There are two types of floats, "fixed" and "inflated."

Retractable Landing Gear

Some of the more refined helicopters are equipped with landing gear that may be retracted during flight. The retraction of landing gear makes the helicopter more aerodynamic.

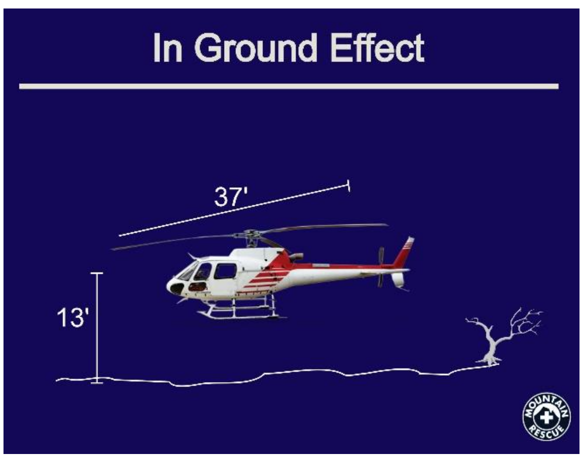
Part
3

Part 3 – Principles of Flight

Certain terms and concepts are vital to helicopter aviation. Familiarity with them is essential for all those working around helicopters. The most common are detailed below.

Ground Effect

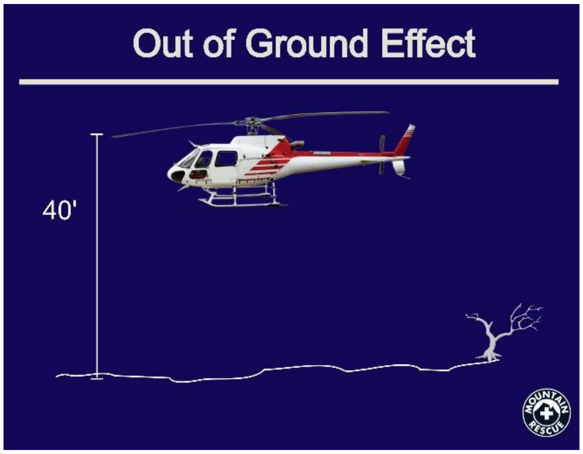
Ground effect is a condition of improved performance that a helicopter experiences when operating near the ground. It arises from an interaction between the helicopter's rotor wash and the ground and becomes more pronounced the closer the helicopter is to the surface beneath it.



In Ground Effect (IGE)

In Ground Effect (IGE) is the effect on the performance of a helicopter caused by the return of the rotor wash from the ground. As the helicopter's main rotor turns, its wash presses against the ground, creating a cushion of air beneath the hovering helicopter. This compressed air provides additional lift to the helicopter. Once the helicopter is above the ground by a distance equal to the diameter of the main rotor, the extra lift furnished by IGE rapidly falls to nothing.

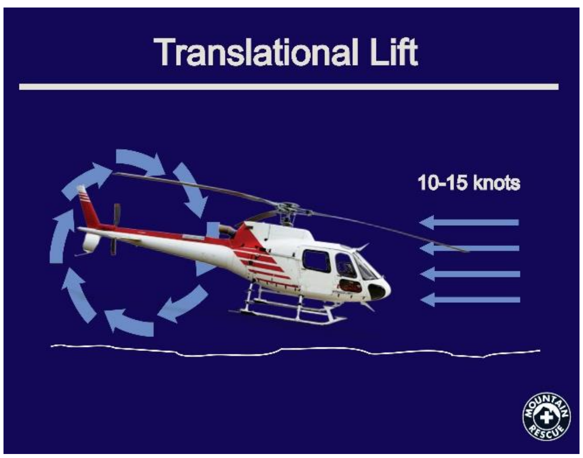
In Ground Effect (IGE) occurs to its greatest extent at approximately one-half of the rotor diameter above the ground. There are additional, technical reasons why ground effect increases lift and allows lift to be sustained with less power. The ground alters the airflow pattern around and through the rotor system. The airflow through the rotor system moves with a lower velocity and, as a consequence, with lower drag. Furthermore, rotor tip vortex generation is reduced.



Out of Ground Effect (OGE)

Conversely, a helicopter experiences "*Out of Ground Effect*" (OGE) performance when the rotor wash is not affected by proximity to the ground. OGE usually occurs when the helicopter is more than one-half of the rotor diameter above the ground. In OGE, a helicopter is power dependent when a hover is maintained. A helicopter will also experience OGE conditions when near to ground if the ground does not allow for the creation of a cushion of air underneath the aircraft. When in hover over tall grass, water, and certain types of rough terrain, a helicopter will not experience In Ground Effect performance. If the pilot is instructed to try to land in these conditions, the helispot should be described as an "*OGE Helispot*."

Many helicopters are able to lift less payload by sling than they can when the payload is on board the helicopter, because sling lifts occur higher off the ground and thus require OGE performance.



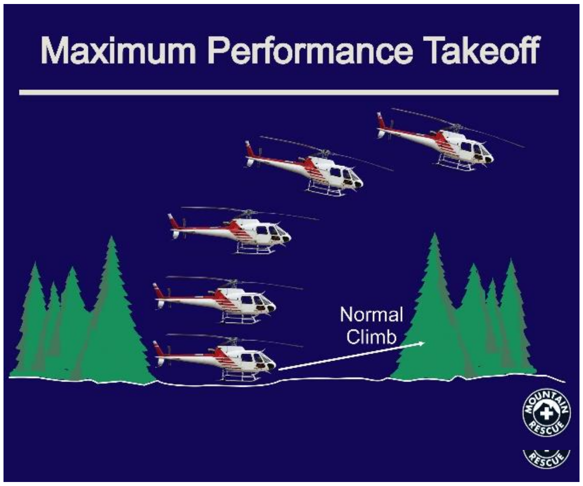
Translational Lift

Horizontal movement of the surface wind increases the efficiency of the hovering rotor. As increasing velocities of airflow enter the rotor system, turbulence and vortices are left behind and airflow becomes horizontal. This improved rotor efficiency resulting from directional flight is called "*translational lift*."

In effect, this is the lift that is obtained from translation from a hover to forward flight. It is felt as a "shudder" in the aircraft.

Effective Translational Lift

At airspeeds between 10 and 15 knots, depending on the model of helicopter, the rotor completely outruns the recirculation of old vortices and begins to work on clean air. Effective translational lift results.

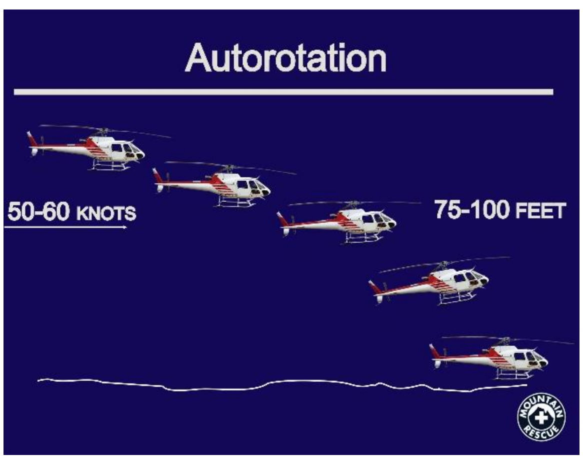


Normal Takeoff

Normal takeoff is the procedure used where flight of the helicopter is not limited by the presence of obstructions---natural or man-made. Normal takeoff is made into the wind to obtain maximum airspeed with minimum ground speed.

Maximum Performance Takeoff

"*Maximum performance takeoff*" is the takeoff procedure used when departing a confined area, that is, where flight of the helicopter is limited by terrain or other obstructions. During the maximum performance takeoff, little use can be made of ground effect or translational lift until the obstruction has been cleared. Thus, the rotor system is less efficient and the takeoff requires a greater demand on the helicopter's power plant, with less engine power in reserve as a safety margin. Confined landing sites are thus less safe and should be avoided whenever possible. It is important to note that the greatest strain on a helicopter's engine occurs during landings and takeoffs, and that confined landing sites leave little room for error.



Autorotation

"*Autorotation*" is the flight condition during which no engine power is supplied to the rotor system and the movement of air up through the rotor blades enables sustained flight. Autorotation allows the pilot to use the inertia generated by this airflow to slow the rate of descent and effect a safe landing. Unlike fixed wing aircraft, rotor wing aircraft are capable of controlled landings during most conditions when power is lost, assuming a suitable landing surface exists below the helicopter. Landing in autorotation is an essential part of training to be a helicopter pilot.

Part 4

Part 4 – Helicopter Management and Safety Precautions

Safety training for any rescue team personnel working with helicopters is essential, and must include which actions to take and which to avoid when working with helicopters either on the ground or in the air.

Those overseeing helicopter operations should conduct a briefing prior to each day's operation. This briefing should set forth the plan of action for the pilots and the ground personnel, including a review of on-the-ground and in-the-air safety precautions. Pertinent safety plans and flight hazard maps should be reviewed before a flight is scheduled. The pilot is responsible for the safety of the helicopter at all times, and should, therefore, participate in operational planning to improve his ability to keep the machine and its occupants safe from harm.

The SAR team should limit helicopter flights to daylight hours whenever possible (defined as ½ hour before sunrise to ½ hour after sunset). The mission's leadership must track wind velocity and visibility in any anticipated flight path and halt any mountain flight when the average wind velocity exceeds a helicopters' limitations.

Passengers of the helicopter should request a briefing from the pilot prior to the flight to ascertain the location of emergency exits, fire extinguishers, the emergency electrical and fuel shut-off, the emergency locator transmitter (ELT) manual switch, first aid kits and survival gear. No unauthorized personnel should be allowed to fly on any mission.

Helicopter hand signals should be used as needed, but only by personnel trained in their use. Finally, all personnel should remain 100 feet away from helicopters, except when loading.

Landing Zones ("LZs")

Contrary to popular belief, helicopters do not normally land "on a dime," but rather require or desire a sizable landing zone, particularly at high elevation. Helicopters generally will not take off or land vertically. Rather, they need a landing zone (often called an "LZ", referred to throughout this material as a "helispot") that may be hundreds of feet long. The ideal helispot is a flat strip 100 feet wide and 300 feet long (roughly the size of a football field). Flat ridges and saddles often provide the best helispots in the field. Highways, streets or roads unobstructed by outlying trees can make for excellent landing zones, but their use requires that law enforcement be available to control traffic and crowds.

A primary reason helicopters need large landing zones is to improve safety. A helicopter is more likely to experience engine failure during takeoff due to the high engine stress takeoff entails, and if it does, it will need extra room to land safely.

Helispots should be defined in such a way that the helicopter can land and take off into the wind to increase lift. Photo: Charley Shimanski

Remember that a helicopter experiences "*Out of Ground Effect*" (OGE) performance when the ground is not close enough to allow interaction with rotor wash. In OGE, a helicopter's hover depends entirely upon engine power, receiving no assistance from the ground. When considering landing zones, it is important to remember that OGE conditions can occur near the ground when the helicopter hovers over tall grass, water, and certain types of rough terrain. As noted above, any helispot with these features should be described as an "OGE Helispot" to warn any pilot trying to land at the site.

Helispots should be designed in such a way that the helicopter can land and take off into the wind to increase lift. SAR teams should create "*hover hole*" helispots only as a measure of last resort. A *hover hole* is a landing zone where, due to its size restrictions or the presence of obstacles, the pilot must slow to a hover above the landing area and then descend to the ground. When taking off from a *hover hole*, the pilot must use all available engine power, leaving little or no room for error. The dangers are obvious; therefore, *hover holes* should be avoided whenever possible.

Since the typical helicopter can kick up rotor wash in excess of 100 mph on takeoffs and landings (significantly more on Chinooks), the helispot should be free of lightweight objects that will blow away. The landing site should be free of tall dry grass and shrubs to prevent possible damage to the sensitive tail rotor. Tree stumps should be less than 1 foot high. A snowfield can make a good helispot, but markers such as backpacks must be placed near the helispot to give the pilot some sense of depth perception.

The last decade has seen an increased ability to undertake night operations as the ability to fly under instrument flight rules has become increasingly common. Since night landings and takeoffs are significantly more dangerous than those made by day, SAR team leaders must consider whether the benefits of night operations outweigh their risks. If the team decides that a night flight is absolutely necessary, then every effort should be made to inform the pilot of the optimal flight paths to avoid hazards such as trees, peaks, ridges and especially power lines. At night, rescuers can use headlamps to mark a helispot, provided the lamps are able to provide steady and consistent light.

Alternatively, two vehicles can illuminate a helispot with headlights. To do so, the vehicles should be positioned 40 yards downwind from and at opposing 45-degree angles to the landing site. The helicopter will then approach between the two vehicles and will land near the intersection of their lights, roughly 40 yards upwind from the vehicles. These vehicles should have **low** beams on so as not to blind the pilot or flood the instrument panel with light.

In the event that the pilot cannot locate the proposed helispot, due to other surface lights in the area, emergency vehicle lights can be illuminated. As the helicopter approaches, put out all lights except those used to illuminate hazards and the touchdown pad. All strobes and rotating beacons must be shut off as well, as this can cause vertigo and affect the pilot's horizon.

Landings and Takeoffs

Landings and takeoffs are generally made easier in the presence of a light, steady breeze (such as 10 knots or 12 mph) than in still air. In addition, the pilot may choose not to take off or land in a wind greater than 45 knots (approximately 50 mph) or with a gust spread of over 20 knots (23 mph).

When landing, a pilot will often make a high level pass over the helispot to note obstacles and wind indicators and then will come in on a "final approach," where he or she attempts to land. All personnel not in the helispot should resist the desire to watch the helicopter and to look away to avoid injury from flying debris kicked up by the rotor wash, especially during Chinook landing or takeoffs. All ground staff must secure any loose gear.

During final approach, only one ground crew – the person working as 'parking tender' - should be in the helispot. With the helicopter some distance away, the parking tender will indicate the touchdown point by standing upwind of the landing site with his or her back to the wind while pointing with his or her arms toward the desired landing spot.

The landing zone should be clear of rescuers during any attempted landing on snow or ice. There is always the chance that the helicopter's weight will cause it to settle in the snow, which could be dangerous for any rescuer in the helispot. This sudden shift in snow after landing led to a nearly fatal accident on Mount Robson, Canada, in 1981.

Parking Tenders

To a helicopter pilot, the parking tender may be the most critical person in the field. This guide, designated by the field site commander, should be the person most familiar with helicopter operations, including landing zones, ground-to-air communications and helicopter safety. Once the helicopter is within radio range, the parking tender should make radio contact with the pilot. Knowing that a knowledgeable parking tender is available will ease the mind of most pilots flying into mountainous terrain. As the ship enters the area of the rescue, the parking tender's communication with the pilot becomes essential.

Knowing that a knowledgeable parking tender is available may ease the mind of most pilots flying into mountainous terrain. Photo: Ryan Schumacher

Ground-to-Air communication during landings and take-offs

Radio communication from rescuers on the ground to the helicopter pilot and/or crew is essential for rescuers to safely land a helicopter at a proposed landing zone. Any pilot on an incoming ship will want to know the precise location of the proposed landing zone. The location should be clearly specified, using landmarks such as roads. Pilots generally do not carry the usual 7.5' USGS quadrangle maps used by ground search teams.

The helispot should also be clearly defined. This may be an empty parking lot near the Incident Command Post. More likely, the landing site will be in the mountains, requiring a general description of its terrain. Its elevation should be stated, as well as any obstructions to include their distances and bearings (e.g. "100 foot tower 300 feet SSE of helispot"). Aerial wires **must** be mentioned, as these are often unmarked and very difficult for a pilot to see. The 1988 KUSA helicopter crash that killed pilot Galanis and photographer Hostetler was the result of unmarked power lines. Today, those same lines have "floaters" on them. The ground team should provide wind indicators whenever possible and alert the pilot to obstacles in the flight path.

Most pilots require longitudinal/latitudinal coordinates when attempting to find a helispot. Any team member proficient in reading topographic maps should be able to provide this information. Those unfamiliar with topographic maps should take caution before reporting coordinates: it is easy to confuse GPS longitude/latitude coordinates with Universal Transverse Mercator (UTM) coordinates. A simple mistake can send the helicopter to Bolivia!

Once the parking tender has the helicopter in sight, it should be easy to direct the pilot to the proposed helispot. This is done using the clock method. Imagine the helicopter mounted on the base plate of a clock. The helicopter's nose points to twelve o'clock, its tail to six o'clock.

Using this orientation, you can easily guide a pilot to your location by telling him or her, for example, "The helispot is at **your** 2 o'clock." Combining this orientation with an estimated distance from the ship to the helispot will greatly assist the pilot.

Finally, the ground team must communicate weather conditions to the pilot. The *ceiling* is the distance from the ground to the lowest clouds, and should be stated in feet. *Visibility* is stated in miles. Temperature is very important, as is an estimate of wind velocity, direction and *gust spread*. *Gust spread* is the difference in speed between the lightest gust of wind and the heaviest, e.g. 10-25 mph. Parking tenders should make note of this information while the helicopter is en route and read from their notes to the pilot as the helicopter makes its approach.

Mountain flight is challenging, and providing pilots with an indication of wind direction and velocity is one of the most valuable tasks that the parking tender can perform. While some groups employ small film-canister size smoke grenades, most teams wisely avoid use smoke grenades altogether because their use entails a high risk of fire. The helispot manager's observations coupled trail tape streamers are equally effective at determining wind direction and are less dangerous. Streamers or plastic flagging in bright colors may be tied to rocks, bushes, trees or poles.

If smoke grenades must be used, the parking tender should activate them downwind of the helispot, and to one side of the approach pattern, as the helicopter makes its high level pass over the helispot. If wind is light (under 10 mph) and variable, smoke may obscure the helispot and become more of a hindrance than help. Commercial smoke grenades, usually about the size of a film canister, will release smoke for less than a minute. Parking tenders should wear gloves when activating them. As opposed to commercial smoke grenades, most military grenades generate too much heat to be safely held in hand.

Wind indicators should be placed as close to the edge of the helispot as is safe, so that the pilot gets a true picture of the wind currents moving close to ground at the site. It is important to ensure that streamers or flagging are secured so that they are not blown free by the helicopter's rotor wash. Parking tenders or other rescue team members should establish these wind indicators well in advance of the helicopter's arrival.

Wind coming over a ridge can change speed and direction throughout the day. By positioning some flagging to the sides of the landing site on the ridge top, the team can note the nature and timing of this change and provide valuable information to pilots and flight crews.

Even in the absence of an experienced parking tender, it remains important that some rescue member still establish communication with any incoming helicopter. A pilot will easily be able to ask the right questions of the untrained person to determine the landing conditions. To a pilot, an inexperienced ground contact is much better than no ground contact at all!

Hand Signals

When properly employed, hand signaling can provide an additional means for those on the ground to communicate with a pilot. SAR teams must take care with their use, however, or risk confusing pilots with unclear or inadvertent (wrong) messages. If a pilot is to successfully receive hand signals by a rescuer, the pilot must be able to identify the individual making signals. This means that, whenever possible, the SAR team should tell the pilot how the signaler is dressed and where he or she is located. The rescuer attempting signal communication must be familiar with the standard hand signals. Arbitrary or improvised signals have no role in the communication between ground teams and air support, and serve only to confuse or mislead pilots. For example, when rescuers attempt to guide a helicopter pilot to a landing zone by waving their arms back and forth, they risk dismissing the pilot. The ‘waving arms’ is the "Wave-off" signal that tells the pilot not to land! In a recent SAR mission, field team members who were expecting a helicopter ride back to the Incident Command Post were left in the field because they used the "wave off" to catch the pilot's attention. The pilot **did** see them, and interpreted this as a signal to leave the area, and he did so. The result... a long walk out for the field team. Their spontaneous signaling conveyed the wrong message to pilot. Be careful not to use hand signaling unless you are using it appropriately.

The "Wave-off" signal tells a pilot NOT to land due to hazards. Photo: Charley Shimanski

When a helicopter is landing at any heliport or helispot, it may be necessary to have a SAR team member acting as helispot parking tender, guiding the pilot to the helispot with hand signals. The hand signals employed in a standard landing are as follows. First, as the helicopter makes its high level pass and as it begins its final approach, the helispot parking tender stands at the end of the helispot, with his or her back to the wind. The arms are extended towards the landing area, which means "Land here, facing me, my back is to the wind." Then, as the helicopter approaches the helispot, the parking tender extends his or her arms outward with clenched fists, which means, "Hold your hover."

As the helicopter skids or wheels get within several feet of the ground, the arms are slowly swept downward, indicating "move downward." As the helicopter skids or wheels touch the ground, the parking tender should hold the arms extended outward at a 45 degree angle to the ground with the thumbs pointing downward. This says to the pilot "Hold your helicopter on the ground. Then, if the helicopter is to come to full rotor stop the parking tender crosses the neck with the right palm facing down (a.k.a. "kill it"). This means "Shut down your engine(s)."

If the parking tender is confident that the pilot is on final approach to the desired helispot, there may be no reason to continue to stand in the middle of the helispot and get blasted by the rotor wash. The parking tender may wish to alert the pilot that she or he will move away from the helispot as the helicopter approaches.

A pilot might often choose to ignore a rescuer's hand signals. In doing so, a pilot is not demonstrating a lack of familiarity with the signals, nor a callous disregard of the rescuer. Rather, a cautious pilot may be uncertain as to whether or not the rescuer is indeed familiar with the signals, or may not trust the rescuer. Pilots are not mind readers and they have every right to trust themselves more than a stranger. Furthermore, the pilot may be aware of terrain challenges and weather conditions unknown to the rescuers on the ground and so may choose his or her own angle of approach. Nonetheless, a simple familiarity with these signals is valuable and should be embraced by any search and rescue team member that may work around helicopters.

Attached to this document are examples of helicopter hand signals.

Rescuers should always approach and leave the helicopter with head and equipment low. Photo: Todd Rector.

Safety Precautions on the Ground

It is vital that SAR teams train their rescuers in these safety precautions to ensure a thorough understanding of how to work safely around a helicopter while on the ground.

Ground personnel should **never** run when approaching or leaving a helicopter. Furthermore, they should always approach and leave the helicopter with head and equipment low, but maintain eye contact with the pilot when doing so. Approaches should be made in a crouched position from the front or side of the helicopter and in full view of the pilot (except with Chinooks).

A helicopter should never be approached from the side where the ground is higher than where the helicopter is standing or hovering.

Rescuers onboard a helicopter must observe safety requirements when flying in commercial light helicopters. First, they should wear a helmet at all times when near or onboard the helicopter. Fire-resistant clothing and leather boots should be worn, if at all possible.

For Department of Interior (United States Forest Service, National Park Service and Bureau of Land Management) contracted helicopters, rescuers MUST have NOMEX clothing, all leather boots, and an approved helmet.

Rescue members should carry a portable two-way radio capable at a minimum of transmission on air-to-ground and ground-to-ground frequencies. If at all possible, rescuers should wear the radio in a chest harness to allow easy access, but should turn the radio off while onboard to avoid feedback with the on-board radio headsets. Rescuers should also carry a backpack. In military helicopters, the pilot may request the backpack be stowed in a cargo bay. Whenever a rescuer is going to offload in a one-skid or hover jump situation, however, the rescuer should store his or her backpack securely between the legs with all loose items secured. (An errant water bottle caused a helicopter at Sequoia-Kings National Park to make an unscheduled emergency landing in 1998).

Passengers must inform the pilot if they intend to carry any explosive, flammable or otherwise dangerous materials on board, to include any firearms.

In-flight Precautions

While helicopters are in flight, rescue personnel on board the helicopter must follow several principles to help ensure safe flight.

First, the pilot's word is final as to whether or not a flight can be made.

Before takeoff, all passengers must fasten and adjust the safety belt and shoulder harness. After landing, they should keep this equipment fastened until instructed to leave the helicopter. The passenger should refasten this equipment on the seat and assure that no belts are outside the helicopter as the door is closed.

Passengers must locate the emergency exits and review exit instructions. There should be **NO SMOKING** during takeoffs or landings. Even at the pilot's discretion, rescue personnel will **NOT** smoke during the flight.

Rescuers must keep clear of all flight controls and must hold maps and papers securely while in flight. They should keep track of the aircraft's general location during the flight, and should assist the pilot by keeping alert for hazards, particularly other aircraft and power/telephone lines. They must inform the pilot when they see these hazards and where the hazards are located. When requested to do so, rescuer should also assist the pilot in watching tail rotor's clearance during landings at field landing sites.

Occasionally, helicopters will be used with the doors removed or left in the open position. In these circumstances, make sure nothing can accidentally fly out of the helicopter. If necessary, put away all maps, notebooks, and secure everything loose. It doesn't take much to damage a tail rotor.

Do not throw objects out of the helicopter at any time, except when instructed by the pilot to do so. It is essential to communicate with the pilot when moving objects into or out of a helicopter, to prevent disrupting its balance. Do not move about the helicopter while in flight.

With the assistance of the pilot, maintain radio communication with the heliport and/or the command post at all times.

One-wheel or one-skid landings should not be performed without the approval of the Heliport Manager, Operations Chief and/or the Incident Commander.

Loading and Unloading

Approaching the Helicopter

SAR team members and other ground crew should not approach the helicopter until it has completely landed and the pilot has given the signal to approach. After initial touch down, a pilot will often make small adjustments to the aircraft's position to ensure it is fully settled before powering off. A noticeable change in the pitch of the engine's hum accompanies this drop in power to the main rotor and alerts ground staff it will soon be safe to approach the ship. Pilots often give the universal "thumbs-up" sign to indicate that they are ready for ground staff to approach.

When approaching a helicopter, rescuers must carry all equipment such as packs, skis, snowshoes, and ice axes horizontally below waist level to prevent contact with the rotor blades. One should never equipment upright or over the shoulder. Skis are especially dangerous, given their length and the tendency of mountaineers to carry them upright over one shoulder. Avoid this practice when approaching a helicopter, unless you like **reeeeeeeeeally** short skis.

Rescuers should approach the helicopter towards its front, in clear view of the pilot. One must **never** approach a helicopter from behind or to the rear of the skids or the side doors. If you must change sides, do so by passing around the front of the aircraft, where you and the pilot can always see each other. Rescuers should move toward the aircraft in a squat to maximize clearance from rotor blades. Although moving in crouched posture, resist the tendency to look down; **always** look at the pilot. Depending on the helispot's terrain, wind and other flight factors, the pilot may have to maintain engine power. If these circumstances, the helicopter may pull off suddenly due to precarious positioning, or if it goes into ground resonance (harmonic imbalance between landing gear and rotor blades causes the helicopter to vibrate dangerously). In either of these cases, the helicopter **must** become airborne. Visual contact between pilot and approaching rescuers allows for emergency communication should the need arise.

If it becomes necessary that a rescuer approach the helicopter without first being signaled to do so, that person should stand directly in front of the ship and wait until she or he has the attention of the pilot or crew chief. The rescuer should then point directly at the ship, an indication that the rescuer wishes to approach the helicopter. The pilot or crew chief will generally signal the rescuer to approach.

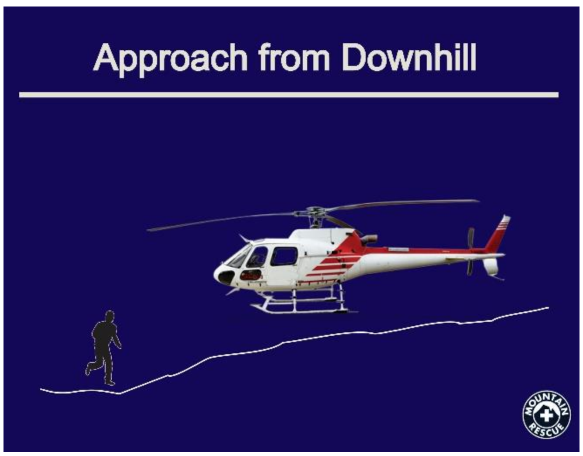
Chinook helicopters present an important exception to this rule. A rescuer should *never* approach a Chinook from the front.

If the helicopter is going to shut down completely (come to a full rotor stop) and the pilot intends to leave the aircraft, then no rescuer should approach the aircraft until the blades have come to a FULL STOP. Plan on at least two minutes per engine to cool down.

There should be no smoking within 200 feet of the helicopter during landing, loading or takeoff procedures. There must be **NO SMOKING** while aboard ANY aircraft at ANY time.

Loading and Unloading Safety Procedures

The guidelines listed below detail proper loading and unloading of a helicopter while the helicopter remains under full rotor power. While terrain, weather and the circumstances of rescue sometimes conspire to require movement into and out of a helicopter underneath its spinning blades, it remains vital to recognize the significant danger such movement poses to both rescuers and flight crew.



All loading or unloading must take place on the downhill side of the ship, since the rotor blade may be as close as 5 feet to the ground in many models, even when the ship is on level ground.

For all but the Chinook, loading should be from within 60 degrees of the front of the aircraft to ensure visual contact with the pilot.

The tail rotor must be avoided at all times. This rotor is not visible while turning at high speed and has decapitated careless passengers. The pilot must see all personnel within reach of the tail rotor so that she or he can avoid striking them with the helicopter's tail should the need arise to turn the aircraft.

Every rescuer on board a helicopter should wear Personal Protective Equipment (PPE). PPE includes the following essentials:

- Helmet with the chinstrap securely fastened
- Eye protection, such as shatterproof glasses
- Ear (hearing) protection

Finally, search and rescue teams should consider use of fire-resistant clothing such as NOMEX suits whenever possible, noting that such suits are often impractical for field rescue personnel in mountain rescue operations. As mentioned earlier, the U.S. Department of Interior requires all rescuers aboard its contracted helicopters to wear NOMEX suits, all-leather boots, and an approved helmet.

Rescuers should carry, not wear, their packs as they approach the aircraft. A worn pack will prevent proper use of the seat harness and removing it on-board can delay proper stowage. Once on board, rescuers should immediately fasten their seat belt and secure their equipment.

It is highly unlikely that SAR team members will be involved in a crash while aboard a helicopter. Still, if your pack is small enough and can be safely secured between your feet (instead of stowing the pack in the luggage compartments), you may want to keep it within reach when loading the helicopter. This way, you have your survival gear and, hopefully, a hand-held radio nearby in the case of a crippling crash.

For one-skid or hover boarding and exiting operations, extra caution must be used, and a few signals and procedures discussed beforehand with the pilot. Photo by Charley Shimanski/Air Zermatt

Unloading the helicopter requires the same attention to safety and follows the same procedures as loading. To reiterate, all personnel will exit downhill toward the front of the ship (except with Chinooks) and NEVER towards the tail. Rescuers should leave the helicopter only when specifically told to disembark and should keep their heads low as they do so. Prior to exiting, rescuers should refasten their seat belts underneath them so that the belt cannot fall outside and bang against the fuselage while in flight.

One-Skid Landings

Generally, a helicopter will be fully on the ground when rescuers enter or exit. There may be conditions, however, when the pilot is only able to put one skid down and may actually be in a semi-hover while rescuers exit the ship. This situation is called a "*one-skid landing*."

One-skid landings occur when one skid or one wheel of a helicopter is in contact with the ground while the rest of the helicopter remains suspended in the air under the power of the rotor blades. Rescuers must employ extra caution when boarding or disembarking from aircraft in one-skid landings or in hover. It is essential that all involved discuss the procedure with the pilot and familiarize themselves with important signals before attempting these potentially dangerous maneuvers.

Helicopters are very sensitive to weight and balance. Stepping in or out of a helicopter balancing on one skid should be done very **e-a-s-i-l-y** to avoid radical weight change on one side of the ship. The probability of a downdraft, power settling, or recirculation effect occurring is high during a hover or one-skid – conditions that can require the pilot to act quickly and can put unprepared rescuers in peril. It is therefore essential that the rescuers communicate clearly with the pilot throughout one-skid loading or unloading. Even when a one-skid load is performed perfectly, the pilot will need time to adjust the controls for the increased or decreased load coming onto or off of one side of helicopter. The last thing the pilot wants is for a clumsy, adrenaline-loaded 200-lb. rescuer to jump anxiously from the ship.

To exit a helicopter in a one-skid landing is careful, multi-step process. You should open the aircraft door only after the pilot has told you to do. Once the door is open, tell the pilot you are preparing to drop your pack out. Shifting weight in a small helicopter can throw the balance of the ship, and the pilot must be prepared. With your headset still on, tell the pilot "On the count of three, I will drop my pack out...one, two three." After gently dropping the pack out of the helicopter, prepare to exit the ship.

Complete all communication with the pilot while wearing your headset. Once the headset is removed, the pilot will be unable to hear you and only simple hand signaling will remain at your disposal. You should inform the pilot the movement you intend to take and ask for confirmation: "I will step smoothly from the ship after I give you the count of three...do you understand?" The pilot will agree or advise otherwise. At this point, upon approval from the pilot, remove your headset. Then remove your seat belt and refasten it behind you while remaining seated. Then prepare to exit, and give the pilot the count of three. Once on the ground, you should quickly distance yourself from the ship, moving towards the front and downhill so the pilot can take flight as soon as possible. If you cannot move away, stay as low to the ground as you can.

If more than one rescuer is to disembark via a one-skid landing, each rescuer should do so one at a time. Rescuers in the back seats of small aircraft must take extra care to communicate clearly since it is often impossible for the pilot to see them.

Terrain challenging enough to require one-skid loading or unloading is often steep and cragged ground. Although such terrain can constrain your movement once you exit the aircraft, you must not run uphill into the path of rotor blades or scramble out along a rock arête where one slip will mean a long fall. If you cannot move away from the helicopter, hold your position and wait for the aircraft to complete its task and take off. It is important to remember the hazards inherent to mountain terrain, hazards easily neglected when the full-throttle of a helicopter engine is screaming close above your head. Allow the helicopter to lift away into the air before continuing your search and rescue work.

SAR teams should try to find or make a place to land, rather than turning routinely to high-risk one-skid or hover-loads. An ordinary evacuation of a lost subject or victim with a broken leg can transform into tragedy the instant a helicopter goes down.

Air-to-Ground and Air-to-Air Communication

The Incident Command Post or Air Operations Branch Director may or may not have direct radio communications with helicopters involved in a search or rescue operation. TV, private, media and HEMS helicopters may or may not be equipped with the local/state SAR or EMS channel. Army helicopters (Chinooks, UH-70 Lakotas and UH-60 Blackhawks) may not be equipped with programmable radios and may be required to use specialized aviation frequencies or other common emergency frequencies such as National Law Enforcement Channel (NLEC) at 155.475 MHz or Fire Emergency Radio Network (FERN) at 154.280 MHz.

Field teams should avoid ground-to-air radio communication unless they have something very important to communicate. Even though field teams will likely hear air-to-ground radio traffic, including inquiries from the helicopter crew, the helicopter crew often has a more difficult time receiving radio messages from the ground.

On board civilian helicopters, either the pilot or the spotter can communicate over specific radio channels, as dictated by the pilot. As mentioned earlier, the spotter should minimize unnecessary communication with the pilot, since the pilot must monitor additional radio traffic that the spotter may not hear on his/her headset. Generally, the pilot will give the spotter specific instructions on how to communicate with the Incident Command Post or ground personnel using the ship's radio.

Rescuers should minimize radio communication with the pilot, since the pilot must monitor additional radio traffic that the spotter may not hear on his/her headset. Photo: Charley Shimanski

If a helicopter employed for searching lacks the local/state SAR or EMS channel on its radio, the spotter can use a handheld radio on board. Magnetic and audible noise often interferes with these handheld devices, however, rendering the quality of their transmission and reception poor. Use of a headset connected to the handheld radio in place of the handheld's built-in speaker and microphone can improve the quality of communication.

Air-to-Air Communications

When multiple helicopters are operational, it is important for SAR command to alert each airborne aircraft when others take flight. These aircraft can often communicate with each other air-to-air (often on a VHF frequency such as 123.025) to prevent interference between aircraft. To do so, however, each aircraft must first know that the other is in flight nearby. Pilots' attention to air-to-air coordination helps the SAR Manager focus on ground operations.

Sterile Cockpit

The *'sterile cockpit'* is a safety concept embraced by the military and professional air carriers and one with which SAR teams should be familiar. A cockpit becomes *sterile* when all crew cease unnecessary and casual communication. It mandates no conversation on the aircraft intercom radio during departures and arrivals until a safe altitude is reached. A sterile cockpit allows the crew to focus solely on clearing the airspace and communicating with air traffic control.

Part
5

Part 5 – Search and Rescue Helicopter Operations

Rescuers aboard Helicopters

Rescuers must board the helicopter fully prepared to hike out. Flying conditions can quickly deteriorate, and a flight in does not guarantee a flight out. In fact, a helicopter may be able to safely land to avoid dangerous weather, then be grounded when the weather fails to improve or when an unforeseen technical malfunction renders flight impossible.

Rescuers aboard any helicopter must board the helicopter fully prepared to hike out. Photo: Bill Vargas

A rescuer aboard a helicopter may find it difficult to follow the course of the ship on a map in unknown territory. For this reason, rescuers should study their topographic map carefully before takeoff, and look for prominent landmarks as soon as the ship is airborne.

When a SAR team has the opportunity to put a rescuer on board a helicopter during a mission, the team's leadership should always choose rescuers experienced with helicopter operations and proven to have stomachs strong enough for helicopter flying. Unlike fixed-wing flights, helicopter flights are often akin to a roller coaster ride without the tracks in front. Search and rescue helicopter flights should not be bestowed to a SAR team member to reward his or her efforts organizing or in the field – they should be staffed with the rescuers well-trained and familiar with helicopter operations.

Dogs aboard Helicopters:

Search and rescue dogs can be trained to ride in helicopters. Dog handlers and other SAR professionals should recognize, however, that dogs will find several aspects of helicopter flight uniquely challenging.

Dogs can be trained to ride in helicopters during search and rescue operations. Photo courtesy Flight for Life Colorado

First, dogs have very sensitive ears and they react to vibrations – especially low frequency vibrations. The larger the helicopter, the lower the frequency of vibrations. Dogs can become fearful when approaching or riding in these larger aircraft. Handlers should be prepared to carry the dog on board. Additionally, handlers should make sure the dog has relieved itself before the helicopter approaches – or the dog may just do so promptly after boarding.

Some dog handlers will use an Ace-bandage to wrap a dog's mouth to prevent the dog biting anyone in response to the stress of loading and flight.

While in flight, the dog handler should talk to the dog, and reassure it that everything is OK. The dog takes its cues from the handler.

Additionally, the fumes from helicopter engines and mechanicals can hinder a SAR dog's ability to search. The smell of burning aviation fuel can be strong and is often disruptive for a dog.

Chinook and other military helicopters generally have some amount of hydraulic fluid on the floors and ramps of the helicopters. This fluid can irritate a dog's paw, especially if the paw is injured or raw.

Nicholas Razum, one of the founders of the search dog unit within the Los Angeles County Sheriff's Department, has developed an informative web site on search dogs and helicopters. (For more, go to http://www.helitac.net/).

Searching From Helicopters

When helicopters are employed during search operations, a rescuer, called a "*spotter*," will fly with the pilot. The pilot must devote full attention to the helicopter; it is the spotter, therefore, who conducts the search.

As noted above, a spotter may find it difficult to follow the aircraft's course on a map in unknown territory. Especially in this case, spotters should study their topographic map carefully before takeoff, and look for prominent landmarks as soon as the ship is airborne. Finding a search subject in the middle of a rocky outcrop provides little assistance to the SAR team if you have no idea where that rocky outcrop is.

If at all possible, the spotter should be an experienced rescuer, one familiar with communications to ground personnel, the nature of the search and the overhead team's definition of "probability of area." The ideal spotter will have experience with helicopter flight, and will not necessarily rely on the pilot to determine which area is best to search. The spotter should also be very familiar with the area of the search, and know where the Incident Commander wants to put the helicopter to work.

The spotter will generally wear a radio headset, provided by the pilot. Using this headset, the pilot and spotter can talk to one another aboard the intercom. In addition, either can communicate over other radio channels, as dictated by the pilot. While aboard the helicopter, the spotter should minimize unnecessary communication with the pilot, since the pilot must monitor additional radio traffic that the spotter may not hear on his or her headset.

Extrication of Subjects by Helicopter

SAR teams must take special care when extricating a subject by helicopter, whether or not the subject is injured. Ground personnel must ensure that everyone, including rescuers, give wide berth to the tail rotor. This is best accomplished by designating two SAR personnel to stand at the front and rear of the ship while it is on the ground.

Rescuers should carefully consider the risk of using a helicopter to extricate uninjured subjects. Photo: Phreakdigital.

Extricating Uninjured Search Subjects

If the subject of a search is located by helicopter, it may be possible to land, pick up the subject and return to the Incident Command Post. Even a straightforward retrieval of the subject can be complicated by weather, poor landing conditions and the subject's lack of familiarity with helicopter safety. Rescuers and pilot must determine if the benefit of immediate evacuation outweighs any risk to aircraft and crew.

If the subject is in good physical condition, the rescue team should consider guiding ground teams to the subject, then walking or driving the subject out of the field. Rescuers must remember that most people are not accustomed to being around a helicopter and that the hazards become very real in the presence of a nervous or excited person approaching a helicopter for the first time. This is no time for heroics when heroics are unnecessary.

Loading of injured subjects will often take place with the rotors turning, increasing the risk to all involved. Photo: Charley Shimanski

Rescuers should not allow subjects to leave the helicopter on their own. In many cases, the first thing a person will do upon exiting the helicopter is walk back towards the tail rotor. The safest course of action, especially when evacuating children, is to allow the engine to come to complete rotor-stop before offloading subjects.

Extricating Injured Victims

Often, rescue personnel will assist HEMS helicopter personnel with field loading of injured parties. Circumstances often require loading while the blades are turning, increasing the danger of the work and, consequently, the need for attention while carrying it out.

As the rescue team members carry the victim to the helicopter, often in a litter or on a backboard, the SAR personnel should seek and accept direction from the flight nurse or pilot, who will choose the path to the loading door of the helicopter. Once the patient is securely loaded on board the helicopter, rescuers should **immediately** exit the area by walking directly to the front of the helicopter as they move away from the aircraft. By doing so, the team avoids the tail rotor and affords the pilot visual contact with all field personnel prior to takeoff.

Emergency Procedures

Unlike fixed wing aircraft, helicopters can often land safely after engine failure if a suitable landing site exists. When power to the main rotor is lost, the pilot will put in negative pitch in the main rotor to initiate a controlled descent at the rate of perhaps 1800 feet per minute in a procedure known as *Autorotation*, as described earlier in this work. As the ship comes within 75-100 feet of the ground, the pilot will add pitch, checking the descent. The pilot often has only 5 or 10 seconds to land an aircraft descending in autorotation.

Once on board the helicopter, passengers should check to see that seat belts and equipment are tightly secured. In addition, they should note the location of exits, door handles, fire extinguishers, as well as the Emergency Locator Transmitter (ELT) and its manual switch before flight. Passengers must stay clear of all flight controls and avionics.

During an emergency, it is possible that the pilot may want heavy items dropped out of the ship, if time permits - although this is unlikely. Do nothing else until told to do so by the pilot, to include exiting once on the ground.

Conclusion

Proficiency in helicopter operations requires study and experience. The essentials of helicopter safety, however, are straightforward. For those beginning work around helicopters, the following are most important:

- THINK! Panic is your worst enemy around helicopters.
- Never approach the helicopter until the pilot gives the OK.
- Always approach or leave the helicopter in the crouched position from the front (except with Chinooks) so that you are in view of the pilot.
- Never approach or leave a helicopter from any side where the ground is higher than the landing pad - you may walk into the rotor blade.
- Never approach or exit a helicopter with the rotors turning unless instructed by the pilot to do so.
- If you have little or no experience around helicopters, rely on team members who have the necessary experience.
- The pilot-in-command is directly responsible for the aircraft under his or her charge, and is the final authority on the operation of that aircraft.

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