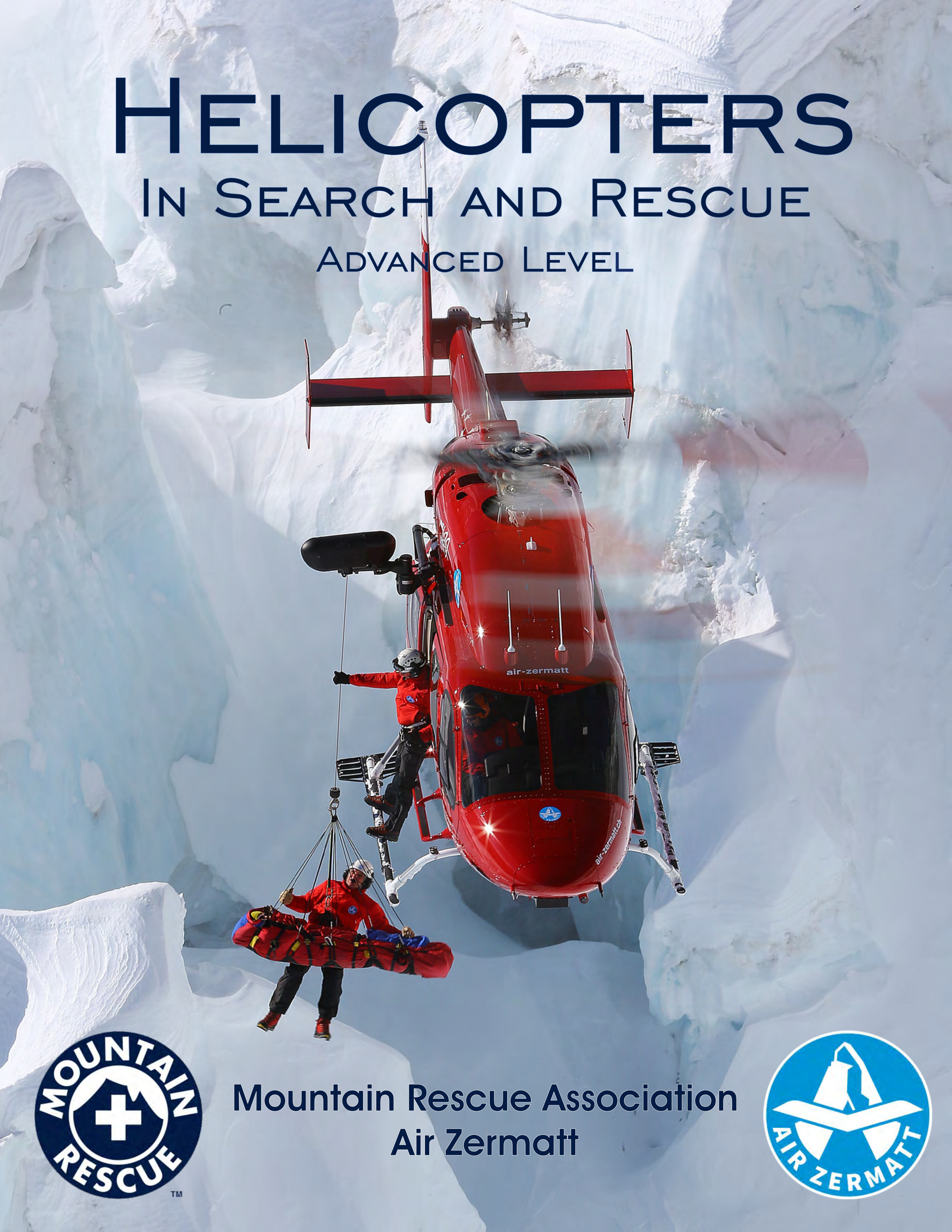
Helicopters
In Search and Rescue
Advanced Level



Mountain Rescue Association
Air Zermatt

MOUNTAIN RESCUE ASSOCIATION

HELICOPTERS IN SEARCH AND RESCUE
Advanced Level

By Charley Shimanski and Dr. Charlie Mize

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Objective

This program is designed to provide information required by mountain rescue and personnel for safe operation in advanced helicopter operations, including those in which rescuers are suspended beneath the helicopter while in flight.

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

- Understand techniques that contribute to safe and effective use of helicopters in complex operations involving human external cargo (HEC),
- Understand the basic functions and safety features of HEC operations,
- Identify key elements of aerodynamics and helicopter operations during hoist and short-haul operations, and
- Implement helicopter management and safety precautions in complex helicopter operations

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.

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.

Contributors: Oliver Kreuzer and Air Zermatt

We wish to recognize the contributions of the leadership of Air Zermatt and its world-renown Air Zermatt Training Center. In particular, Oliver Kreuzer played a pivotal role in the development of this program, both through his hands on education and his vast experience. Oliver is a 13-year veteran and Flight Paramedic with Air Zermatt and a leader of their training program since 2010. Oliver is also a flight medic in the US Army Reserve. The authors deeply appreciate the wisdom and insight of Oliver, for his inspiration, dedication, and thoughtful instruction.

Part
1

Part 1 – Rescue Helicopters and Crew

Photo: Air Zermatt

Introduction

For many years, helicopter search and rescue (SAR) operations made the treatment onboard of the lost, ill or injured their primary focus. SAR missions initially limited the use of helicopter flight to support ground-based operations and to provide rapid transport of the critically-ill or injured to definitive medical care.

In the past few decades, however, SAR personnel on the ground have increasingly confronted complicated terrain features and/or environmental conditions (avalanche, flood, etc.) that render access, stabilization, and evacuation of an injured or stranded subject either impossible or dangerous. Rescue in these circumstances demands action certain to put the lives of rescuers on the ground at high risk. Faced with these challenges, emergency responders have turned to rescue helicopters and their specialized crews to provide a novel form of rescue. These techniques include lowering, raising, and/or transporting rescuers and subjects suspended below the aircraft while in flight. The development of SAR rescue helicopters capable of inserting and extracting rescuers by hoist and short-haul has made it possible for helicopter rescue personnel to perform complex rescue operations in terrain and weather where a helicopter landing is out of the question.

Of course, rescue personnel do not limit their use of helicopter rescue to these challenging techniques; the use of helicopter aviation in SAR and rescue has a wide scope.

This training will address the basic components of helicopter rescues that include these specialized rescue techniques. It is intended for paid and volunteer rescue professionals who work in rescue programs that train in and use these technical helicopter rescue techniques.

Human External Cargo (HEC)

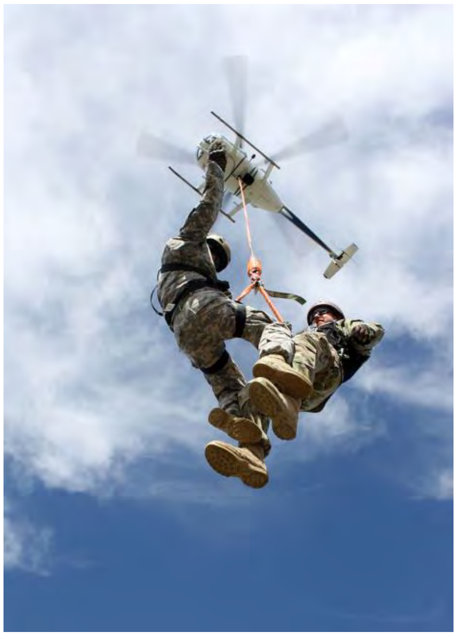


Photo: U.S. Army National Guard Short Haul by 1st Lt. Kara Siepmann)

Specially-equipped SAR helicopters may include external cargo capability including "human external cargo," commonly referred to as "HEC." The term HEC refers to hoisting and short-haul operations used to transport SAR personnel or rescue subjects to and from difficult-to-access locations, or when time is short and rapid extrication is critical. While many rescue programs employ hoisting operations, numerous rescue programs also transport human cargo by short-haul operation.

The US Federal Aviation Administration has formally defined HEC in FAA AC 27/29.865 as *"A person(s) that at some point in the operation is carried external to the rotorcraft.* For the purpose of this training, we will refer to HEC as "the transport of individuals outside the aircraft with a simple and/or complex Personnel Carrying Device System (PCDS) connected to the cargo hook or hoist."

In Part One, we define the types of rescue helicopters used, and the categories of rescue crewmembers that comprise a technical helicopter rescue unit.

Types of Rescue Helicopters

In this training, we will focus on two primary categories of helicopters performing SAR work that may include technical rescues and human external cargo, these are:

- Search and Rescue (SAR) helicopters
- Emergency Medical Services helicopters (HEMS)

Photo: Charley Shimanski

For simplicity, we will refer to both of these types of helicopters as "rescue helicopters" throughout this training, except when the distinction is important.

Each type of helicopter is critical in life-saving SAR work, and may share overlapping scopes of work with its counterpart. While not common, some SAR helicopters are equipped to provide advanced life support and critical care. This is particularly true in military operations, as well as in rescue programs serving a high volume of backcountry responses in rugged terrain, such as the European Alps. In these cases, the high level of knowledge, experience and advanced patient care capability these units bring can significantly benefit the victim/patient.

Search and Rescue (SAR) Helicopters

Photo: Ahlstrom Air/Rocky Mountain House SAR (Canada)

Numerous helicopter programs worldwide possess a specialized SAR capability. These programs may operate under the authority of government agencies (federal, state, local or military), or private operators that may include hospitals or other providers.

SAR Personnel on board

The crew of SAR Helicopters include rescue specialists in addition to their pilot(s). These rescue specialists can include volunteer or paid SAR team members, mountain guides, and/or advanced life support/critical care emergency medical providers. Many SAR helicopter programs work closely with the local SAR team, integrating and training the SAR team members into their helicopter operations.

Specialized Helicopter Rescue Equipment

In addition to HEC capability, SAR helicopters are often equipped with specialized tools, collectively referred to as "remote sensing" equipment/devices," to empower rescue operations. These tools include the RECCO detectors, both handheld and helicopter mounted, a Girsberger long range Helicopter Antenna System, the Lifeseeker System, and the Forward Looking Infrared (FLIR), which detects the heat signatures of objects on the ground.

RECCO Helicopter Detector

Emergency Medical Services Helicopters (HEMS)

H145-Interior from Nicolas Gouhier-Airbus/Vertical Magazine,

There are hundreds of critical care medical helicopters worldwide. These helicopter programs and their crews are called Helicopter Emergency Medical Services (HEMS). While the use of the title HEMS is near-universal, the US Federal Aviation Administration (FAA) also refers to these aircraft as Helicopter Air Ambulances (HAA). These helicopters carry both the medical equipment and the personnel to provide advanced life support (ALS). Depending on their response area, geography, helicopter type, and medical capability, some HEMS helicopters will serve a simple air ambulance while others will act as a prehospital intensive care unit, providing state-of-the-art critical care (ECMO, cardiac pacing, balloon pumps, etc.).

The primary difference between a SAR and HEMS helicopter is the rescue equipment onboard and the medical and technical rescue qualifications of the crewmembers who provide the medical care. HEMS crewmembers are highly trained in critical care and usually flight paramedics, nurses and/or physicians. The US is mainly operating with a nurse/paramedic crew, where European countries are usually seen physician/paramedic-based teams.

For some time, HEMS programs have trained with local SAR teams to develop programs to integrate mountain rescuer specialists into their helicopter rescue operations. *Flight For Life Colorado*, the first HEMS program in the United States, was created partly as a result of a mountain rescue incident following the 1970 crash of a plane carrying members of the Wichita State University Football team. The *Flight For Life* program has now evolved into a highly sophisticated and technical program that integrates rescue mountaineers as crewmembers in three different rescuer integration programs.

Rescuers working with Flight For Life Colorado
Photo: Flight For Life

HEMS programs that collaborate and partner with SAR teams in mountain and backcountry settings often provide training for their own medical crewmembers that includes operating and surviving in austere environments. This can include education on high-altitude physiology and the provision of care in severe weather, circumstances certain to present challenges to both patient care and crew safety.

SAR and HEMS Helicopters

It is important to emphasize the significant overlap in the work of SAR and HEMS helicopters. Many SAR helicopters possess the ability to provide critical care and emergency medicine, and many HEMS aircraft are equipped with SAR and/or HEC capabilities.

Air Zermatt HEMS-equipped Bell 429 (front) and SAR-equipped Astar AS350-B3e (back). Photo: Charley Shimanski

In a few cases, rescue agencies have both types of rescue helicopters, affording them the ability to launch one SAR helicopter to begin a rescue operation, followed by a more specialized HEMS helicopter to support the subject. In the case of Air Zermatt in Switzerland, the "rescue helicopter" first launched might be an Airbus AS350-B3e (aka H125) which they use initially to drop rescuers at the scene. The second helicopter, a Bell 429 HEMS-configured aircraft, can then support with medical personnel and equipment.

Definition of Rescue Helicopter Personnel

In its Draft "Hoist Operator Training Guide," (LINK HERE) the European Safety Promotion Network - Rotorcraft (ESPN-R) defines HEC operations as follows:

> *"During the flight, Pilots, Hoist Operators, Rescuers, Medical Personnel and other human external cargo (HEC) are identified as a group of interdependent individuals working together to complete a specific task. The Crew, considered as a team, must depend on each other's knowledge, skills, and abilities to achieve the same goal."*

Job titles and definitions of rescue helicopter personnel can be as diverse as the programs themselves. In this section, we detail the most commonly used terms.

Pilots

Of course, all helicopter programs require a pilot. In circumstances where the operational complexity or aircraft requires more than a single pilot, one will be designated as the Pilot in Command (PIC) and the other will be designated as the Second in Command (SIC), a non-flying pilot who sits opposite the PIC, with his/her own set of controls. While the PIC handles flying the aircraft, the SIC has important duties, often including communication and navigation.

Air Zermatt veteran rescue pilot and CEO Gerold Biner. Photo: Air Zermatt

If there is only a single pilot, that pilot is the PIC. The PIC is certified in the specific type of helicopter he or she flies.

The excellence of a helicopter rescue program is tied to the caliber and experience of its pilots. Flight hours are an important marker of experience, but not all flight hours are equal. A pilot who flies offshore daily (aka "point-to-point" flying; 3 hours out, 3 hours back) would log hours of flight, but few crucial hours of HEC operations. A pilot who flies firefighting operations, making many bucket drops, gains valuable experience more pertinent to the safe execution of external load operations.

HEC work is all about repetition, as repetition is the key to proficiency. HEC pilots with little experience with placement of precision external loads in flight will be less prepared to meet the unforeseen challenges of a rescue operation. Pilots cannot master a technique with minimal experience. While there are many training programs that pilots can attend, programs should consider additional training opportunities to increase the amount of experience their pilots and crew receive:

When opportunities exist for programs to train with neighboring programs, these training exchanges should be encouraged. At the same time, there may be opportunities form one agency to support another - flying in personnel and material to do lookout maintenance for the forest service, dropping off material for repeater towers etc.

Programs that also perform firefighting duties can use water bucket drop training to give their pilots experience using non-human cargo in an environment where it is difficult to gain visual reference to indicate altitude. This is valuable experience without the need for daily, real-world HEC operations.
In bringing clients to isolated runs, heli-ski pilots can also gain experience on how to determine landing conditions at different altitudes. These pilots often land many times in a single day.

Photo: Yosemite National Park (USA) Search and Rescue

Non-Pilot SAR/HEC Personnel

Rescue helicopter programs worldwide employ different language to describe their non-pilot rescue crewmembers. Many of these terms are commonly used, but can vary geographically or within different types of rescue services.

Terms most commonly used include:

Air Operations Ground Support Team Members

Rescuers specifically trained to support air operations, and especially HEC operations, from the ground.

Crew Chief

The crewmember who oversees all activities in the rear of the helicopter.

Crewmember/Rescue Specialist

Any non-pilot member of the helicopter rescue team, including those with or without medical capability.

Medic / HEMS Crewmember

Typically, the flight paramedic, flight nurse crewmember, but also can be used to refer to any crewmember with any emergency medical certification. The European Union Aviation Safety Agency (EASA) describes this person as a HEMS Technical Crew Member (HEMS TCM), "a technical crew member who is assigned to a HEMS flight for the purpose of attending to any person in need of medical assistance, carried in the helicopter and assisting the pilot during the mission.

Helicopter Hoist Operator (aka "HHO" or "HO")

The rescuer on board the helicopter that operates the hoist mechanism, usually from the back of the aircraft. EASA describes this person as "Helicopter Hoist Operator Technical Crew Member (HHO TCM); a technical crew member who performs assigned duties relating to the operation of a hoist. lt is common practice that both roles are assigned to one single person, who would perform these tasks according (sic) the needs of the mission."

A Pilot, Hoist Operator (HO) and Rescue Specialist/Crewmember all contribute to the operation.

Photo: Air Zermatt/Vertical Magazine

PJ

Pararescuemen, U.S. Air Force Special Operations Command (AFSOC) and Air Combat Command (ACC) personnel who are involved in search, rescue, recovery and medical treatment in rescue operations.

Spotter

A rescuer whose primary role is to observe and augment the team's situational awareness. Sometimes the role includes responsibility for the actions of the rescue personnel under observation.

Types and Definitions of HEC Systems

HEC aircraft largely deliver and retrieve rescuers or injured subjects through two methods:

- Hoist (also known in British usage as "winch"), and
- Short-Haul (also known as "longline")

A hoist operation includes a raising and lowering mechanism on the side of the aircraft

Photo: Priority 1 Air Rescue

In a short-haul operation, rescuers and subjects are suspended on a fixed line .

Photo: Charley Shimanski

Throughout this training, we will use the terms "hoist" and "short-haul" in lieu of "winch" and "longline."

Vertical Reference and the Differences between Hoist and Short-Haul Operations

Both hoist and short-haul operations enable a rescue helicopter crew to insert or extract rescuers and subjects from sites where safe landing is impossible. There are key differences between hoist and short-haul operations, with each method carrying its own advantages and limitations. The most significant of these differences is the position of the line itself. In short-haul operations, rescuers and subjects are suspended on a fixed line whose length cannot be adjusted in-flight. During short-haul operations, whatever is suspended on the line - whether human operators, rescue subjects or inanimate cargo - moves in direct response to the movement of the aircraft. The pilot thus directs all movement of the short-haul line in the horizontal and vertical axis. By contrast, hoist operations provide another element of control. While the pilot still positions the aircraft, the hoist operator can raise or lower human cargo independently of the aircraft's position through use of the mechanical hoist system.

Both short-haul and hoist can be performed under high fidelity direct or indirect vertical reference. During Direct Vertical Reference operations, the pilot is able to see the rescuer/load (through direct visualization or a load mirror) and can thereby properly position the aircraft for the short-haul or hoist. By contrast, Indirect Vertical Reference performance occurs when the pilot is unable to see the rescuer/load and is dependent on a hoist operator, crew chief, or spotter to help the pilot position the aircraft over the rescue site.

A "bubble window" is designed to maximize the viewing capability during vertical reference operations.

Photo: Air Zermatt

While hoisting operations reduce the time that rescuers are exposed beneath the helicopter - many hoist mechanisms allow the rescuer and subject on the hoist cable to be brought into the aircraft cabin- short-hauls require less weight to operate. A lower operating weight means more available power margin. This difference can be significant: some short-haul operations can lift 4-6 victims at once, while rescue hoists are often limited to roughly 600 pounds or less (a limitation placed on the rescue hoist by the manufacturer, which therefore takes into consideration everything from the installation bracket to the hoist mechanism and cable). In addition, short-haul programs require less program maintenance and crew coordination.

For those programs that maintain BOTH a hoist and short-haul program, the decision of whether to perform a hoist or a short-haul operation can depend on many variables. These include the availability of each platform, the scheduled and unscheduled maintenance of hoist equipment and aircraft, the location of the rescue and the challenge that location presents, as well as the power, availability and skills of air and ground crews, the patient condition, and the number of victims to be rescued.

Hoists

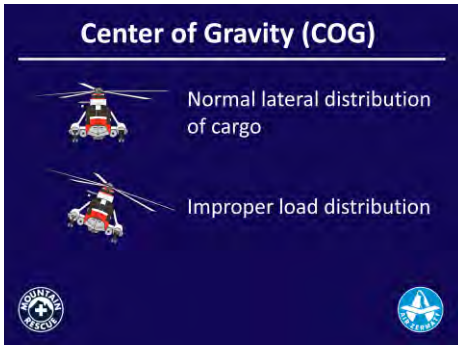
The use of rescue hoist systems can reduce the amount of time human external cargo remains exposed outside the aircraft by enabling the pilot and crew to insert and extract rescuers and injured subjects and bring them into the aircraft quickly. Hoist systems also make it possible to extract a subject over terrain where landing would be unsafe and ground rescues unlikely to succeed.

Photo: AH+RT/Vertical Magazine

Most hoist programs are designed to lift rescuers and a patient up to the aircraft door where they can then be loaded directly into the aircraft. Internally mounted hoist mechanisms are designed to pivot inside the aircraft once the load has been fully raised to enable the safe transfer of human cargo from the hoist line to the aircraft cabin. Alternatively, the human cargo is brought into the aircraft by the rescuer, crew chief and/or medic. Some hoist programs lift the rescuer and patient only to the helicopter skids, and require landing to fully transfer the rescuer and patient inside the aircraft. Cabin space limitations often dictate which loading strategy a team will employ.

Center of Gravity

Center of gravity (CG) is a key concern with hoist operations. Consider, for example, a hoist-equipped helicopter with a pilot sitting on the right side, the hoist mechanism on the right side, the hoist operator on the right side, and a patient and rescuer being hoisted onto the aircraft on the right-side of the aircraft. For this reason, crews need to be careful not to overcome/exceed the lateral CG. This can be accomplished by loading one subject at a time, moving any incoming subjects to the opposite side of the aircraft, positioning any additional crew members on the opposite side of aircraft, etc.



Graphic: Charley Shimanski © MRA

Difficulties with Hoist Operations

Hoist operations present important challenges, to include:

- Hoist programs require an experienced pilot AND an experienced hoist operator.
- The addition of a hoist operator increases the required payload for the operation.
- There is a greater training burden on programs with a hoist system to ensure the teams executing hoist operations can do so in a safe, efficient, and methodical way.

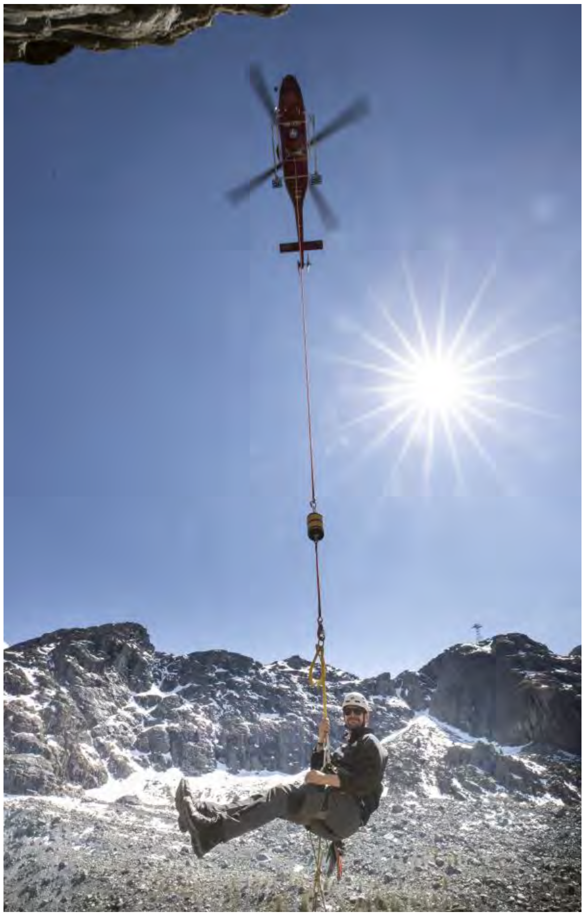


Photo: Bild am Sonntag Magazine/Christian Spreitz

Short Hauls

It is important to remember that the name "short-haul" refers to the short duration of time it takes to perform the HEC operation, not to the length of the rope used. For most programs, the short-haul line measures between 30 and 60 meters. Although some short-haul operations can require lines as long as 200 meters, the 30-60 meter length is the best compromise for most operations. Lines between 30 and 60 meters are long enough to be less affected by rotor wash (vs. shorter lines) but remain short enough to enable accurate positioning of the line (vs. longer lines).

Short-haul programs offer several advantages when compared to hoist operations. These include:

- Short-haul lines and load are much less likely to compromise the aircraft's center of gravity.
- The suspension of load under the center of the aircraft reduces its exposure to rotor wash/flow.
- Because there is no hoist operator, short-haul operations require less weight.
- Short-haul lines can be extended to much greater lengths than can hoist cables.

Limitations of Short-Hauls

The benefits of short-haul programs are many: lower risk, lower training burden, less equipment and lower cost. Still, inherent to short-haul operations are several important limitations, which include:

Night dramatically increases the difficulty of short-hauls. The recognition and assessment of hazards and the response to emergency situations are all complicated by night.

Short-hauls are more difficult to place compared to hoist operations if vertical reference is not possible. Vertical reference presents a challenge for the pilot, spotter, and crew chief, and can require additional training in verbal communication when operational conditions preclude accurate visual orientation. Short-hauls require more time to deploy than do hoist operations.

Mission Planning

While all helicopter rescue operations require careful planning, none require planning more than those involving humans suspended outside of the aircraft. A meticulous study of weather and terrain maps by the pilot is key prior to flight operations, and a discussion by pilots and crewmembers of prior rescues and rescue attempts made in the same or in a geographically similar area often adds value.

Helicopter rescue veteran Drew Davis briefing US Army pilot. Photo: Charley Shimanski

Mission Pre-Planning and Inter-Agency Coordination

If a HEC helicopter rescue mission is in support of another agency (i.e., law enforcement or public land management agency), the pilot and crew may wish to land near an incident command post or staging area to discuss/brief the intended operation with the incident leadership before carrying out the task.

Reconnaissance Flight

Once airborne, the pilot and crew should take the time to perform a "reconnaissance flight" so that all involved can gain situational awareness and discuss what they see and anything that might concern them (and what data their intuition brings to the moment). This gives the crew time to determine the correct course (and sequence) of action, and to assess environmental and other factors that may impact aircraft and/or crewmember performance. All on board can use this reconnaissance flight to evaluate visible hazards including trees, wires, slope angles, civilians on scene, other aircraft, etc.

For a short-haul operation, the reconnaissance will also guide the pilot and crew in determining a suitable helispot from which to stage and prepare the short-haul equipment. For short-haul, hoist, and hover load operations, the pilot can use the reconnaissance flight to perform a power check to determine available power as well.

When combined with careful mission planning, the data collected during the reconnaissance flight will inform the pilot, crew, and incident command team of the best and safest course of action for the rescue response.

Photo: Bob Wagner

Risk Assessment

There is an important distinction between risk management and risk assessment. While helicopter rescue programs work to reduce risk through careful attention to equipment and human behavior, each rescue presents unique elements that go beyond a program's equipment, personnel, and training. Weather, terrain, and other operating conditions add risks unique to each operation. Successful mitigation of these risks requires that helicopter rescue teams carefully search for, identify and evaluate all possible hazards before planning a rescue.

This "real time" risk assessment is an essential part of every HEC operation. Risk assessment is not an exact science. However, helicopter rescue operations have moved away from casual, purely subjective estimates of risk towards more rigorous risk analyses that are both more objective and more quantifiable.

The most widely used risk assessment tools follow a "GREEN-AMBER-RED" (aka "GAR") model, which produces a "risk score" based on several inputs from users. As a rescue operational plan is developed, rescue team members use the GAR program to rate the risk based on several factors. For most GAR tools, these factors include:

- The personnel involved in the rescue (leadership, qualifications, experience)
- The rescue plan (is it known, hurried, complex, is there consensus?)
- The rescue environment (weather, terrain, altitude)

Ideally, several rescuers input their personal "ratings" into the GAR model, and upon completion, the rescue team evaluates the aggregate "risk score" in its entirety, as well as any composite outlier scores from each individual. This process should take only a matter of minutes, and produces a highly valuable assessment variable when the entire team participates in the final evaluation of the aggregate and composite scores. The National Park Service (USA) Helicopter Short-Haul Operations Plan maintains that GAR programs, "are used to open critical conversations and prompt individuals involved to consider the added risk of a helicopter short-haul."

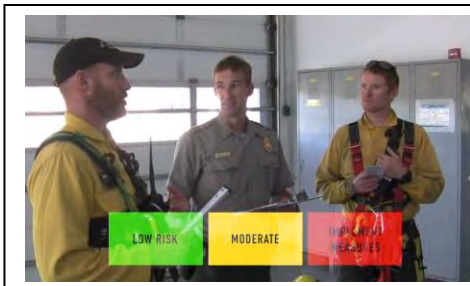
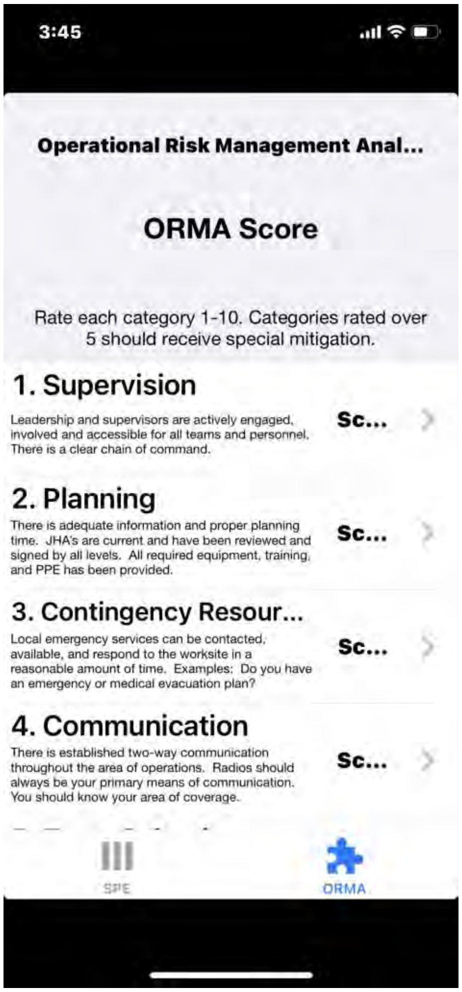


Photo: National Park Service (USA)

Ken Phillips, author of "Helicopter Rescue Techniques – Civilian Public Safety and Military Helicopter Rescue Operations," describes this model and defines why a GAR procedure really works:

> *"The ability to assign numerical scores or color codes in the GAR Model is not the key ingredient in how this process serves to perform effective risk assessment. The key ingredient occurs when team members discuss their post-scoring results together, because it generates valuable discussion toward understanding the risks and how the team will manage them. Ultimately, it slows down the operational tempo and forces rescuers to carefully think rather than simply react."*

GAR Programs



Two GAR programs have become widely used in the SAR community, each of which offers a special app for smartphones. They are:

[Risk: SPE, ORMA, and GAR Calculator] (◄◄◄ ON THE LEFT) by the National Park Service, Department of the Interior (USA) (NOTE: A formal GAR Risk Assessment is required for all Park Service rescue short-hauls.) ([LINK HERE])

[RADeMS] (ON THE RIGHT►►►) by the British Columbia Search and Rescue Association, (Canada) ([LINK HERE])

Pre-Operational Briefing

Prior to the initiation of a rescue operation, the pilot, onboard crewmembers, and rescue personnel should engage in a pre-flight briefing. This briefing affords the opportunity for members of the team to articulate their personal assignments and roles, and their expectations of the mission. The pre-operational briefing should consider contingency plans and the events that would prompt them. The team should anticipate any scenario that will require the team to adapt its plan, and what that adaptation will be. (e.g., What if ground-to-air communication is lost? What if onboard communication is lost? What if weather deteriorates after insertion of rescuers to the scene?).

Photo: Bild am Sonntag Magazine/Christian Spreitz

Øyvind Henningsen, Team Coordinator and Rescue Technician with the Snohomish County Helicopter Rescue Team, states, "At times, we also do a pre-operational rehearsal, particularly if it is a high-risk, low-frequency operation; for instance, picking off a climber on a rock wall. We would rehearse this several times before taking off."

"Talk-Through, Walk-Through"

A "Talk-Through, Walk-Through" pre-flight briefing can occur alongside the aircraft, and enables each participant to express any concerns they have about the proposed plan. At the end of the Talk-Through, Walk-Through, each rescuer should then take a moment of intentional silence to regain situational awareness and reflect on his/her particular role in the coming operation.

Photo: Alpine Rescue Team, Colorado (USA)

Post Event Debrief

There are many names for a debrief that occurs immediately following a helicopter rescue, including "After-Action Review (AAR)," "Hot Wash," or simply "debrief." Regardless of its name, the debrief that occurs immediately following a rescue is a critical element of team performance and improvement. To be effective, this debrief should create a safe space for open and transparent dialogue, and then encourage all involved to share and reflect while the rescue remains fresh in the mind. Ken Phillips describes AARs well:

The overall goal of any rescue review is to improve future responses, which prevents repeating known deficiencies and operational shortcomings. Conducting an after-action review (AAR) immediately at the conclusion of the rescue effectively captures feedback from all involved personnel. The strength of immediacy conducting the review is that personnel are actually more receptive then to discussing any flaws in the operation. With the passage of time, personnel develop mental justifications for less than optimal performance and are less receptive to discussions critical of their actions.

Lessons Learned? Not Necessarily

For decades, rescuers have used the term "Lessons Learned" in their after-action reviews to describe corrective actions they might take after an incident or accident. The problematic character of this usage is in its implicit suggestion that naming the corrective action alone is sufficient: the lesson is "learned" after the error has been identified. The authors of this text believe nothing could be further from the truth. Incidents and accidents have lessons to teach, but to learn those lessons - to improve the safety of helicopter rescue operations - demands reflection and action. They demand the implementation of new protocols, training and equipment and, sometimes, a change to an entire operational culture. For this reason, we suggest that "Lessons Learned" be abandoned in favor of "Lessons Taught."

Part
2

Part 2 – Equipment for HEC Operations

Successful SAR and HEMS operations require more than the helicopters themselves. They require specialized equipment that are fundamental to the safe completion of HEC missions. This lesson will explore these essential components.

Specialized Equipment

Suspending rescuers and/or subjects beneath a helicopter in flight is a dangerous operation, one that requires specialized equipment. Certain pieces of equipment are essential for both hoist and short-haul operations while other pieces are unique to one or the other.

Standard Equipment for Both Hoist and Short-Haul Operations

Helicopter Hoist Hook

At the end of the cable is the "hoist hook," a specialized assembly that usually includes a safety-gated large hook and a much smaller equipment ring (also referred to as "utility eye," or "eyelet") that is used as an attachment point for equipment, static discharge cables, hook weight bag, etc.

It is important that rescue personnel connect themselves ONLY to the larger safety-gated hook. The smaller equipment ring (and smaller gated-hook, if one exists) must NOT be used for personnel, as these pieces are not rated for human loads. Rather, the equipment ring is intended for lighter utility loads such as trail lines, tag lines, static discharge cables, and weight bags. While the utility eye can take higher loads, using them as primary connection points is not recommended as the hook will load off-center. This places an offset strain on the cable that can, over time, cause cable damage at the hoist hook/cable connection point. Hooks should be loaded in the main hook body to ensure a centered load.

Photo: Eva Sophia Shimanski/Air Zermatt

Prompted by rescue accidents, many programs have transitioned to rescue hooks that include an auto-locking gate, an additional safety feature that provides protection from accidental "dynamic rollout." All programs should strongly consider its use. According to the US Federal Aviation Administration (FAA), dynamic ring rollout is a condition that results from, "the unintended release of the primary engaging ring from the winch (hoist) hook that may occur subsequent to a pause in the winching (hoisting) sequence." When the connecting ring in a rescue system and the gated rescue hook are temporarily relieved of the load, it is possible for the connecting ring to flip over the tip of the hook and come to rest on the spring-loaded gate. Once the weight of the load is re-applied, it is possible for the connecting ring to force open the spring- loaded gate, enabling the connecting ring to disconnect from the gated rescue hook. US-based Lifesaving Systems offer an excellent demonstration of dynamic ring rollout in the video below.

According to a FAA Safety Alert for Operators (SAFO-16015):

Winching and longline operators should:

- *Develop procedures which list the specific D-Rings or equipment which may be attached to a specific rescue hook wherein the possibility of D-Ring reversal is physically impossible.*
- *Use only rescue hooks which have a mechanical locking keeper or guards to prevent D-ring reversal or dynamic roll-out.*
- *Ensure initial and recurrent winch operational training is tailored for each helicopter type and winch combination and is conducted on a regular basis.*
- *Operate and maintain winches, hooks, and harnesses in accordance with approved data.*

It is the responsibility of every rescuer involved in HEC operation to understand the concept of "ring geometry" to prevent dynamic rollout. As Ken Phillips reiterates, "Just because a ring fits a hook does not mean it should be used."

Connecting Hardware

Most HEC programs have a mechanism to carry multiple rescuers at the end of their hoist or short-haul system at the same time, thereby increasing the efficiency of the transport of rescuers to a scene. Briefly, this specialized equipment is connected between the rescue hook and the rescuers so that multiple rescuers can be suspended from the rescue hook in a manner that increases safety and reduces human error. This connecting hardware will be explored in greater detail later in this training.

Photo: Vertical Magazine/Air Zermatt

Static Discharge Cables

Rescue helicopters can generate significant amounts of static electricity while in hover. This is especially true of larger helicopters, as well as helicopters operating under certain types of weather: in dry climates, especially with blowing snow for dust, in snowfall, in mist, or near a thunder storm. This static electricity becomes a danger to rescuers if they touch the rescue hook at the end of a hoist or short-haul line as it approaches from the air, or if they are lowered to the ground at the end of a line. The static discharge from larger helicopters, such as UH-60 Blackhawks, can be significant, and can cause a rescuer to lose balance, and potentially fall from technical terrain.

There are two techniques that can discharge the static electricity to the ground without contact to the rescuer. These include:

- The use of a Static Discharge Cable
- Enabling the cable to touch the ground before rescuers touch the cable

Photo: CAPEWELL Aerial Systems

Static Discharge Cables are specialized metal cables, generally about 3 meters long, that hang below a suspended rescuer to provide a conduit to discharge static electricity before the rescuer touches the ground. These cables are attached to the hoist hook equipment ring and include a "weak link" that will fail and release the cable if the cable somehow becomes entangled during an operation.

Rescuers who do not employ static discharge cables should first allow the hoist cable to touch the ground before grabbing it to avoid receiving a shock. While this action may be counter-intuitive - it is an important safety measure, particularly in dry climates, or where there is dust or snow in the air.

Although the cable discharges its static electricity when it touches the ground, it is important to remember that the static will recharge immediately once the cable lifts off the ground if the helicopter remains in hover. Rescuers must be vigilant and recognize that the potential of a shock remains, particularly with larger aircraft.

At the same time, rescuers must balance this risk against the dangers presented by a discharge cable or hoist cable left unattended on the ground. A static discharge cable or rescue hook can become entangled in many types of terrain, creating a hazard for the entire rescue operation. For this reason, a static discharge cable is often connected with a low-strength breakaway connection, like with a zip tie or Velcro connection.

Equipment Unique to Hoist Operations

Certain equipment is unique to a hoist operation, and is detailed below.

Hoist Hardware and Cable

The hoist mechanisms themselves generally come in two forms:

- A fixed mounted hoist mechanism that extends outward above the wide door of the helicopter, and
- A pivoting hoist mechanism that swings out from inside the helicopter when in use.

With both installations, the hoist and its cable are arguably the most important link in the hoist rescue safety chain, and careful cable management by the Hoist Operator is critical.

Swivel at the End of the Rescue Hook

Photo: Bild am Sonntag Magazine/Christian Spreitz

The end of the hoist cable usually includes a swivel that spins freely, often built into an integrated hook. This enables the hook to spin, reducing the amount of torque transferred to the cable. If the spin did transfer to the cable, not only would it load the cable with additional tension in the form of torque, but the eventual release of this torque could cause the cable to spin back in the opposite direction, creating a dangerous situation.

The swivel is an important safety element of the cable system, and rescuers must take care when grasping the cable to do so in a way that does not inhibit the function of the swivel. Particular care should be taken when holding the cable above the swivel, as gripping the cable here is more likely to impair the free movement of the swivel. There are times when it is appropriate to grab the cable above the swivel (for example, when loose cable gathers on the ground). What is important is that rescuers remain mindful of the swivel when manipulating the cable.

Hoist Training Facilities

Specialized helicopter rescue training companies and many helicopter rescue programs that operate a hoist program will have a training facility with a separate hoist mechanism for live training in an environment that does require flight. Often this equipment is a training tower or a hoist mounted inside the hangar (as pictured to the left in the Air Zermatt hangar), enabling rescuers to train on techniques to prevent and reduce spin, such as forward flight, rapid transition through rotorwash, and the use of hand and leg position during hoist. Some programs also employ high-fidelity "virtual reality" equipment to conduct hoist operator training. Such training, however, does not provide ground rescuers with an opportunity to practice collaborative exercises with the hoist operators.

Photo: Eva Sophia Shimanski – Air Zermatt Training Center

Hoist Training Consultants

Effective hoist-equipped programs require significant training, which is now available from a number of rescue consultants worldwide. These consultants offer high-quality, hands-on training, either at their own facility or at the site of the rescue program.

Equipment Unique to Short-Haul Operations

Certain equipment is unique to short-haul operations, and is detailed below.

Short-Haul Anchor System

To conduct short-haul operations, an aircraft must have a specially-designed anchor system to which the short-haul line is connected. In its Helicopter Short-Haul Operations Plan, the U.S. National Park Service defines a short-haul anchor system as "the points of attachment of the short-haul rope system to the helicopter. This system will include both a primary and a secondary anchor. The primary and secondary anchors must be designed for pilot and/or spotter release in an emergency. The load must be fully jettisonable, using two separate and independent actions for release."

Photo: Eva Sophia Shimanski/Air Zermatt

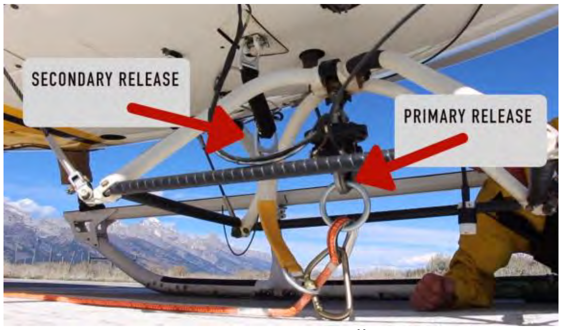


Photo: National Park Service (from "An Introduction to Short Haul Rescue" (LINK HERE))

The pilot and/or a crewmember must have the ability to jettison the line (cut the rope free from the system) in the event of an entanglement or other problem with the cargo beneath. Using a dual-hook connecting system, the pilot or crewmember must take two actions to jettison the load, but to be clear, with a dual-hook connection, either the pilot or crewmember can independently jettison the short-haul line; but the independent action of that person requires two steps.

(Note that the National Park Service developed a ten-minute "Introduction to Short Haul Rescue" (LINK HERE) that is valuable, and describes the primary and secondary releases well.

Rope for Short-Haul Systems

Unlike the cable used for hoist systems, short-haul systems generally use a static rope to connect rescue personnel and subjects to the helicopter anchor.

The ropes used in short-haul are often made of dyneema and synthetic fibers, and can vary in length. Program requirements, aircraft type and the specific needs of the rescue at hand dictate the lengths of rope used in a short-haul rescue operation. Air Zermatt, for example, uses a 14 mm diameter rope that is manufactured specifically for human external cargo. That rope can hold as many as six people. Although that may seem like a lot of weight on a 14mm rope, keep in mind that this rope was not designed to withstand the force of a dynamic fall or shock.

As with ropes used by rescue teams during technical ground-based rescues and training, HEC programs should document the date and use of each short-haul rope, and inspect them carefully for damage after each use. Ropes should be retired when age, damage, or the end of predefined life-cycle compromises their structural integrity and safety.

Rescue Rings

While the use of a rescue hook at the end of a short-haul line is common in many short-haul systems, some use a ring spliced to the end of the line in lieu of a hook.

Photo: Eva Sophia Shimanski/Air Zermatt

Weight at the End of the Line

Short-haul operators will often attach a weight to the short-haul line above the rescue ring/hook to reduce the ability of the line to swing in an uncontrolled manner, to trail behind the aircraft while in flight, or from acting as a pendulum when the aircraft transitions to hover. Many rescue teams permanently mount a weight ball roughly 2 meters above the rescue ring/hook. For short-haul fixed lines longer than 100 meters, additional weight may be necessary, or rescuers may wish to have a human rescuer on the line.

The weight on a short-haul line can pose a danger to the unaware rescuer. As the helicopter delivers an unattended short-haul line to rescuers on the ground, those rescuers need to be careful to not be hit by the weight, which could injure them or knock them off their feet.

Equipment for Securing and Transporting Injured and Uninjured Subjects

There are numerous unique pieces of equipment designed to transport injured and uninjured subjects from rescue scenes. Often, it is the subject's injuries (or lack thereof) that determine which device will be used.

These pieces of equipment are detailed by Ken Phillips in his "Helicopter Rescue Techniques" manual, which may be found at THIS LINK.

Equipment for Transporting Severely Injured Subjects


Photo: Charley Shimanski/Air Zermatt

Rescue operators employ specialized equipment to transport subjects with injuries that require spinal cord protection, transport in the supine position, or transport with splints and/or spinal restriction protocols. These include:

- Helicopter Rescue Bags
- Medevac Litters

Key to these specialized rescue bags and litters is the ability to secure the patient in a way that not only provides spinal cord protection, but reduces the possibility of patient movement in the litter while in flight.

Photo: Charley Shimansko with Bernalillo County, New Mexico (USA)

Equipment for Extricating Uninjured Subjects

Equipment specifically designed for extricating uninjured subjects and/or those who do not have injuries that necessitate transport in a supine position include:

- Rescue Net (Billy Pugh Net)
- Collapsible Rescue Basket
- Rescue Seat or Forest Penetrator (Jungle Penetrator)
- Rescue Strop and Quick Strop
- Rescue Evacuation Triangle
- Screamer Suit
- Hoisting Vest

Again, these types of equipment are detailed in Ken Phillips' *"Helicopter Rescue Techniques"* manual, which may be found at THIS LINK.

Personal Equipment for Rescue Personnel (Part One)

Safety Harnesses for HEC Rescuers

Harnesses for HEC rescue personnel must be easy to use, with an easy-to-identify connecting point. These harnesses must provide suspension comfort, as rescuers could be suspended in a harness for long periods of time. The rescuers' flight program should approve the harnesses authorized for their programs, and these harnesses must conform to appropriate and applicable governmental, international and society recommendations. Rescuers must inspect their harnesses and associated connecting equipment regularly, and retire equipment when it becomes compromised by age or damage.

Photo: Eva Sophia Shimanski

Broadly considered, there are three different designs of rescuer harnesses: a lower-body only, a lower- and upper-body combination, or a full-body "class III" harness. Each rescue program should evaluate the advantages and disadvantages of each harness type against the specific demands and environment in which the program operates.

The harness of a HEC rescue technician should be kept free of equipment unnecessary for HEC work to reduce the risk of entanglement and the possible impairment of the rescuer's downward visibility. Most harness connection systems use one carabiner that will be clipped into the short-haul or hoist system, ideally a tri-action steel carabiner (as recommended by the International Commission for Alpine Rescue's Air Rescue Commission - LINK HERE), although some harnesses do not rely on a carabiner to make the connection to the hook. Rather, the connection is made with a delta ("V") ring on a bridge ("lifting strap") that cannot roll off the hook. One or two carabiners clipped in the very back of the harness may give the rescuer the ability to quickly connect to a ground anchor in technical terrain, or additional equipment or personnel during the operation itself. To the extent possible, additional rescue equipment should be carefully stored in the rescuer's backpack and not on the harness. After the helicopter inserts the rescuer, the rescuer can then unpack any needed rescue equipment and attach it to his or her harness.

Many rescuers prefer a rescue harness that makes it difficult to inadvertently clip in to the wrong attachment point. A harness like the Petzl Falcon, for example, has a shiny steel connecting point that makes it easy to identify where the hook connects.

The key to any rescue harness is in its fit. It should sit above the hips with a snug fit around the waist and through the leg loops. As long as a harness is appropriately secured to the body, it is unlikely that a rescuer can fall out, even if inverted.

Seat harness or full-body harness

Photo: Charley Shimanski with Bernalillo County, New Mexico (USA)

There are a few noteworthy differences between a lower-body harness and a full-body harness. A full-body harness can limit the ability to quickly add or remove clothing. These harnesses may pose a problem for rescuers who must dress in layers, and who need to doff and don jackets quickly to accommodate the temperature change from rescue site to aircraft cabin to medical facility. This is particularly true of rescue personnel working in high altitude and austere environments.

A lower-body harness provides a lower connection point than do full-body harnesses, and many rescuers believe they hang on a HEC hook much better when the connecting point is lower. When loaded with heavy backpacks, however, rescuers may find that a lower-body harness suspends them with an awkward center-of-gravity. In these cases, a full body harness may be the best option, or the rescuer can tether the pack to the cargo loop so that it hangs independently on the rescue hook/ring. The website of Canada-based Boost Systems includes a number of harnesses and patient transfer devices worth reviewing.

Safety Check of Harnesses

Photo: Eva Sophia Shimanski/Air Zermatt

Whenever possible, rescuers should perform a pre-flight safety check of each other's harnesses prior to every HEC operation. This safety check is to ensure the harness is properly worn and in condition suitable for use. Sometimes referred to as a "ten-point check," this review looks for:

- Any damage to the harness
- Adequate tightness of the leg loops
- Adequate tightness of the waist bands
- The condition of the harness connecting point
- The presence of any extraneous and unnecessary equipment

Personnel Carrying Device Systems (PCDS)

The term Personnel Carrying Device Systems (PCDS) is a recent addition to both rotorcraft harnesses and the regulations that govern them. PCDS are essentially the harness/restraint systems that enable rescuers to attach a rescue subject and/or themselves safely and effectively to the hoist or short-haul cable.

The European Union Aviation Safety Agency (EASA) defines a PCDS as "a device or system that has the structural capability and features needed to transport occupants external to the rotorcraft during HEC operations. A PCDS includes, but is not limited to, life safety harnesses (including if applicable quick release and strop with connector ring), rigid baskets and cages that are either attached to a hoist or cargo hook or mounted to the rotorcraft airframe."

Simple or Complex PCDS

EASA classifies PCDS as "simple" or "complex." In their Certification Memo, EASA gives the following examples of simple design:

- A safety harness or rescue triangle for max. 2 individuals conforming to the harmonized EN-Standard (Personal Protective Equipment (PPE) in accordance with a EN standard under EU Directive 89/686/EEC, incl. mountaineering equipment (e.g., EN 361 for body Harnesses, EN 358 for restraint systems [straps], EN 362 for Karabiners/fasteners). The harness could be attached directly to the hoist hook, or to the cargo hook via means of rope system.
- A fixed rope system to be attached under a single cargo hook or Y-rope to be attached to a dual hook. The ropes must be certified according to an EN standard and be designed to transport maximum 2 persons.
- Elements restraining a single hoist or cargo hook operator inside the cabin, when the ropes are certified according to an EN standard.

EASA further provides examples of complex design, as follows:

- A cage which hosts one or more individuals
- A system connecting 3 persons or more to the cargo hook

Helmets

Flight helmets are specially-designed helmets normally worn by pilots and HEMS crewmembers on board the aircraft, and are an essential safety element for crewmembers while in flight. The typical flight helmet includes integrated, noise-canceling earphones and microphone for intercom within the cabin and air-to-ground communication.

While flight helmets facilitate communication on board, they can impair communication in the field: it is hard to hear ambient noise and conversation with a flight helmet on. Moreover, flight helmets can limit a rescuer's vertical field of vision, and often include a mount for night vision goggles, which can limit the field of vision further still. For this reason, HEC rescuer personnel that operate in austere mountain environments generally do not wear flight helmets when undertaking extended work outside the aircraft. Impaired hearing and sight also pose significant risks to rescuers operating near or under the rotor disk of a running helicopter. (A visual field restriction was cited in a final report of a rescue accident during which an experienced flight crewmember was killed by a main rotor strike to the head.)

Several manufacturers of climbing and rescue helmets have developed custom adaptations to attach specialized communication equipment, such as microphones and earphones. Petzl, Kask, and Team Wendy have each developed rescue helmets that are specially designed to accept communication systems, including those available from 3M/Peltor. These helmets provide the safety and visual field of a rescue helmet and are equipped with specialized noise-reducing earpieces and microphones that enable the wearer to communicate while onboard the helicopter, but can pivot off when outside the aircraft. Despite these adaptations, rescue helmets lack the protective features of a true flight helmet and so should be used sparingly in the flight environment. There is no ideal solution for helicopter SAR personnel and so the choice of flight helmet vs. rescue helmet should be based on where the rescue personnel spend the majority of their time. If rescue personnel work predominantly in and around the helicopter, then a standard flight helmet is the better choice. If, on the other hand, rescuers spend the majority of their time on the ground, then a rescue-type helmet is preferred.

Specialized Helmet-Mounted Equipment for Ground-to-Air Communications

Simple handheld radios are impractical for ground-to-air radio communication during an HEC operation. These radios typically require the use of hands, and their audio quality is often compromised by the noise of the helicopter. To circumvent these limitations, many rescue helmets are built to accept helmet-mounted headsets with a pivoting microphone, noise cancellation and push-to-talk (PTT) controls. Most of the 3M/Peltor headset/microphone combinations are built with a conventional aviation plug (U-174, also known as the NATO Plug) so that the operator can plug into the aircraft intercom system (ICS) while in flight. These units can be fitted with a specialized adapter that enables that male U-174 plug, used with the helicopter's ICS, to also work with the user's handheld radio as well. This gives the rescuer the ability to quickly transition from the helicopter's ICS to radio upon exiting the aircraft.

The ideal helmet-mounted headset includes a simple "push-to-talk" (PTT) switch. Many agencies utilize one that can be operated in the rescuers hand so that the rescuer does not require a free hand to activate the PTT microphone. The ability to engage a PTT switch while using hands for signaling or while retaining grasp of equipment improves the safety and efficiency of the rescuer's work. Others mount a switch directly to one of the earpieces, making operation relatively simple, and removing the possibility of a hand-held PTT switch being dislodged from the hand at an inopportune time.

Communication manufacturers have developed wireless and Bluetooth systems to enable wireless communication within a helicopter's intercom both inside and around the airframe. Some wireless intercom models have been troubled by interference with aircraft's many electronics systems, but future models anticipate improved clarity and reliability.

Other Personal Protective Equipment (PPE)

Rescue personnel must be certain to have and employ personal protective equipment (PPE) to protect themselves from the hazards of working in and near helicopters. Specialized eye, ear, and hand protection is key, as is appropriate footwear and outerwear.

All rescue personnel should strongly consider the following PPE:

- Protective helmet.
- Ear protection, often in the form of disposable aviation ear plugs.
- Shatterproof sunglasses, safety glasses, or goggles.
- Fire resistant or leather gloves.
- Quality boots that are suitable for the austere and extreme environments in which the rescuers operate.
- Knee pads for work in rocky terrain and on the floor of the aircraft.

- Specialized equipment, as necessary, including:
  - Avalanche rescue equipment, including a personal transceiver, shovel, probe, and avalanche airbag.
  - Life vests or specialized survival equipment for over-water flight operations
  - Lighting for night operations, including headlamps, Cyalume glow sticks, etc.

In mountain environments, helicopter rescue crewmembers are often inserted into austere environments and may find themselves in situations where the aircraft is unable to retrieve them. In these cases, footwear, outerwear, and additional gear should be suitably robust to enable long travel over ground through harsh weather conditions and difficult terrain. When the helicopter cannot retrieve rescuers, rescuers must be able to walk out or endure a prolonged wait.

Carabiners for HEC Rescuers

Carabiners are the most important specialized equipment that HEC rescuers must carry and use to connect to a HEC system.

Carabiner Types

Most agencies operating HEC programs employ steel carabiners, and of these, the use of tri-action carabiners is strongly encouraged (as recommended by the International Commission for Alpine Rescue's Air Rescue Commission - LINK HERE). Many rescue operators have discontinued use of aluminum carabiners after their use contributed to several incidents and near-misses.

Oxan high-strength oval carabiner from Petzl

Steel Carabiners

Steel carabiners are among the toughest pieces of equipment on the helicopter. Many believe that other components of a rescue system will fail before a steel carabiner does.

Tri-Action vs. Double-Action Carabiners

The tri-action carabiner requires three steps to open:
1. Disengage the locking mechanism
2. Twist the locking mechanism to the unlock position
3. Pivot open the carabiner

A double-action carabiner requires two steps to open:
1. Twist the locking mechanism to the unlock position
2. Pivot open the carabiner

Double-locking carabiners are easier to open, but that ease comes at the cost of safety: vibrations and inadvertent rubbing against the carabiner can unlock the sleeve.

Screw carabiners are the quintessential carabiner locking system. While versatile and universal, their use has its own pros and cons. A strength of these carabiners is that once closed and locked, they generally remain closed - although vibration has been known to open the screw when placed in the wrong orientation. The downside of these carabiners is that the operator must remember to close and lock them, and that, in winter conditions, the screw can freeze.

As with all other rescue equipment, carabiners should be inspected regularly to ensure their gates open and close and that the locking components function. Carabiners should be maintained according to manufacturer suggestions (e.g., wash with soapy warm water, lubricate the spring, etc.).

Part
3

Part 3 – Principles of Flight

 **Short-haul operation** **Photo: Rocky Mountain House SAR, Canada**	 **Hoist Operation** **Photo: Air Zermatt**

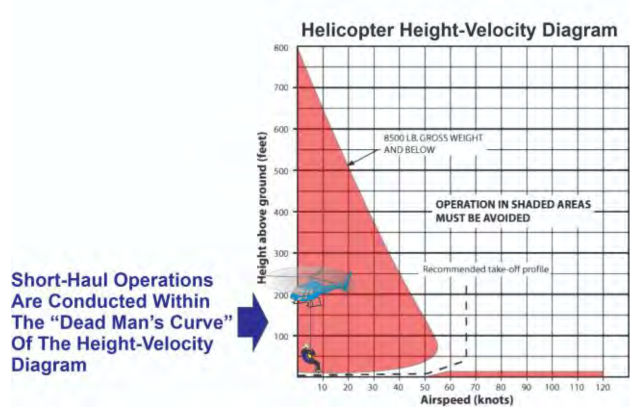
When to Use Hoist vs. Short-Haul

The needs of each helicopter rescue program are unique, and each program must determine which HEC model best meets these needs, whether hoist, short-haul, or both. The choice to run hoist or short-haul operations is an important one, and should be made only by HEC program managers, with their rich understanding of a program's history and operational needs. Some countries' programs use both short-haul and hoist, while others use only short-haul (Austria, Norway, Sweden), and others use largely hoists (France).

Hazards of HEC Operations

HEC operations can succeed where conventional helicopter rescue is impossible, but the added power and versatility of HEC operations come always at the cost of increased risk. Two technical challenges underpin these risks, and are:

- The pilot must hold the helicopter in a hover, and during the most critical parts of an operation, must often do so while making high power demands from the engine.



Ken Phillips, Helicopter Rescue Techniques - NSARA Manual

The aircraft will often need to hover within 300 feet off the ground, with little to no forward airspeed. This position renders safe autorotation challenging should engine failure occur. Rescue operators should consider aircraft performance, aircraft weight, terrain, and environmental factors to mitigate this risk.

Constrained by these technical challenges, HEC operations provide little or no margin for error. Nonetheless, there are times when hoist and short-haul provide the only way to save a life. (For a further exploration of the benefits of HEC operations, see lesson one.)

Execution of a Hoist Operation

The Role of the Hoist Operator

If the pilot is the most important crewmember during a HEC operation, the Hoist Operator is a close second. While the pilot is responsible for the operation and performance of the helicopter, the Hoist Operator is responsible for:

- The technical and safety components of the hoist cable, to include preventing the shock-loading of and damage to the cable.
- Control of the hook: raising and lowering and pivoting it into the aircraft.
- Close coordination with the pilot to ensure proper hook placement at chosen target site.
- Directing the efforts of rescue crewmembers

Photo: Air Zermatt/Vertical Magazine

Successful deployment of the cable requires careful, choreographed interaction between hoist operator and pilot. This collaborative positioning of the aircraft, referred to as *conning* of the aircraft, requires experience and training. The hoist operator manages a handheld hoist control unit that enables him or her to safely and easily pay out or retract the cable, while the pilot positions the aircraft. In many aircraft, the pilot has redundant hoist controls on the collective.

Hoist operators work at the door of the aircraft, often standing on a skid. To perform this task safely, the hoist operator must be secured to a safety tether in the open doorway of the helicopter. Hoist operators frequently wear long tethers to enable them to reach to operate the hoist, to spot for the pilot, or to move about the cabin. Having a reliable, one-hand-adjustable tether (like the *Petzl Grillon*) can prevent the hoist operator from falling out of the aircraft when working in the cabin, but can be easily adjusted to allow for harnessed work outside the aircraft on the skid when necessary.


Photo: Oliver Kreuzer/Air Zermatt

Safety with the Hoist Cable

While the primary responsibility of the hoist operator is the safe raising and lowering of human external cargo, he or she must also protect the integrity of the hoist cable itself. The cable can encounter varied forms of mechanical error or failure while reeling in and out of the hoist mechanism, and the hoist operator must guard against them with vigilance. In particular, the hoist operator must keep the cable free from the exterior of the helicopter (especially the skid) to prevent abrasion of the cable and aircraft. With few exceptions, the cable should only be unreeled and retracted while the cable is not touching the skid. (As an additional measure of protection, some helicopters have a strip of High-Density PolyEthylene, or HDPE, installed along the outward edge to protect against cable abrasion.)

When a hoist load begins to swing, it can become a pendulum that can cause repeated, successive damage to the hoist cable as it rocks back and forth against the skids. To correct this dangerous movement, the hoist operator will reel out the cable to greater length. Forward flight can also reduce the pendulum swing of a hoist cable.

<u>Rescuers Secured to the Inside of the Aircraft</u>

SAR members are occasionally involved in insertion and extraction operations with open doors, and sometimes the aircraft is configured without seats to save weight. In these cases, the rescuers must sit on the floor and tether themselves and their gear to a suitable anchor point within arm's reach. Specialized equipment (such as the Petzl Progress-Adjust lanyard combined with a Petzl AM'D twist-lock carabiner or the Eashook Open connector) provides easy, one-handed attachment and adjustment to help SAR personnel get themselves and their equipment quickly and safely secured for flight.

Once on Scene of a Rescue Incident

A HEC rescue helicopter may be called to a backcountry scene that ground rescuers have yet to reach. When this occurs, the pilot and aircrew first perform an airborne reconnaissance and scene assessment before attempting any rescue. Once rescuers locate the subject in need of aid, the pilot and crew will assess hazards in the area. These could include:

- Technical terrain that adds risk to rescuers when they are inserted.
- Danger posed to persons on the ground from rockfall caused by rotor wash.
- Danger of avalanche and other natural hazards for rescuers who are to be inserted.
- Other civilians at the scene.

Picking up Rescuers and/or Subjects by Hoist

The delivery of the hoist hook to rescue personnel on the ground must be a well-rehearsed and well-coordinated effort by the pilot and hoist operator. In general, the hoist operator will adjust the vertical depth of the line while giving directional/conning commands to the pilot. These conning commands are direct, clear and usually limited to the horizontal plane (e.g., "forward 10," or "left two," or "right five," etc.). Successful delivery of the rescue hook to rescuers on the ground can resemble the threading of a needle. When 60 to 90 meters of cable are reeled out, precise movement of the hoist hook becomes difficult.

Communication between pilot and hoist operator is not merely essential to place a rescue hook in the right horizontal and vertical planes, it is also essential to ensure ***the timing*** of hook delivery to ground rescuers is perfect. An intercom exchange between the hoist operator and pilot might sound something like this

- "Forward 20" (indicating 20 feet forward to reach the ground rescuer)
- "Right three" (indicating drift the aircraft right three feet)
- "Forward ten" (indicating ten feet forward to reach the ground rescuer)
- "Three, two, one" (indicating a countdown in seconds for the rescuer to receive the hook)
- "Hold position" (indicating hold forward flight and any movement left or tight)
- "Rescuer has the hook" (indicating the rescue has the rescue hook in hand (and is presumably attaching)
- "Hooked in" (indicating the hand signal has been received from ground rescuers that the load has been clipped to the rescue hook)
- "You take the load" (indicating that the pilot can lift the load using the collective and perform a power check)
  - In some programs, the pilot picks up the load, in others the Hoist Operator does. This depends on the experience of the program.
- "Load up off the ground" (indicating that the aircraft now is carrying the entire weight of the load). There can be a momentary pause here where the rescuer performs a final cross/safety check.
- "Clear for forward flight" (indicating that the helicopter is clear for forward flight)

There is variability in how hoist operators communicate. In many programs, these commands are NOT a measurement of distance. They are simply a countdown of space and a means to track movement by verbal cadence until a target is reached. The result is the same but the method eliminates the difference in people's estimation of distance.

At the same time, if the load includes a rescuer who is able to communicate with the aircrew by radio, that rescue crewmember may also signal that the load has left the ground. It is essential that this rescuer also communicate if the load is blocked by or free of obstacles in the horizontal plane. In the absence of radio, the suspended rescuer can communicate clear passage to the aircrew by a specific hand signal.

If the rescue cable is not delivered with precision to rescuers on the ground, or if the hoist hook is swinging in a pendulum motion, the best corrective action may be for the pilot and hoist operator to exit the scene and return for a second try. This is particularly true for hypothermic casualties or those at risk of becoming so, because the longer the aircrew attempts to correct a misplaced hook, the longer the helicopter downwash rapidly cools those beneath it. Extended hover time is not only a hazard for the hypothermic - it can pose a danger to the helicopter and its crew. Although capable of hover, helicopters operate more safely in forward flight.

Whenever an incoming helicopter is about to deliver a rescue hook, rescuers on the ground should assign a single member, the rescue leader, to take the rescue hook. The rescue leader should position him or herself and make ready to grab the hook, taking static discharge into account (as detailed earlier in this training).

Rescuers on the ground should assign a single member, the rescue leader, to take and attach the rescue hook.
Photo: Air Zermatt

Because the helicopter may descend from above or ascend from below, the rescue leader should be prepared to use hand signals to guide the pilot to climb or descend to deliver the hook at the proper altitude. On near-vertical technical terrain, a rescuer on the wall should be the one directing the height of the hook relative to the rescuers but NOT its horizontal movement. The Hoist Operator can see whether the hoist hook needs to move left or right as the aircraft is approaching the rescuers, and can notify the pilot accordingly.

Execution of a Short-Haul Operation

Attaching the Rope to the Short-Haul Anchor

In short-haul operations, rescuers must attach the short-haul system to the bottom of the helicopter, often while the rotors are turning. Preparation of the short-haul system in advance of the helicopter's arrival is key to ensure the safe execution of these operations, although ideally the short-haul rope itself should be deployed following arrival of the helicopter.

Photo: Oliver Kreuzer/Air Zermatt,

Connecting the short-haul anchor system requires practice. Consider, for example, when a short-haul connection must be made in winter in the field, and the aircraft has sunk into a snowy landing zone. In this difficult scenario, the rescuers may have to dig their way to the connecting points to attach the line to the helicopter's short-haul anchor, or undertake the connection while the helicopter hovers close to ground.

Connecting Multiple Rescuers to the Rescue Hook

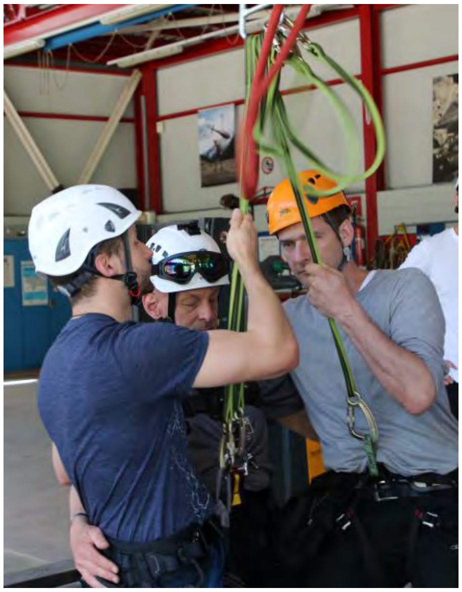


Photo: Eva Sophia Shimanski/Air Zermatt Trqining Center

Many programs employ connecting mechanisms that enable multiple rescuers to be short-hauled into and out of a scene at one time. With these mechanisms, the rescuers are all attached to individual components that are part of one piece of connecting equipment. One lead rescuer is assigned to attach that rescue component by carabiner to the short-haul rescue ring, which should be done quickly when the helicopter arrives to pick up the personnel.

Once rescuers are attached by carabiner to this multi-rescuer connecting device, they must remain attached to that device while it is connected to the short-haul rescue ring. Once brought back to the ground, the pre-assigned lead rescuer detaches the connecting device from the rescue hook. The lead rescuer who is "clipping out" from the rescue ring is responsible for the safety of the area and the whole team. In general, rescuers should not detach from the connecting device until the aircraft has departed (and the rescuers are either secured to a ground anchor or certain that such anchoring is unnecessary).

While the ability to lift multiple rescuers on a single short-haul line is a useful one, the interconnection of rescuers on a single line can pose a risk to the entire team. On cliffs and other complicated technical terrain, the rescuers might become so focused upon the incoming ring that they do not pay attention to their precarious position on the ground. In this setting, the interconnection of all rescuers can increase the consequences of a fall. One rescuer's slip and fall can cause the fall of the entire team. When the hook approaches, rescuers must be careful not to "chase" it - to focus on the ring and forget the terrain - and so invite peril to the entire operation.

<u>Picking up Rescuers Already on a Connecting Device</u>

There are a few key safety considerations for situations where rescuers, attached by a connecting device, are to be lifted from the ground by a helicopter that has landed to connect the short-haul line.

- When the pilot takes off, she or he should perform a very quick power check, which gives rescuers on the line a chance to look at the system and confirm all is OK. If a power check is not done, ground-to-air radio communication is essential to enable rescuers to inform the pilot of a problem while the human cargo is still on the ground.
- Each rescuer must make sure his or her connecting carabiner is not cross-loaded as the helicopter begins to take up the load. This can usually be accomplished by having one rescuer hold the connecting device overhead.

- Rescuers must watch out for the weight ball as the pilot takes off, as this can be lifted off the ground and swing into rescuers.
- Once the pilot takes the weight of the rescuers at the end of the short-haul line, he or she may lift the load only slightly to perform a power check. If the power is marginal, the pilot may gently lower the load and tell the rescue group to reduce the number of rescuers on the line. It is important to recognize that the power check will normally be static, which may cause the load (in this case, the suspended rescuers) to gently spin.

Dropping off Rescuers - Scene Safety

In steep and technical terrain, a rescue helicopter pilot will often approach from below, which gives him or her the ability to get an assessment of the rescue scene and any hazards in the area. These hazards could include terrain issues for the rescuer to be inserted, or entanglement hazards for the rescue system. Still, the rescuers on the line are often better positioned to assess the terrain as they descend.

When rescuers are to be dropped off by short-haul on a connecting device, the pilot may position the rescuers just above the ground where he or she wishes to have the rescuers eventually unload. Because the pilot cannot reliably evaluate the terrain of the proposed drop site, it is incumbent of rescuers to check the site before completing the drop off. If rescuers find themselves being lowered to unsafe ground, they should not unclip from the short-haul, but instead communicate to the pilot by radio or hand signal that the proposed drop zone is unsafe.

Considerations in Safe Terrain vs. Steep and Technical Terrain

If rescuers are to be inserted by short-haul into safe and benign terrain, there remain several actions to consider:

- The lead rescuer should detach the connecting device from the rescue hook as soon as the rescuers reach the ground.
- Once the main line is free, the lead rescuer should extend an arm out with the line and its hook, and release it immediately. If the rescue ring is held as the helicopter pulls away, the line can swing when released, posing a danger to ground crew (from the swinging weight ball) and the aircraft (from entanglement of the line).

If rescuers expect to be inserted by short-haul into steep and technical terrain, there are other actions to consider:

- In such steep and technical terrain, there is more exposure time while the rescuer(s) commits to the mountain and attempts to safely anchor him- or herself to the slope. Attention to this anchoring is key. There have been numerous accidents where rescuers inserted by helicopter were injured or killed from falls from technical terrain after their insertion.
- Rescuers should be prepared to clip into any available fixed anchor or have a camming device ready to anchor themselves. In general, rescuers should not anchor into the terrain before they have completely disconnected from the helicopter, unless they train for this high-risk transition often. For these types of rescues, there are both simple and complex systems for the complicated load transfer from the ground to the helicopter (as is described in In *Lesson 5, Special Considerations*). One example

is the *Petzl* "Lezard," designed specifically for this purpose. The Munter/Italian hitch or simple cutaway are other methods.

- If the area is rocky with cracks or gaps between rocks, rescuers must be careful not to let their feet become stuck between rocks while still connected to the short-haul system. Wind or other factors may prompt the pilot to reposition the aircraft, which can cause the rescuer to be caught or injured when the line moves but he or she cannot.

Radio Communication for HEC Operations

Radio communication and coordination between helicopter rescuers on the ground and their pilot and aircrew are vital, but it must be precise and disciplined. Ground rescuers should limit ground-to-air radio communications to the essential. Unnecessary communication can reduce the situational awareness of pilots and aircrew, and introduce danger during complex operations.

Air Zermatt rescue crew from The Horn, courtesy Red Bull Media

Onboard, rescuers should keep intercom radio communication to a minimum. Many rescue helicopter pilots may not want a rescuer to speak on the radio much at all. The preparation and execution of complex HEC operations is no time for unnecessary chatter. A general rule is "speak only when you see an in-flight hazard" and operate a "*sterile cockpit*" when complex operations are underway. A *sterile cockpit* is one in which no one engages in conversation on the aircraft intercom radio, and uses the radio for mission-specific communication only. HEC crews will often keep a sterile cockpit during departures, arrivals and key operational moments, relaxing the rule only once a safe altitude is reached. The sterile cockpit enables the crew to focus on mission-critical activity without distraction.

If radio communication is lost completely during a HEC operation, rescuers can transition to the use of hand signals and the operation may continue at the discretion of the pilot and crew. The loss of radio communication may not require terminating the operation if this adverse situation is anticipated, and a second means of communication (e.g., hand signaling) has been created and practiced by the team.

Hand Signals for External Loads

The use of hand signals in HEC operations is more important than their use in simple landing and take-off procedures at helispots because of the increased complexity and risk associated with HEC operations. This is especially true if radio communications between ground rescuers and crewmembers on the aircraft are lost. For all their usefulness, however, hand signals are limited by sight: they become difficult to interpret at night and with very long short-haul lines.

Rescuer waving hand horizontally to indicate "hold hover/leve.l" Photo: Oliver Kreuzer/Air Zermatt

Even when ground rescuers have radio contact with the aircrew, the team may prefer to have those on the ground communicate via hand signal. If the pilot and aircrew are communicating by intercom, the ground rescuers can signal without inadvertently introducing cacophony into the cabin while the hoist operator and pilot are coordinating their work.

Specific Hand Signals for HEC Operations

There are several hand signals that are particularly valuable for HEC rescue operations. These include the following:

- COME UP – Swing the right arm clockwise *above the head* in wide and exaggerated circles indicating "increase altitude."
- COME DOWN – Swing the right arm clockwise *below the waist* in wide and exaggerated circles indicating "decrease altitude."
- HOLD HOVER (LEVEL) – A horizontal wave of the hand (perhaps as many as three times), to indicate to hold present altitude. This signal is used to indicate that the rescue hook is at the appropriate height as it approaches rescuers, or by a rescuer on the rescue hook to indicate that he or she is at the appropriate altitude for a drop-off.
- CLEAR OF OBSTACLES – An arm pointing in the direction of travel, indicating the rescue load is above all obstacles on the horizontal plane.
- WAVE OFF – A swinging of both arms over the head, back and forth, indicating "Do Not Land" and "abort."

Rescuer waving both arms horizontally to indicate "clear of obstacles/tree canopy." Photo: Charley Shimanski with Bernalillo County Sheriff's Office, New Mexico (USA)

Operational Considerations for HEC Operations

Transferring the Load from the Ground to the Helicopter

There are two ways to transfer load from the ground onto the helicopter's HEC cable. The first method is when the pilot lifts the aircraft to take the load. The second is when the hoist operator takes the load by retracting the hoist line.

Pilot Taking the Transfer of the Load

In some programs, the pilot leads the transfer of the load from the ground to the helicopter. In this case, when the pilot and crew are ready to take the load, the pilot lifts the load with the aircraft using the collective, and checks to determine that there is sufficient power to fly with the additional weight. If there is not sufficient power, the pilot can lower the collective and bring the load back to the ground safely, as long as the terrain and situation allow.

Veteran HEC and HEMS helicopter program director Casey Ping notes that there may be some cases where bringing the load back to the ground is not feasible, including near-vertical rock walls, areas of dense trees, etc. In these cases, once the pilot takes the load, he or she is committed to the load. This point-of-no-return should be anticipated and discussed prior to the operation. As Casey notes, *"In most cases we already inserted the rescuer. We should be assessing power during the insertion. We are probably burning fuel before extraction. If we don't believe we have power we should be doing something about that before commencing extraction."*

A load transfer that begins with the pilot taking the load may be preferable to those transfers where the hoist operator takes the load. When the hoist operator initiates the transfer, the pilot may not know with certainty when the load is off the ground, and absent that certainty, it is difficult for the pilot to know how much power is available with the new added weight. If the pilot transfers the load, it is easier for her or him to determine if there is sufficient power, and if so, the pilot can tell the hoist operator to begin to reel in the load. Once that load is clear of obstacles (which may be immediately), the pilot can transition into forward flight and the hoist operator can continue hoisting the load up to the helicopter.

When the load transfer occurs in an area with wires, cables, very tall trees or other obstacles above ground level, the pilot can continue to lift the load with the collective (by gaining altitude) without forward flight. Doing so allows the helicopter and its suspended load to clear the obstacles without retracting the hoist line and could bring the load inside the "danger zone" of 1.5 times the rotor diameter below the helicopter. In this danger zone, the rotor downwash can cause the load to spin, possibly into the nearby obstacles. Once the load is above any obstacles (indicated by a hand signal or radio call from the rescuer on the line), the pilot can transition into forward flight, and the hoist operator can then safely reel in the load at a normal rate.


Photo: California Highway Patrol Air Operations

Additional loading of the helicopter often requires more power from the engine if the helicopter is to stay aloft; increasing engine power increases rotor downwash. The hoist operator should avoid raising a load into that downward rotor flow. By waiting until the helicopter is forward flight and the rotorwash is behind the load, the hoist operator can more safely raise the load.

Hoist Operator Taking the Transfer of the Load

In the majority of hoist operations, the pilot cannot see the load and the hoist operator has the best picture of the operation, and is thus in a better position to take the load. Other instances when the hoist operator might take the load include:

- Terrain that would prohibit returning the load to the ground once transferred to the helicopter.
- When helicopter power/performance is not in question (power check completed prior to initiating the extrication).

Providing Critical Medical Care during HEC Transport

Bild am Sonntag Magazine/Christian Spreitz

Performing invasive medical procedures during HEC transport is difficult, if not impossible. Forward airspeed will create a windy environment for patient care in short-haul rescues, a challenge exacerbated by the position of the rescuer relative to the patient. As an example, CPR during HEC transport is impossible without a mechanical CPR device. To continue adequate medical care, it is key that the rescue team transfer the patient quickly from the HEC line to a qualified HEMS aircraft. Pain management prior to a technical external cargo helicopter operation should be considered. At the same time, the HEC litter attendant should be aware that motion sickness, anxiety, litter spin and the movement of the rotor overhead can cause rescue subjects to vomit and potentially aspirate during a HEC operation. For this reason, pretreatment of nausea should also be considered.

Transition of a Patient from the Hoist/Short-Haul to a HEMS Aircraft

There are a number of methods used to transfer a patient from a hoist or short-haul operation to the inside of a HEMS helicopter. Efficient patient transfer from line to cabin is essential to continue medical care. The proper method depends on the rescue helicopter used to retrieve and transport the injured subject, and the HEMS helicopter available to provide critical care.

For example:

- If the rescue helicopter is not HEMS-capable, and a suitable helispot is available that can accommodate two helicopters, a "Nose to Nose" transfer operation may be the method of choice. In this case, a HEMS aircraft can be pre-positioned at the designated helispot, and the crewmembers of both aircraft can transfer the patient from the rescue helicopter to the HEMS aircraft.
- If the rescue helicopter is not HEMS-capable and the subject is rescued using a short-haul, the rescue helicopter crew may choose to transport the subject and rescue litter attendant by short-haul to the location of the HEMS helicopter. In this case, the HEMS helicopter must be at full stop, with rotors not turning, when the HEC aircraft arrives. The HEMS helicopter crewmembers must be ready to transfer the patient to their aircraft once the HEC load is safely on the ground.

In addition, some HEMS helicopters with hoist capability are not able to transfer the patient from the end of the hoist line to be *fully inside* the aircraft while in flight. These programs often hoist the patient and rescuer to the skid, then land to safely transfer the patient onboard.

Part
4

Part 4 – Helicopter Management and Safety Precautions

In this lesson, we explore operational considerations related to all HEC rescues as well as advanced helicopter rescue elements that are independent of HEC operations.

Helicopter Service Ceiling, Hover and Flight

All helicopters have a *service ceiling*. A helicopter's service ceiling is the height above sea level at which the helicopter can no longer climb at a rate of 100 feet per minute. A helicopter rated to fly at a certain altitude cannot hold a hover at the same altitude, because the power demands of hover are greater than those for forward flight.

The *transverse flow effect* is a major contributor to the helicopter's ability to fly at altitudes higher than it can hover. This effect describes the behaviour of the helicopter's rotor system in response to the airflow generated by forward flight. A full discussion of the effect is beyond the scope of this text, (interested parties are referred to [FAA-H-8083-21A – Helicopter Flying Handbook](FAA-H-8083-21A) chapter 2), but a simplification is that hover requires the use of air recirculated through the rotor blades, which creates less efficient lift than does forward flight. Forward flight also tends to stabilize the helicopter's torque, and so requires less use of the tail rotor. With less engine power directed to the tail, more is available for the main rotor to generate lift. In other words, a helicopter certified to fly at 23,000 feet is very unlikely to be able to hover at 23,000 feet.

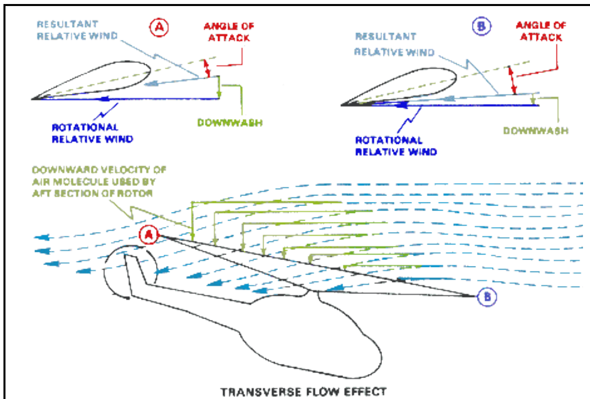


Image by: DynamicFlight.com

INTERAGENCY HELICOPTER LOAD CALCULATION Electronic Version (12/03)		MODEL	Bell 407
		N#	123WH
PILOT(S)	Bo Duke	DATE	
MISSION	Initial Attack	TIME	
1 DEPARTURE	Helibase	PA 4000	OAT 25
2 DESTINATION	Helispot	PA 6000	OAT 20
3 HELICOPTER EQUIPPED WEIGHT		2911	
4 FLIGHT CREW WEIGHT		206	
5 FUEL WEIGHT 50 gals X 7 lbs/gal		350	
6 OPERATING WEIGHT (3 + 4 + 5)		3467	
	Non-Jettisonable HIGE	Non-Jettisonable HOGE	Jettisonable HOGE- J
7a PERFORMANCE REFERENCE (List chart/supplement from Flight Manual)	FMS 3 4-2	FMS 3 4-4	FMS 3 4-4
7b COMPUTED GROSS WEIGHT (From Flight Manual Performance Section)	5000	5000	5075
8 WEIGHT REDUCTION (Required for all Non-Jettisonable loads)	155	155	0
9 ADJUSTED WEIGHT (7b minus 8)	4845	4845	5075
10 GROSS WEIGHT LIMITATION (From Flight Manual Limitations Section)	5000	5000	5500
11 SELECTED WEIGHT (Lowest of 9 or 10)	4845	4845	5075
12 OPERATING WEIGHT (From Line 6)	3467	3467	3467
13 ALLOWABLE PAYLOAD (11 minus 12)	1378	1378	1608
14 PASSENGERS/CARGO			
15 ACTUAL PAYLOAD (Total of all weights listed in Item 14) Line 15 must not exceed Line 13 for the intended mission (HIGE, HOGE or HOGE-J)			0
PILOT SIGNATURE			HazMat Onboard
MANAGER SIGNATURE			Yes No

USFS Load Calculation Worksheet example

To determine whether a helicopter has sufficient power to perform a rescue operation, the pilot and/or crewmembers must assess a number of related variables, including temperature, humidity, density altitude, weight of the aircraft and its payload, wind direction, and wind speed at the time of the operation. Precise load calculations for the conditions of each flight are critical, and miscalculation of helicopter power can have catastrophic results. The importance of this flight-and-mission-planning calculation cannot be overstated, and many fatal helicopter rescue accidents have occurred due to incorrect or inadequate load calculations. Further information on load calculations can be found on Page 29 of "Helicopter Rescue Techniques."

Amount of Fuel on Board at the Start of an Operation

When flying rescue operations at altitudes that might challenge an aircraft's performance, one strategy is to fly with the least possible fuel to reduce weight. The more fuel on board, the more fuel the pilot may have to burn off to achieve the required performance to execute the operation at the required altitude.

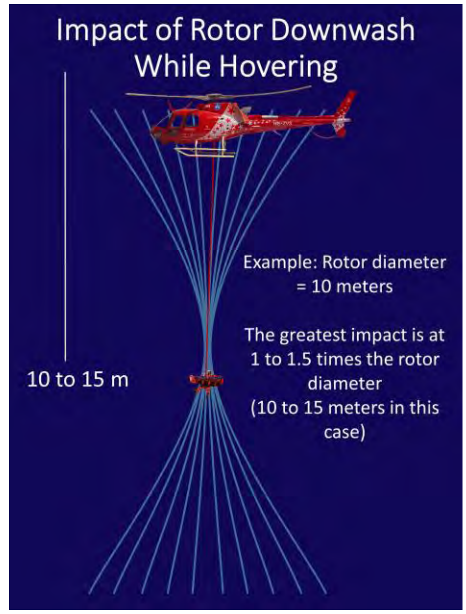
That said, underestimating the fuel requirements of a rescue operation can result in serious complications. Needing to leave a rescue scene to refuel may add delays, and if the helicopter fuel level drops below the final reserve, the pilot would normally have to declare an emergency and land, seriously disrupting the rescue operation.

Aerodynamics of Human External Cargo

While attaching HEC below a helicopter seems straightforward, the interplay of HEC and flight is not as intuitive. Even if a helicopter has more than sufficient available power to lift an external load, the presence of HEC in flight brings other challenges, to include:

1. Wind vortices beneath the helicopter caused by the rotor downwash.
2. Obstacles that increase the risk of entanglement.
3. The heightened situational awareness HEC operations demand and the increased cognitive workload on pilot and aircrew required to sustain that awareness.

While in hover, the greatest impact of the rotor downwash occurs at a distance between 1 and 1.5 times the rotor diameter, where the vortices created by the rotor downwash are at their greatest. For a helicopter with a rotor diameter of 12 meters, the downwash would be greatest between 12 meters and 18 meters beneath the main rotor. When an external load is suspended in that range 12 to 18 meter range, it has a greater risk of spinning.



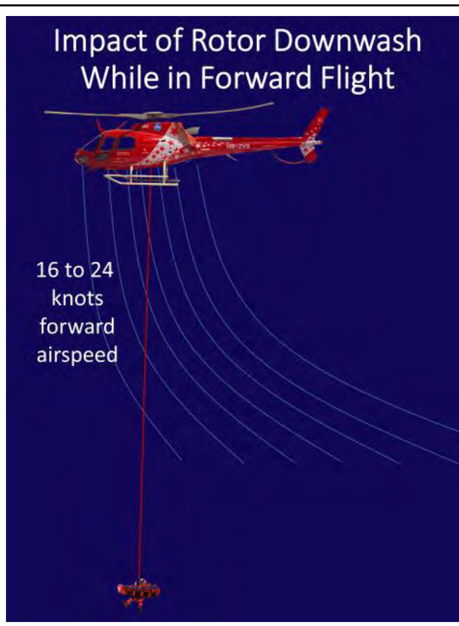
Graphic: Charley Shimanski/Air Zermatt

Hoist Operations and Downwash

It is important that HEC rescue personnel understand that the vortices created by a helicopter's rotor downwash can affect the movement of an external load.

Hoist Operations, Spin and Oscillation

The impact of rotor downwash on the suspended load is the primary driver of load spin. A litter and any rescue attendants will generally not spin while in forward flight greater than the helicopter's effective translational lift (ETL), which is often between 16-24 knots. In forward flight greater than ETL, the rotor downwash is forced *behind the external load*, and therefore has no impact on the load. Furthermore, forward flight creates a wind equal to the helicopter's airspeed minus the tailwind, if any. This wind also acts to reduce spin. Rescuers on the line can take small physical actions to counteract a modest spin, for example, by simply holding one arm and hand out. These maneuvers to counter spin should be practiced during training.



Graphic: Charley Shimanski/Air Zermatt

Keep in mind that 20 knots of wind off the nose of the helicopter essentially produces the same effect as ETL. Rescuer Casey Ping notes, *"During training we induce litter spin and show how it occurs, how air speed can mitigate it. The Hoist Operator can, when possible, pay out hoist cable which can also move the load out of the rotor downwash vertically. In some cases, we have been unable to intentionally cause a litter to spin because of wind at the training site."*

Main rotor downwash *will* have an impact on an external load when the load is directly below the helicopter and the helicopter is *not* in forward flight. This generally occurs when the helicopter first takes up the load and when it approaches the area where it will drop off the load. The time spent in this situation can be minimized, however, if the rescue load is ready for pickup prior to the arrival of the helicopter and the helicopter pilot is prepared to perform a dynamic hoist extraction – one where the helicopter, cable, and rescue hook must only be stationary for the brief moment during which rescuers are attaching the external load to the hoist hook.

"Oscillation" of the load is another aspect of low-speed (near-static) operations that can be dangerous. Oscillation is the rapid movement fore and aft of a load, and can occur when an external load transitions in and out of the rotor downwash while it is pulled only *slightly* behind the aircraft due to a *slow* fly-away speed (below the helicopter's ETL or in winds less than 16 knots). A pilot increasing forward airspeed to greater than ETL will generally overcome this situation.

If the load begins to spin excessively during the final approach to deliver it, the pilot can consider aborting the attempt, and circling around to come back in under a greater airspeed.

Static Hoists vs. Dynamic Hoists

It is important to distinguish between *static* and *dynamic* hoists, because these two hoisting maneuvers carry their own advantages and liabilities.

Static Hoist

In a *static hoist* maneuver, the helicopter remains stationary in a hover above the rescue scene while the load is hoisted onboard. This technique, most frequently performed with larger helicopters, brings the load into the rotor downwash, which is likely to cause the load to spin, particularly if that load includes a human subject in a litter. To counter this spin, rescue teams have employed anti-rotation rudders operated by a rescue litter attendant


Anti Rotation Rudder by TYROMONT

Other teams have incorporated "tag lines" operated by rescuers on the ground. While taglines can be an effective means to prevent spin, they introduce their own problems, which include:

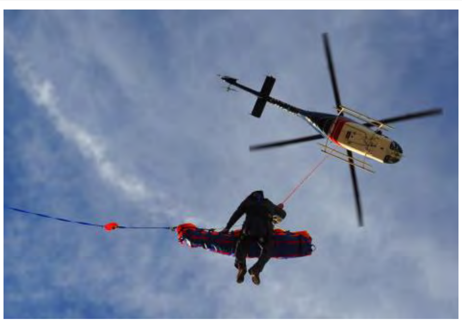


Photo: AirMed&Rescue Magazine

- The aircraft *MUST* remain stationary, and therefore at full power.
- An extra rescuer, trained in the operation of tag lines, is required on the ground.
- The hoist operator has an added responsibility when the load reaches the aircraft, namely to disconnect and drop the tag line.
- A tagline will not prevent spinning if the helicopter remains directly overhead. Once the connection is made, the helicopter must "offset" to the side so the tag line guides the load outwards as it is hoisted upwards.
- The tag line rescuer should not hold too tight and just before the load reaches the helicopter the rescuer should relax their hold on the line, so the hoist operator can detach the tag line.

Dynamic Hoist

An effective alternative to the static hoist is the *dynamic hoist*, a technique that reduces the likelihood that an external load will spin, and eliminates the need for tag lines. In a dynamic hoist, the pilot moves the helicopter into forward flight as soon as is safely possible once the load is taken. Similarly, a rescuer inserted in a dynamic hoist operation is lowered by the hoist operator while the aircraft is in forward flight and on final approach to the rescue scene – enabling the rescuer to safely reach the ground just as the helicopter approaches the scene.

When the ground rescue team is ready for hoist extraction and the HEC rescuer is ready to be picked up, the helicopter returns, again in forward flight, and delivers the hoist hook directly to the rescuer just as it arrives over the rescue scene. For a dynamic hoist extraction to be successful, the crew should prepare on site for the retrieval well before the aircraft arrives directly above the scene. The hoist operator will unreel the cable while the helicopter is in forward flight and moving into position, and will try to extend the cable so that it reaches the rescuers just as the helicopter approaches overhead. Preparation is key for dynamic extraction. The rescuers on the ground must be prepared to take the hook and immediately clip in to continue the extraction.

Once the load is connected and a signal is given by the ground rescuer, the pilot performs a power check, ensures the load has cleared all obstacles and then quickly transitions to forward flight. With this dynamic hoist load technique, the load might spin slightly as the helicopter initially takes the HEC load. But as the helicopter transitions into forward flight and higher speeds, the downwash is increasingly left behind the aircraft (and no longer in the path of the suspended load).

Dynamic hoist operations offer several advantages, including:

- They reduce the amount of time that the aircraft hovers over the rescue scene, reducing both time on-scene and time employing high engine power.
- They all but eliminate the possibility of a litter spin during the hoist operation (attending rescuers can reduce any subsequent modest spin by extending an arm while in flight).
- They provide the pilot more options (in forward flight) in the event that power or the tail rotor become compromised.

Bob Cockell, Vice-President of Air Rescue Systems, says of dynamic hoisting:

> *"The benefits of dynamic hoisting are under-utilized for several reasons, including misunderstanding of the technique, and the mistaken belief that there is necessarily greater risk involved. When correctly performed, dynamic hoist operations reduce risk through decreased exposure, and the team gains increased situational awareness by performing checklist functions, pre-door opening safeties and hoist hook-ups prior to arrival at the target. Through completion of these requisite procedures early on, the team has time to gain composure, reassess the go-no-go statement and choose alternate tactics prior to taking on the exposure associated with the extended hover."*

Spinning Litters in Hoist Operations

One mistake that pilots and crews often make when a litter starts to spin is to slow the forward flight in an attempt to give the crewmembers a chance to correct the spinning problem. In fact, slowing forward flight is precisely the ***wrong*** thing to do. Ideally, as soon as the pilot has the rescuer and the subject, the pilot should transition quickly to forward flight, perhaps to 40-45 knots. In this case, the helicopter outruns its downwash, slowing any spin of the HEC load. Alternatively, if forward flight is not an alternative, the hoist operator can reel out cable while the pilot gains altitude until forward flight is possible, and the load can then be safely raised.

Leadership Knowledge of Rescue Helicopter Capabilities

The leadership of SAR agencies that employ HEC rescue programs must possess a thorough understanding of the operational complexities detailed above. To achieve and maintain this understanding, leadership should *regularly train with the helicopter rescue teams under their authority*. The authority having jurisdiction (AHJ) must be equally aware of the skills and capabilities of the search and rescue air assets available to them, whether HEMS or SAR.

Hot-Loading/Unloading and Power-on Landings

Photo: Bild am Sonntag Magazine/Christian Spreitz

Occasionally, rescue helicopters will need to load and unload rescuers and patients while the helicopter is on the ground with rotors turning. This method is called "hot-loading and unloading," and refers to the 'hot' engine, which is running.

Hot loading and off-loading can increase efficiency - it is faster to perform repeated shuttles of personnel without shutting the engine down with each transfer. They can also allow for landing where fuel, terrain, and impending weather would render a full engine stop dangerous or impossible. But the decision to load and unload "hot" is not without consequence: any operation that requires rescuers to work or move beneath spinning rotors increases risk to both helicopter and crew, and so should be avoided when possible. Rotors can droop if engine RPM is reduced, with the most pronounced droop at the nose of the helicopter. Shutting down the aircraft to load personnel or a rescue subject effectively eliminates the chance that someone or something inadvertently strikes a spinning rotor. When the team decides that hot loading or unloading is necessary, rescuers must prepare carefully, pre-brief and secure loose debris, gear and equipment height in advance.

A *power-on landing* is a type of hot-loading/unloading where an unstable landing site makes it impossible for the pilot to disengage the engine and power-off the aircraft. The pilot must maintain adequate power to prevent the aircraft from tipping or rocking in its precarious perch. Because the engine is not idle during power-on landings, but is powering the main rotor to hold the aircraft in position, the air drawn through the rotor is significant. For this reason, rescuers must anticipate rotor downwash stronger than that experienced during other hot loading/unloading.

Photo: Charley Shimanski/Air Zermatt

Photo: Arizona Department of Public Safety from AirMed&Rescue Magazine

One-Skid and Toe-In Landings

One-skid and *Toe-in* landings are types of power-on landings that pose even greater danger to rescue teams and those they attempt to save. These are specialized landings where terrain makes it impossible for the helicopter to land with both skids (or wheels) on the ground, necessitating a landing where the helicopter is perched one on skid with the engine fully engaged. A one-skid landing is not a complete landing because the pilot must maintain a full power hover while placing a skid or wheel on the ground on the side of the aircraft where the rescuers will load or unload. Prior to positioning the helicopter at the desired one-skid location, the pilot will generally check controllability, hover out-of-ground effect power levels, and tail rotor authority while also ensuring that he or she has a clear escape route in the event of a power issue or unexpected wind gust or turbulence.

Even more dangerous than a one-skid landing is a toe-in landing. In a toe-in landing, the pilot is only able to place the front tips of the skids (or the nose wheel) on the terrain, providing contact with the ground only at the helicopter's 12 o'clock position. This type of operation is even more challenging for pilots than are one-skid landings, since they have to make a dramatic turn to escape the scene in the event of wind or turbulence or compromised engine power.

Photo: Pprume.net

Hover Insertion and Extraction

There are situations where technical terrain renders even a one-skid or toe-in landing impossible, but it remains possible to insert or extract rescuers and the injured while hovering just above the ground. These operations are often referred to as *hover loads*.

Central Okanagan Search & Rescue (COSAR), Wildcat Helicopters, and Vernon SAR's Helicopter Winch Rescue team from YouTube.

The Inherent Risks of Hover Loading and Unloading

Loading and/or unloading in low hover above uneven terrain exposes all involved to high risk. There are several elements of low hover that increase risk, to include:

- The helicopter is generally operating at full power, where there is little margin of error.
- Tail-winds make loading and unloading in hover very difficult.
- The main rotor blades are close to the ground and at full power, presenting a danger to all near them.
- There may be no escape route for the pilot in the event of compromised engine power.
- Snow can conceal the hazards of terrain. When rescuers move from a helicopter in hover onto snow terrain, they expose themselves to these hidden hazards.

For these reasons, pilots, flight crewmembers, and rescuers must exercise extreme caution during hover operations.

Safety Considerations for Hover Loading and Unloading

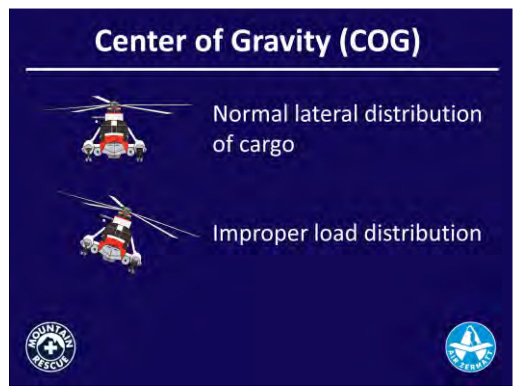
Is a Hover Load/Unload Necessary?

For many reasons, helicopter rescue operations that necessitate loading and/or unloading in hover should be carefully considered before they are executed. Countless accidents and incidents, including fatal accidents, have occurred during these types of helicopter rescues. A thorough risk assessment could include questions such as:

- Does the rescue subject's condition warrant a high-risk hover load/unload of rescuers and/or the subject?
- Does the program have significant experience and training in such techniques?
- Is there an alternative (short-haul, hoist)?
- Are there other elements in the risk assessment that should be considered?

For rescue teams that do not perform these types of operations often, these techniques fall into a "high risk, low frequency" category, a dangerous category that reinforces the need for a thorough risk assessment.

The Importance of Center of Gravity



Charley Shimanski © MRA/ Air Zermatt

Hover loading and unloading operations present a challenge to a pilot's control of the helicopter's center of gravity (CG). If more than one rescuer is boarding the aircraft during a hover load, the first rescuer on board must move to the opposite side of the aircraft after loading to make room for other rescuers. In smaller aircraft, this movement can cause CG issues, especially if it is done quickly. To reduce their impact on CG, rescuers should cross the interior of the aircraft gradually. Rescuers should be careful to distribute their weight on board, and if two rescuers are boarding into the back seat with only one pilot in the front, rescuers should be careful not to load directly behind the pilot to avoid disrupting the aircraft's CG. These same considerations apply for hover egress (unloading).

Keep Extra Gear in a Pack

If a rescuer in a hover load or unload is wearing a rescue harness, he or she should place as much hardware as possible in a pack to prevent hardware attached to the harness from catching on equipment in the helicopter interior during ingress or egress.

Know the Specific Aircraft's Landing Gear

To prevent slipping from the skid and to likely injury, rescuers should make themselves familiar with the aircraft's skids. Some skids have a non-stick surface, others do not. It is all too easy to slip when stepping onto skids wearing 4-season mountaineering boots in very cold weather.

Hover Loading and Helicopter Doors

When attempting hover loading in the field, the rescuers must be very familiar with the operation of the aircraft doors, since the doors will normally be closed as the helicopter approaches for the hover load. Each model of helicopter has its own door handles and operates differently, and it is not safe to assume that familiarity with one set of aircraft doors will convey familiarity with another. Hover load operations are no time to struggle with the doors; rescuers should know how the doors operate in advance.

Photo:Eva Sophia Shimanski, training with Rocky Mountain House SAR and Ahlstrom Air, Canada

Helicopter doors are designed in a way that enables them to be removed easily and are therefore *fragile* and should be opened G-E-N-T-L-Y. If a rescuer uses too much force to open a door, the door may literally come off from the aircraft, or become partially disengaged and inoperable. Similarly, rescuers should be careful to not pull on any doors or external components as they enter the aircraft in a hover load, as these components can become disengaged from the aircraft if pulled with too much force. Rescuers may be able to grab onto seat frames, however, in order to gently climb in. Rescuers should also be aware that hover loading is a suboptimal way to load a rescue subject who has little or no experience around helicopters, although certain circumstance may render it necessary.

Photo: Air Zermatt

Sequence for Hover Loading

When attempting a hover load operation on difficult terrain, rescuers should all huddle together down low on one knee as the helicopter moves into its final approach. The pilot will usually move into a low hover with those rescuers at the helicopter's nine or ten o'clock position, often on the opposite side of the pilot. This means that when the helicopter is in position, the rescuers will not need to take more than one or two steps to access the skids and doors.

Video by Eva Sophia Shimanski, training with Rocky Mountain House SAR and Ahlstrom Air, Canada

If the pilot wishes to come into low hover directly next to the rescuers for a hover loading in challenging terrain, there are a few key rules to follow:

- Once rescuers are in position and the helicopter is on final approach, rescuers should be careful not to move, and to let the helicopter come to them.
- Most rescue programs will generally follow the same predetermined procedure. (E.g., always loading on a particular side, etc.) If terrain, wind, or other flight conditions require deviating from that procedure, rescuers and the pilot need to communicate to create a clearly understood shared plan.
- The pilot may wish to hover somewhat parallel to a slope so that he or she can depart quickly should need arise. Remember, pilots always look for an "escape route."

When performing hover loading, rescuers should consider this sequence:

- Rescuers should step on to the skid gently, one rescuer at a time.
- When transferring weight from the ground to the skids (or vice versa), rescuers must do it S-L-O-W-L-Y, transferring their weight gently.
- Rescuers can board in sequence, and should not wait for each rescuer to be buckled into his/her seat belt before commencing.
- As each rescuer has donned his or her helmet or headset, they should announce that they are "on comms" with the pilot.
- Once the last rescuer is on board, the doors should be closed, even if seatbelts, helmets, and communications are not completed.
- Rescuers should maintain a "sterile cockpit" during this operation, limiting their intercom radio traffic to essential communication.

Hover Unloading

While hover unloading (also known as "egress") presents similar challenges to loading in hover, it also requires different attention to the terrain and aircraft. When preparing to unload while in hover, rescuers should carefully assess the terrain, and move deliberately. As Oliver Kreuzer, a paramedic crewmember and trainer with Switzerland's *Air Zermatt* says, "don't jump out of a helicopter like you just escaped from prison. There is a difference between 'running down the stairs' and 'sneaking down the stairs.'"

Photo: Tomas Kika, Air Zermatt/Vertical Magazine

Rescuers who are to be inserted into technical terrain from hover will most often remain in place on the ground directly outside the aircraft until the helicopter departs. In the unlikely event that the pilot prefers that rescuers move farther from the aircraft, rescuers must communicate clearly with the pilot what actions they intend to take once on the ground. Will they immediately descend downhill from the aircraft, and if so, in which direction? The pilot must know what the rescuers will do once on the ground so that he or she can determine the safest means to fly from the scene. In general, however, the safest course of action rescuers can take is to remain on the ground directly next to the aircraft until the aircraft has departed.

As the helicopter begins to hover, rescuers must determine if the terrain is safe to enter before exiting the aircraft. Rescuers must be careful not to insert themselves into terrain that will cause them to fall.

If many rescuers aboard a smaller helicopter are going to hover exit, those rescuers should be careful to NOT move at the same time across the helicopter to the exit door. As noted above in the discussion of hover loading, the shifting of weight across the helicopter cabin can compromise the pilot's ability to manage the aircraft's center of gravity.

Sequence for Hover Unloading

Video by Eva Sophia Shimanski, training with Rocky Mountain House SAR and Ahlstrom Air, Canada, narrated real-time by veteran pilot Kyle Wadden

When performing hover unloading, rescuers should consider this sequence:

- Confirm that the proposed drop zone is safe. Once confirmed,
- The rescuer near the departure-side door should announce to the pilot the intention to open the door and begin egress.
- Rescuers should remove seat belts first and communications equipment last, maintaining communication with the pilot for as long as possible.
- Once out of their seatbelts, rescuers should fasten their seatbelts behind them to avoid any loose equipment hanging outside the door.
- As with loading, rescuers should move carefully and slowly, recognizing how their shifting weight can complicate control of the aircraft's center of gravity.
- When possible, rescuers should gently step off the skids onto the ground to avoid sudden shifts of weight on the aircraft, transferring their weight from the skids to ground S-L-O-W-L-Y.
- The last rescuer should close the door, if instructed to do so by the pilot. With certain models of aircraft, there is a latch on the sliding doors that can lock the door in the open position. This latch is typically located near the sliding rail at the top of the door, a location that can make it difficult, if not impossible, for the rescuer to reach after exiting he aircraft.
- After the aircraft exits, rescuers on the ground should recognize that the terrain remains incompletely known. They should therefore move slowly and deliberately to further evaluate the terrain. Is it safe to comfortably exit the drop zone? Are all rescuers secure in this terrain? Should rescuers quickly clip in to any natural anchor or to a camming device?

Complex Loading and Unloading - Is There Another Way?

Each of the loading and unloading procedures detailed in this lesson are dangerous and afford little margin for error. Moving into and out of a helicopter in hover, or one perched on a single skid, requires movement on precarious terrain under rotor blades spinning at full power. Rescue teams should avoid these maneuvers, if at all possible, and undertake them only after careful risk analysis. Are there alternate LZs available that are safer, and reduce the need for this complex ingress/egress? Can the patient be moved to a more suitable location? Pilots and rescue crewmembers must not allow themselves to become blind to alternative routes of action. There may be more than one way to perform the mission.

Winter Landings in Snow

Photo: Charley Shimanski

Using a Rescuer as a Point of Reference

Landing a helicopter on snow (or dust) is difficult because the rotor downwash carries the snow into the air where it can obscure sight and vertical reference and lead to spatial disorientation. For this reason, a pilot may wish to have a "visual reference" in a winter landing zone (LZ), ideally a rescuer who remains in the LZ at the location the helicopter will land.

The sequence for using a rescuer on the ground as a visual reference is as follows:

- The "target" rescuer stands in the proposed LZ, holding his or her arms in the classic "Y" signal.
- As the helicopter moves into final approach, the rescuer drops his or her arms to the side and drops to one (and only one) knee. (Dropping to a single knee allows the rescuer to move or change position more quickly and with greater ease than when kneeling on both knees.)
- The pilot will fly directly to the rescuer and land such that the rescuer is kneeling essentially at the nose of the helicopter, often close enough to reach out and touch the nose when the helicopter touches down. For this reason, it is critical that the rescuer not move when the aircraft makes its final approach.

In lieu of a rescuer marshalling in close proximity to the landing helicopter, a weighted pack can be placed in the same location, performing the same role. The pilot maintains visual reference with the pack through the chin bubble all the way to touchdown, which reduces risk to personnel.

Photos: Dale Atkins, Alpine Rescue Team

It is important to recognize that snow landings may need to be power-on landings, since the quality and firmness of the snow - and thus its ability to support the weight of the aircraft - may be difficult to judge. For this reason, the target rescuer should describe the ground snow conditions to the pilot before the helicopter lands. Rescuers can also bring themselves and a carefully prepared rescue subject onto the LZ to serve as the pilot's visual reference in a winter operation. This technique puts rescuers and helicopter at higher risk, and so should be practiced by only the most experienced programs.

Video courtesy Red Bull Media/Air Zermatt; edit by Charley Shimanski

Static Electricity in Winter Hover Loads

When helicopters attempt hover loading in snow conditions, the blowing snow can increase the amount of static electricity. To prevent a dangerous electrical discharge to rescuers, the pilot may need to electrically-ground the helicopter by lowering it into contact with the snow on the earth.

Part
5

Part 5 – Search and Rescue Helicopter Operations

HEC Rescues on Near-Vertical Walls

Photo: Yosemite National Park Search and Rescue

Throughout the world, there are public lands with vertical rock walls celebrated by the climbing community. These vertical faces summon climbers from far and wide to test their skill, and force rescue programs to attempt highly technical rescues when misfortune strikes. These rescues require specialized techniques to insert highly-trained helicopter rescue mountaineers into a complex technical scene to package and extract an injured climber. In these cases, the rescuer is often delivered by short-haul or hoist to the accident site. The rescuers must then anchor themselves to a safety anchor on the wall in a carefully choreographed but rapid maneuver to minimize the amount of time that the rescuer is connected to the aircraft and the rock face at the same time.

The same challenge exists when a rescue helicopter comes to an accident scene to extract a subject in a rescue litter, and the attending rescuer. On highly technical terrain, the litter will be tethered to an anchor on the wall when the helicopter returns to extract the subject and litter attendant. As with rescuer insertion, transferring the litter and attendant from the wall to the HEC line must again be a carefully choreographed and rapid maneuver to minimize the amount of time that the rescuer and litter are connected to the aircraft and wall at the same time.


Yosemite National Park Search and Rescue

A helicopter cannot hover directly above rescuers and injured subjects on a completely vertical wall, complicating insertion and extraction from this type of terrain. These cases require highly trained rescue units to employ specialized and complex procedures to successfully transfer the rescuer litter and litter attendant to the helicopter. Yosemite National Park Search and Rescue (YOSAR), for example, has developed the "Offset Technique" whereby a short-haul line is pulled over by rescuers at an offset angle to the wall. Rescuers then quickly attach their helicopter load line just as they "cut" the litter/attendant-dedicated attachment from the wall anchor, allowing the rescuer and subject to transfer to the helicopter as it flies away from the wall.

For these types of rescues, there are different types of systems to manage the complicated load transfer from the ground to the helicopter. As previously mentioned, Petzl has developed its "Lezard" for this purpose, while some programs may use a Munter/Italian hitch or simple cutaway to accomplish the transfer. It is worth restating that this load transfer is complicated and likely to lead catastrophic injury if performed incorrectly. For this reason, the YOSAR team trains this procedure far more often than they use it. A nuanced description of this technique is beyond the scope of this training.

Rotor clearance from the rock wall is also a critical concern on rescues in near-vertical terrain. While the Hoist Operator is often charged with evaluating rotor clearance during the operation, the rescuer on the wall can call also out the rotor clearance (although this added responsibility runs the risk of task overload).

An advantage of helicopter rescue in steep terrain is the vertical space afforded sheer rock face. If there is a problem while the helicopter is at full-power hover, the pilot can escape by turning the aircraft and diving to pick up forward airspeed. In general, the pilot will hover sideways to the mountain, facing the wind, and can fly into that wind when making an escape.

Night Operations


Photo: US Army

Hoist operations at night present an even greater level of operational risk and challenge than daytime operations. Limited visual reference and the reduced capability of the human eye may cause pilot disorientation, resulting in unstable positioning of the aircraft. For rescuers on the ground, darkness complicates work already rendered challenging by mountainous terrain. Rain, snow, moonless night and the absence of ambient light all heighten the risk inherent to nighttime operations.

For all of the reasons above, rescue crews should carefully evaluate whether a night operation is truly necessary. This determination should start with the patient's condition, since many rescue subjects are stable enough that they can withstand a few hours of care delivered in the field by rescuers as they wait for daylight to perform a well-lit operation.

Night Vision Goggles

NVG training web site example by www.Helistream.com

To augment vision during night operations, helicopter rescue teams use night vision goggles (NVGs). As their name suggests, NVG enhance vision at night and thus increase the aircrew's overall situational awareness. Pilots and crewmembers alike find that the "aided" vision from NVGs is most effective when combined with their "unaided" natural vision (without looking through the NVGs). Since the NVGs are suspended a short distance in front of, and not in direct contact with, the user's eyes, a user can switch from aided to unaided vision without necessarily removing the NVGs.

Advantages of NVGs

NVGs offer distinct advantages for SAR operations. For example, an SAR team using NVGs might be able to find a lost subject at night that would remain invisible during the day because NVGs can more easily detect a light source that would be faint to the unaided eye, especially against the background of remote terrain. A cell phone display, while not necessarily a bright light to the unaided helicopter searcher, is easy to see under NVGs. Crewmembers using NVG will also be able to detect even a small signal fire with ease. And as noted above, NVGs allow the crew to increase their situational awareness during nighttime operations. A hoist operator equipped with NVGs can see obstacles or hazards that may remain hidden to the naked eye despite the use of rescue or aircraft lights.

Disadvantages of NVGs

There are many challenges to using night vision goggles, which include:

- The field of view is only 40 degrees, which requires the operator to continually move his or her head to see all possible hazards.
- NVGs greatly reduce the operator's depth perception, a significant limitation during hoist operations. (Hoist operators should move from aided to unaided vision periodically to benefit from both perspectives.)
- Operators may believe that all obstacles and hazards are easier to see under NVGs, since NVGs not only illuminate but exaggerate light sources. NVGs may not improve the visibility of hazards such as wires, however. The newer white phosphor NVGs offer a significant improvement in visibility, but aircrews must continue to remain vigilant to the technology's limitations.

Since NVGs are sensitive to lighting inside the aircraft, programs must develop onboard displays and lighting compatible with the goggle technology.

Program Considerations Prior to Developing Night Hoist Operations

Night hoist operations require extensive and continual training, training that might be hard to justify depending on the program's budget and the operational demand for nighttime operations. Absent adequate training and current experience, the danger of night hoist operations become more dangerous still. Program managers should consider the many elements of a night rescue program and their alternatives before electing to begin one.

If a HEC program has decided to begin night operations, an argument can be made for keeping these operations as simple as possible, using lights and avoiding the use of NVGs - and waiting for daybreak to attempt complex rescues.

Night Operations for Human External Cargo Programs

Arizona Department of Public Safety, AirMed&Rescue Magazine. Photo by Barry Smith

HEC programs that carry out operations at night should set clear training standards and experience currencies to help ensure these operations are as safe as they can be. These standards can include:

- Course requirements for pilots, mechanics, crewmembers, and rescuers.
- Hands-on training requirements for pilots, mechanics, crewmembers, and rescuers.
- Minimum experience required before pilots, mechanics, crewmembers, and rescuers can participate in live operations.

For HEC hoist operations at night, ongoing training is critical. Rescuers must be able to demonstrate proficiency to remain current and mission-ready. Operational proficiency with NVGs also requires consistent training.

Night Operation Considerations for the Rescuer on the Hoist

An HEC rescuer should be rated by the program for day operations first, and should have significant experience in day operations prior to training in night operations. The rescuer should then receive training in night hoist operations. Prior to transitioning to night operations, the rescuer should have performed a minimum number of operations in accordance with the program's requirements.

Photo: Dale Atkins, Colorado Hoist Rescue Team

Night Operation Considerations for the Pilot

For pilots operating at night, experience with both NVGs and daytime hoist operations is key. By obscuring a pilot's horizontal and vertical reference, night renders the essential ability to hold a hover during a hoist operation more difficult than during the day. NVGs can mitigate this loss of visual reference, but, as noted above, requires training in their use and an appreciation of the technology's limitations.

Night Operation Considerations for the Onboard Crewmembers and Hoist Operator

Photo: AirMed&Rescue Magazine by Barry Smith

Aircrew should receive training in nighttime operations, to include content similar to that received by pilots. Crewmember training can include:

- NVG initial course (length of course would be dependent on experience).
- Mountain rescuer NVG course (including a minimum number of flight hours in summer and winter flights).

Many programs do not allow crewmembers to perform night hoist operations for a minimum number of months from initial NVG rating while performing only training operations.

Night Operations Hoist Procedures


Photo: Airbus Helicopters

Hoist procedures may vary depending on the pilot and crewmembers' familiarity with the area of the rescue.

Responding to the Scene

While responding to the rescue scene, all crewmembers should be employing NVG. While flying using goggles, the pilot should overfly the scene to improve the team's situational awareness and to search for any obstacles.

When en route to the rescue site, crewmembers should consider if, when, and how to activate the search light. Some use the searchlight en route while others do not. Once on the scene the pilot and crew may elect to use the search light to aid in reconnaissance and provide additional ambient light or to increase the functionality of NVGs. Once the crew has developed sufficient unaided visibility of the ground, they should inform the pilot.


Photo: LTG Global web site

The Hoist Operation at Night


Photo: Charley Shimanski

NVGs mounted on a helmet may prove a hindrance to dropping into a scene by hoist or hoisting back into the helicopter. Once the aerial reconnaissance is complete, the rescuer may wish to remove the goggles and stow them in the aircraft or pack them in his or her backpack to hoist in with them.

Lighting Considerations

Lighting of the Rescue Scene

Most aircraft light their belly lights during night operations to illuminate the scene for rescuers and to make the hoist operator's precision work less difficult. HEC programs should evaluate whether the belly lights on its aircraft provide adequate lighting at night. Some belly lights/search lights may not provide enough illumination, especially as the length of the hoist increases.

On vertical wall rescues at night, the pilot may choose to use the search light for aide visual reference while in hover. This light may be too bright for the rescuers below, but essential for the pilot. When possible, the pilot will consider engaging the helicopter autopilot and hold/auto hover.

Hoist Operators

Hoist operators should alternate between NVG and unaided vision while scanning the scene to compensate for the limited depth perception afforded by NVG. They may choose to use NVGs to scrutinize objects in the distance and to identify hazards and then transition to unaided vision during the execution of hovering operations when depth perception becomes critical. To more efficiently make this visual transition, the hoist operator should consider adjusting goggles to a high-up-and-out position. Comfort with the transition between NVGs and unaided vision empowers the hoist operator to move seamlessly to the naked eye should the goggles fail.

In some programs, the hoist operator will work without NVG. These programs believe the helicopter's lights with the hoist operator's unaided vision offer better situational awareness and depth perception.

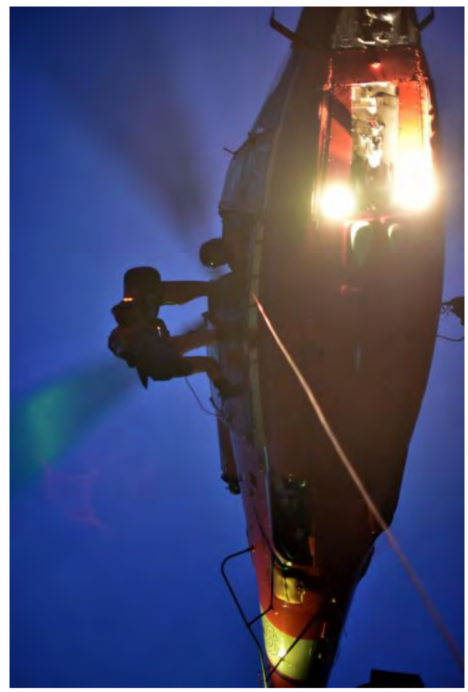


Photo: AirMed&Rescue Magazine by Barry Smith

Lighting for the Rescuer

During the execution of night hoist operation, the rescuer on the hoist should be equipped with bright lighting, usually helmet-mounted. Some rescue helmets are equipped with rail systems that include helmet-mounted lights.

Lighting of Equipment and the Scene

Many rescue programs use "chem-lights" on the hoist hook to make the hook more visible to rescuers and the hoist operator. Other programs may use lighting from the hoist bumper, such as dual headlamps that point downward.

Rescue teams also should consider dropping chemlights from the aircraft to the ground to provide additional reference of distance and terrain. In addition, a V shape of reflective tape on top of the rescuers' helmets can serve as a visual reference for the hoist operator (The "V" shape enables the hoist operator to recognize which direction the rescuer is facing.) Rescuers may also have flashlights and/or chem lights mounted to their rescue vests.

Rescuers should keep light discipline while on the ground and should generally turn off lights when feasible as they approach the aircraft. This reduces the chance that an exterior light beam creates a hazard in the cockpit, blinding pilot or crew, or interfering NVGs.

Communications – Handheld Radios and Hand signals

Hand signals are difficult to see when lighting is poor. The hoist operator is usually unable to see hand signals from the rescuer on the hoist, and the bright lights of the fuselage can make it difficult for the rescuer to see the hoist operator when he or she looks up at the aircraft. For this reason, rescuers should have a separate two-way radio to ensure effective communication. The rescuer should perform a radio check of the two-way radio prior to exiting the aircraft on the hoist.

In some programs, rescuers connect chemlights to their wrists so that simple hand signals can be understood. There should be standardized hand signals for normal, abnormal, and emergency procedures, particularly in the event of radio failure.

Risk Management Considerations for Night Operations

While night hoist operations may be an option for many HEC programs, teams should always ask whether it is possible to stabilize the rescue subject in the field for the remaining hours of darkness and conclude the rescue operation during daylight. If immediate retrieval from the field is not necessary, the arrival of daybreak will remove the limitations - and the risk - of night operations.

CONCLUSION

The development of SAR helicopters capable of inserting and extracting rescuers by hoist and short-haul has saved human lives. HEC operations make it possible to perform rescues where terrain, weather and geography would otherwise render such rescues impossible. This remarkable ability comes at the cost of risk to helicopter, pilot, aircrew, rescuers and those they save; a risk that cannot be overstated. This text has attempted to address the essential components of helicopter rescues that include these specialized rescue techniques, but is not and has never intended to be a substitute for complex, elaborate, and consistently-practiced hands-on training.

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Additional Materials

- "Helicopters in Search and Rescue - Basic Level" - by Charley Shimanski/Dr. Charlie Mize/MRA; a Mountain Rescue Association certificate course covering the basics in helicopter safety, communication, helicopter management,
- "Helicopters in Search and Rescue - Intermediate Level" - by Charley Shimanski/Dr. Charlie Mize/MRA; a Mountain Rescue Association certificate course covering helicopter landing and takeoff areas, heliport management, safety, communication, helicopter management
- "Helicopter Rescue Techniques – Civilian Public Safety and Military Helicopter Rescue Operations" - Ken Phillips; former Branch Chief of Search and Rescue, National Park Service (NPS),
- HeliNOTS (Helicopter Non-technical Skills) is a series of behavioral marker systems, developed by Oliver Hamlet, Dr Amy Irwin, Professor Rhona Flin and Nejc Sedlar of the Applied Psychology and Human Factors Group of the University of Aberdeen.,
- Federal Aviation Administration (USA) Advisory Circular AC 133-1B, which also provides guidance and information for certificated rotorcraft external-load operators.