Abstract
Yosemite National Park has long been recognized as an international climbing destination. The quality, size, and accessibility of the rock faces in Yosemite draw thousands of climbers yearly. Every year a small percentage of those climbers need to be rescued from Yosemite’s walls. The grandness of the terrain that attracts climbers also increases the complexity of rescuing them. Traditional rope rescue techniques are often used especially when rescuing climbers with stable conditions. Even when using traditional rope rescue tactics, it is often necessary to use helicopters to transport rescue personnel and equipment.

Yosemite has developed a high angle helicopter rescue program that can accomplish the same goals as a traditional rope rescue in a timelier manner. These tactics are utilized when the patient presents with an unstable condition, when conducting a traditional rope rescue would significantly compromise the safety of rescuers, or when the logistics of a traditional rope rescue are unwieldy. The program currently conducts high angle helicopter rescues using short haul techniques with Yosemite’s contract helicopter, a Super Huey 205 A1++, and using hoist techniques with the California Highway Patrol’s A-Star AS350 B3, based out of Fresno, California.

Yosemite’s high angle helicopter rescue tactics have evolved from rough concepts that were used on-the-fly into well-defined regularly practiced techniques. In high angle helicopter rescue the transitions between the rock wall and the helicopter are the most difficult and dangerous times. The inability of the aircraft to hover plumb over a rescue site, the proximity of the vertical rock face to the rotors, the presence of sometimes unpredictable wind conditions, and the fact that the litter is typically free hanging before extraction, all contribute to the complexity of this type of rescue. This presentation will discuss the helicopter rescue tactics Yosemite uses to access and extract patients in high angle terrain as well as the programmatic boundaries established to prevent mishaps during these high risk operations.

Bio
Chris Bellino is a Supervisory Law Enforcement Ranger in Yosemite Valley. Chris is heavily involved in Yosemite’s Search and Rescue program and is responsible for authoring Yosemite’s Operating Plan for High Angle Helicopter Rescue techniques. Chris has worked for the National Park Service for 13 years. He spent the first half of his career at Rocky Mountain National Park where he was also very involved in mountain rescue. Chris is an avid rock climber with 20 years of rock climbing experience. His climbing resume includes one day ascents of El Capitan and Half Dome. Prior to becoming a ranger Chris worked as a ski patroller for six years in Colorado and Vermont as well as an outdoor educator for the Colorado Outward Bound School.
Near Camp 4 on the Nose Route, El Capitan
Traditional Rope Rescue Techniques were used to access the scene.
The Throw Bag Technique was used to deliver the end of the empty short haul line to the scene.
The Cut Away Technique was used to extract the injured climber.

Photo Credit: Clay Usinger
A.1 Document Overview

A.1.1 Justification
Yosemite National Park is one of the premiere hiking and rock climbing venues in the world. As a result visitors frequently become injured or stranded in extremely technical terrain. It can take many hours or even days to rescue some of these people using traditional rope rescue techniques. Furthermore, traditional rope rescue techniques often expose far more personnel to risks in high consequence terrain. Often time’s helicopter rescue is the only reasonable means to safely and efficiently evacuate victims from these areas.

A.1.2 Purpose of Document
This document is intended to outline the general procedures and considerations that should be used when performing helicopter short-haul or hoist missions in high angle and technical environments. Helicopter rescue in the high angle environment is extremely dynamic. Some topics addressed in this document are broken down into step by step processes that should be completed the same way every time. However many of the topics discussed in this document are concepts that one must use to make judgment calls in changing situations. Therefore, this document, rather than being just a list of procedures, is intended to help develop the knowledge base of personnel so that they can make better decisions during these dynamic events.

A.1.3 Scope of Document
This document specifically discusses concepts and techniques utilized during short-haul missions with Yosemite Helicopter 551 (Bell 205 A1++) and hoist missions with California Highway Patrol Helicopter H40 (A Star AS350 B3).
A.2 Important Principles

A.2.1 Overview
Helicopter Rescue in the vertical environment is complex. It is important to understand a number of factors in order to affect a safe and efficient rescue. This section is intended to establish a general framework from which to discuss techniques and strategies.

A.2.2 High Angle Technical Terrain
Yosemite National Park’s Short-haul Operating Plan defines High Angle Terrain and Technical Terrain as follows:

High Angle Terrain is terrain where helicopter rotor clearance is limited by the proximity of a vertical rock wall.

Technical Terrain is terrain where the rescuer must be secured to an anchor on scene to prevent a fall due to steep slopes or uneven ground. Often the rescuer must be simultaneously attached to both the anchor and the helicopter during insertion and extraction.

Usually terrain is both high angle and technical. However, in some situation, terrain is only high angle in nature (at the base of a large vertical rock wall) or only technical in nature (on a moderate angle slab climb).

A.2.3 Rotor Clearance
One of the most significant risks in high angle helicopter rescue is rotor strikes. It is very difficult for crew inside the aircraft to accurately estimate rotor clearances. Rescuers deployed on the line or rescuers at the site must provide this information to the crew. Yosemite National Park has established a minimum rotor clearance standard of 20 feet for the high angle environment. The mandatory 20 foot rotor clearance parameter is intended to provide a reactionary gap in the event of an unanticipated wind shift or mechanical failure. Although 20 feet is the minimum standard, larger rotor clearance limits can be established on a case by case basis to mitigate specific hazards identified during a mission. Many of the techniques outlined in this document can be employed with the specific intent of increasing rotor clearance.

A.2.4 Anchor
The term anchor is used to describe a fixed or natural protection anchor that is on a rock wall or other terrain feature. An anchor provides the rescuers and/or patients with fall protection.
A.2.5 Anchor Transitions
In technical terrain rescuers must be anchored in order to provide themselves and their patients fall protection. Due to the steepness of the terrain, these anchors are often supporting the rescuer/patient’s entire weight. During rescuer insertion, the rescuer must transition from the line onto the anchor. In order to maintain fall protection, the rescuer must attach to the anchor before disconnecting from the helicopter. This means that the rescuer will temporarily be connected to both the helicopter and the anchor. This situation becomes more complex when extracting some sort of free hanging load, like a patient packaged in a litter. During extraction the load must be released from the anchor and onto the helicopter using one of several special techniques that are discussed later in this document.

A.2.6 Plumb Line Operations
In situations where rotor clearances allow the helicopter to hover directly over the rescue site a plumb line operation can take place. This means that the line hangs in a straight vertical (plumb) line from the helicopter to the rescue site.

A.2.7 Lateral Offset Operations
In most high angle situations it is not possible for the helicopter to hover directly over the rescue site because of rotor clearance limitations. Therefore, the helicopter must be laterally offset from the site. This causes the line to hang at an angle. The size of this angle has a significant impact on the complexity of insertions and extractions. Larger angles make it difficult to access a site or to acquire an empty line or cable while at a site. During extractions, loads released from the anchor will have to swing into plumb, the larger the angle the larger the swing. This document outlines several techniques that can be utilized to access sites and manage swings during lateral offset operations.
A.2.8 Throw Bag Technique

During lateral offset operations inserting a rescuer or even an empty line becomes difficult. In the throw bag technique, personnel on the aircraft toss a throw bag (essentially a bean bag) to someone at the rescue site. The throw bag is attached to a lightweight pilot line. When delivering personnel or loads, the pilot line is attached to an 8mm deflection line. The deflection line is attached to the load that is suspended at the end of the short-haul line or winch cable. Once the deflection line is established between the site and the aircraft it can be used pull over a rescuer, equipment, or an empty line for extraction. The technique incorporates breakaways (weak links) that will fail under moderate tension to allow the helicopter to immediately depart the scene in the event of an in-flight emergency.

A.2.9 Deflection Angles and Forces

When using the throw bag technique, the process of pulling a load that is hanging under the helicopter out of plumb is referred to as deflection. The deflection angle is measured at the cargo hook for short-haul and at the winch body for hoist. It is the angle between the plumb line and the sloped line when deployed to the rescue site. The size of the deflection angle plays a major role in determining the forces necessary to pull a rescuer or load out of plumb. It also plays a major role in determining the size of the swing that must be managed during extraction. The size of the lateral offset and the length of the short-haul line/cable both can affect the size of the deflection angle. The use of longer lines/cables can reduce deflection angles. Deflection forces can be reduced by reducing the size of the deflection angle or by reducing the weight of the load. High deflection forces typically result in failed throw bag technique attempts.
**A.2.10 Breakaways**

Many of the high angle technical rescue techniques that follow involve the establishment of rope systems between the helicopter and the wall. Breakaways are weak links that are incorporated into those rescue systems to allow the helicopter to immediately depart the scene in the event of an aircraft emergency and to prevent injury to rescuers in the event that they are entangled in a rope during an emergency. Breakaways are designed to provide only enough strength for the intended use. The breakaways are sewn with webbing. The weak link loop is closed with Velcro. The length of the Velcro attachment determines the strength of the breakaway. There are three breakaway lengths in use: 125 pounds (long), 75 pounds (medium), and 50 pounds (short). Breakaways are typically only utilized in deflection line systems or tag line systems that are used to prevent load spin. Breakaways cannot be utilized as part of the primary attachment system for a load. Unintentional failure of a breakaway in a primary attachment system would be catastrophic for the patient and possibly the aircraft.

**A.2.11 Extraction of Free Hanging Litters and Non-Ambulatory Loads**

Two different techniques can be utilized during high angle/technical extraction to transition free hanging litters/loads from the anchor onto the line. The choice of technique depends on the aircraft, the terrain, the weather conditions, whether the extraction will be via short-haul or hoist and whether it is a plumb line operation or an offset operation. What follows is a brief description of each technique:

**Cut Away Technique:**
The litter is attached to the anchor with a primary (tensioned) attachment and a secondary (slack) attachment. When the line is attached to the load, the litter’s secondary attachment is disconnected from the anchor. As the helicopter pulls tension on the line the rescuer cuts the litter’s primary attachment to the anchor.
Lower Out Technique:
The litter is attached to the anchor with a primary (tensioned) attachment and a secondary (slack) attachment. The primary attachment is a doubled rope. It is fixed to the anchor at one end. It is fed through a carabiner on the load and is then secured with a munter mule knot to the anchor. This creates a 2:1 mechanical advantage system. When the short-haul line or winch cable is attached to the load, the load’s secondary attachment is disconnected from the anchor. The mule knot is then removed to allow immediate lower out of the load. As the helicopter pulls tension the rescuer feeds the rope through the munter hitch until the load has transferred onto the short-haul line or winch cable. The rope is then retrieved from the load by disconnecting the munter hitch and pulling the end of the rope through the carabiner that is attached to the litter (much like retrieving a rope after a double rope rappel).