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COOPERATIVE PARK STUDIES UNIT

UNIVERSITY OF IDAHO

A Social Risk Analysis of the
Olympic National Park Mountain Goat Removal Project
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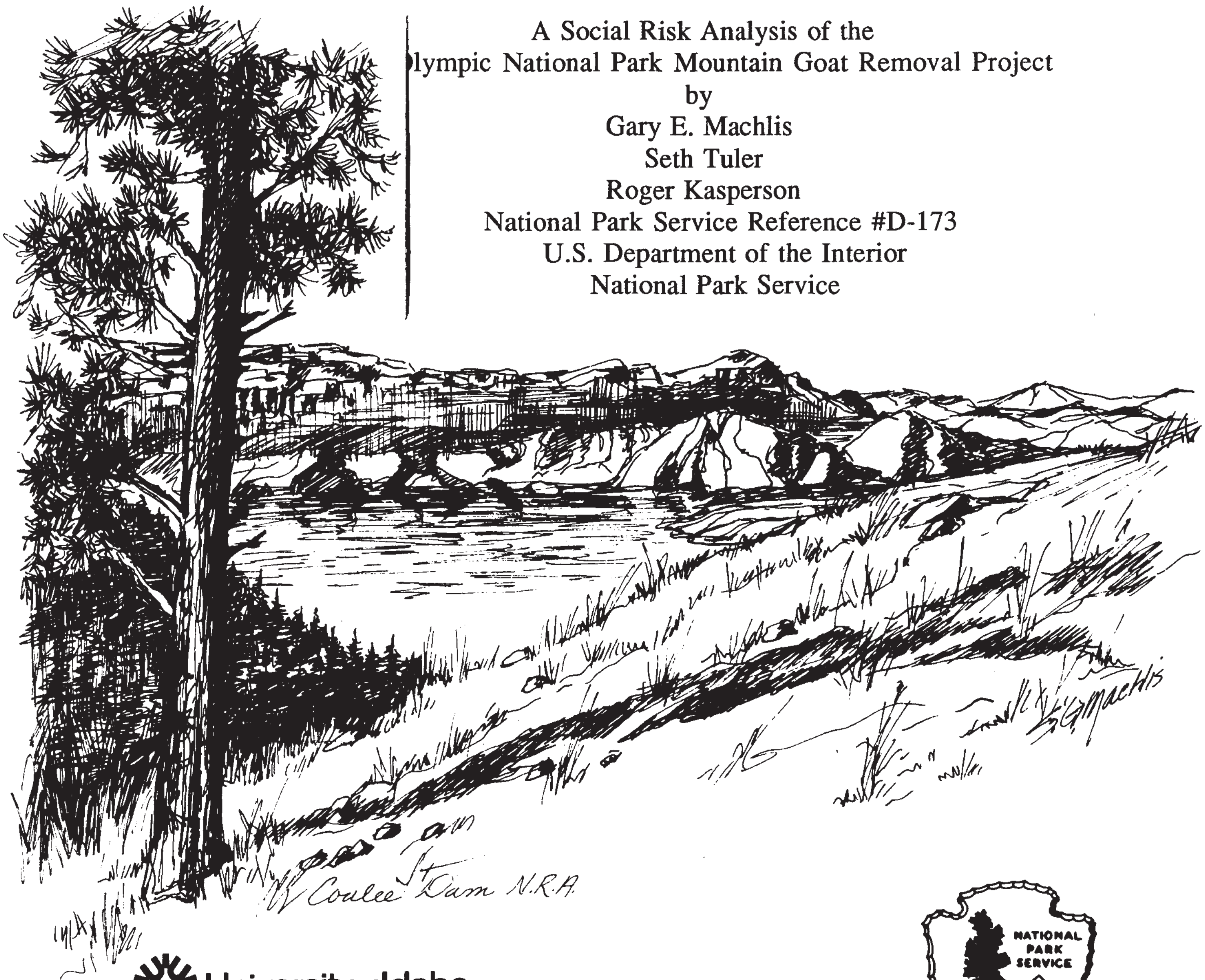

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Table of Contents

Introduction

Mountain goats were introduced to the Olympic Peninsula in the 1920s and are causing damage to portions of the unique ecology of Olympic National Park (Olympic National Park 1987). To prevent further damage, the National Park Service (NPS) began an experimental program in 1981 to rid the park of mountain goats. In 1988 an intensive live capture and removal program was inititated. This program requires innovative and difficult activities in the remote and rugged backcountry areas of Olympic National Park. Successful completion of the activities depend on effective, safe, and reliable human performance at all times.

For wildlife translocation projects such as this to be successful and to minimize hazards to employees, agencies like the NPS must understand, accommodate, and manage social factors that contribute to personnel risk. While specific activities at Olympic National Park are unique, the objectives of wildlife translocation and removal are common to a number of programs in the United States and abroad. For example, deer have been the subject of translocation and removal programs in Florida (McCurry 1990), Big Bend National Park (Machlis 1990), and New Zealand (Caughley 1983). Wild horses and burros have been translocated in Grand Canyon National Park and Death Valley (Rafulski 1990; Janda 1990), and big horn sheep in Lake Mead National Recreation Area (Herman 1990) and Idaho (McCurry 1990).

Risks to personnel result from the nature of capture equipment, characteristics of the animals, method of capture and removal, and drugs used to sedate the animals. Risks can arise from social factors such as overlapping authority, errors due to fatigue and stress, employee values, attitudes, and behaviors.

In this report, the set of activities that form the operational portion of the Olympic National Park Mountain Goat Removal Project are called the "technical task." A "technical task" is defined as <u>a set of practices combining people and technologies to fulfill specific management objectives</u>. The technical task of the Olympic National Park Mountain Goat Removal Project is based on the use of a helicopter to transport both personnel and goats. These activities result in the exposure of personnel to a number of safety hazards. At several stages of the technical task, personnel could possibly be injured or killed in accidents.

Purpose of the Report

This report focuses on personnel risks that are related to the social context of the project. The objectives are to:

1) describe the technical task;
2) provide a representative review of relevant social science literature on risk;
3) summarize the implications for managing risk associated with the Olympic National Park Mountain Goat Removal Project; and
4) develop recommendations that can increase personnel safety.

The report does not evaluate specific risks associated with mechanical failure or provide a quantitative risk assessment of the project. While safety to the mountain goats is of much import and concern, it is not examined in the report.

Methods

The report is based on information collected by a review of the literature and interviews of key personnel involved in the Olympic National Park Goat Removal Project. A planning meeting established the scope of the project, and introduced us to the concerns of NPS staff. The literature review used the library at Clark University's Center for Technology, Environment and Development. We travelled to Olympic National Park and met with the Chief Ranger, the capture team leader, and the owner of the helicopter company involved in the project (the owner has also served as a pilot in the project). These interviews provided basic information on the technical task and attitudes toward risk. The capture team leader was also interviewed by phone, to clarify details and answer questions regarding the technical task. Interviews were also conducted with knowledgeable experts in the fields of aviation safety and social risk. A draft report was prepared and reviewed by NPS personnel and several social scientists knowledgeable about social risk. A final report was prepared.

Overview of the Report

After this <u>introduction,</u> there is a detailed <u>description of the technical task.</u> This description provides a basis for identifying key areas of concern for personnel safety, and the characteristics of the technical task that contribute to risk. Next, a <u>literature review</u> summarizes the available social science literature on risks associated with activities similar to those in the Goat Removal Project. The review presents what can be learned from previous research.

The next section describes the potential social risks associated with the technical task. Using concepts from the literature review and the description of the technical task, key factors influencing personnel safety during goat removal activities are discussed. Finally, a series of recommendations are presented, both short-term and long-term. A conclusion, bibliography, and appendices follow.

The Technical Task

The technical task of goat removal involves many individuals. The personnel that participate in the project include the capture team of a pilot and two "gunners" (a gunner is required to have additional qualification as an animal restraint crewmember), and the ground crew, including animal handling specialists and recipient-agency personnel. These include:

- staging area manager;
- assistant staging area manager;
- technical specialists in animal handling;
- security manager;
- traffic control personnel;
- liaison officer; and
- recipient agency personnel.

An NPS organizational chart and detailed descriptions of NPS personnel responsibilities and qualifications are in Appendix 2.1.

The basic sequence of activities involved in mountain goat capture and removal are shown in Figure 2.1. The sequence of stages often form a loop, because multiple goat captures may occur during a day's activities. In 1989 the average number of goat captures per day was six. The loop is formed when goat search and selection activities begin after a previously captured goat is transported to the staging area and the gunners are recovered by the pilot.

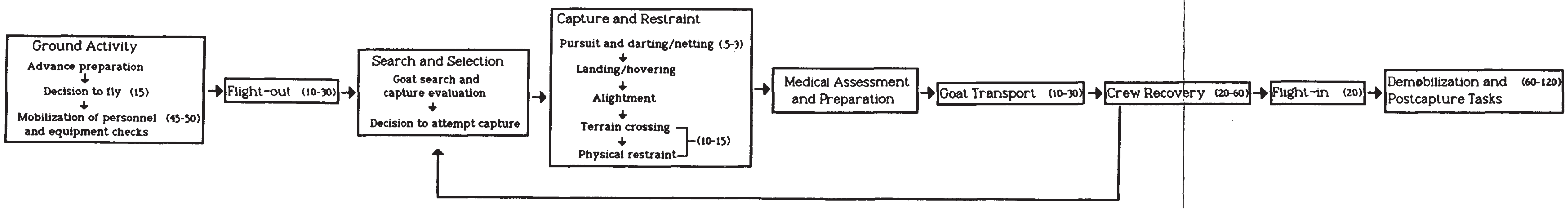
Stage 1: Preliminary Ground Activities

Decision to Fly

The first important activity is the decision to perform or cancel operations for the day. The capture team leader (who is also a gunner) is responsible for this decision and awakes at 5 a.m. to assess weather conditions. He goes to the Hurricane Ridge staging area before 6 a.m. and allows approximately 15 minutes to judge current weather conditions in Olympic National Park and how they may or may not change during the day.

The assessment of weather is critical and involves predicting potential variability early in the morning. Helicopter flight, search, and capture cannot be conducted in adverse meteorological conditions. This requirement is an important limiting factor in Olympic National Park--in 1989, 14 of 39 capture days.

Figure 2.1. Stages of the technical task (minutes)



(48%) were cancelled due to unsafe flying weather. Weather conditions must be satisfactory in two places simultaneously as:

- the helicopter is based in Forks and is flown each morning to Hurricane Ridge to rendezvous with the capture team;
- goat capture flights originate at Hurricane Ridge Ranger Station.

If weather conditions in either location are unsuitable, the day's operations are cancelled or delayed. The need for adequate weather in two locations requires a joint decision between the team leader and the pilot to proceed with the day's operations.

A second important determinant of the decision to fly is the availability of the capture crew, which includes a pilot, and one or two gunners. For example, if anyone on the capture team is sick, the day's operations will be cancelled. If the designated pilot is ill, the team can operate with a replacement. In the past, four pilots have been used on the project (and three different helicopters). However, according to the capture team leader, it is unlikely operations would occur with a replacement pilot. Unavailability of pilot or aircraft due to unscheduled maintenance will cancel the operation for the day.

Mobilization and Equipment Check

If the capture team leader's decision is to fly, other members of the capture crew and staging area personnel are alerted via a "phone tree" beginning around 6 a.m. Unlike an illness in the capture team crew, a missing member of the ground crew due to illness is not critical and would not necessitate the cancellation of the day's goat removal operations.

By 6:45 a.m. the pilot arrives with the helicopter at Hurricane Ridge from Forks. This flight takes approximately 30 minutes. The helicopter, a Hughes 500-D, is contracted on a "call-when-needed" rental agreement from Eagle Air Helicopters, Inc. The pilot is an employee of Eagle Air Helicopters, Inc. and is "dedicated" to the project for the duration of operations each summer (in 1989 this was five weeks). However, the pilot may also work on other jobs when he is not required for the goat removal project.

The 500-D can seat four people, two in front and two in back. In the goat removal project, two or three people fly in the helicopter and the rear-right seat is used to store equipment needed by the gunner (see Figure 2.2). When flying goat capture sorties, the rear door is removed and the gunner sits behind the pilot facing out toward the left side of the craft. Thus, the pilot and gunner both face the same side. This facilitates coordination of activities during pursuit and capture of goats.

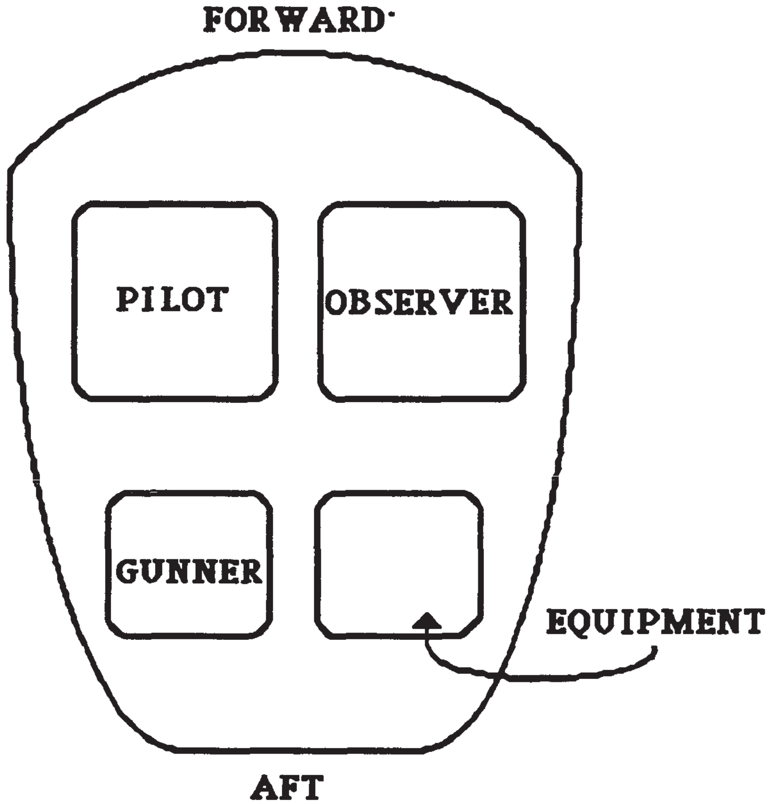


Figure 2.2. Helicopter seating / equipment arrangement

The right-front seat is sometimes occupied by a third member of the capture team. The third passenger is a passive observer during a goat capture operation. Usually this individual is also a "gunner" so that more goats can be captured per day. During normal activities, the only time all three individuals are in the helicopter together is during the initial flight into the backcountry, pursuit of the first goat in the morning, during the final flight out of the backcountry in the afternoon, and during travel between widely separated areas of the backcountry.

After the pilot arrives, 15-20 minutes are spent on helicopter preparation, personnel preparation, and equipment loading. Helicopter preparation includes:

- evaluation of fuel requirements. The Hughes 500-D can carry fuel for approximately 1.25 hours of flying time. During a day's operations as many as three to four refuelings may be required;
- testing of radio equipment. If any communication equipment components are not working properly, the day's operations are cancelled. The communication equipment used include the helicopter radio, portable ground-to-air radios used by gunners when on the ground, and the aircraft intercom system.
- evaluation and check of pre-flight plans;
- removal of the left rear door. This allows the gunner easier and faster exit and entry into the helicopter. It also facilitates dart or net gun sighting and shooting; and
- other equipment safety checks and preparation. Safety gear and protective equipment, firearms, and goat capture supplies must be prepared, checked, and loaded into the helicopter in the appropriate way. This gear is loaded into the rear-right seat of the helicopter.

Each member of the capture team is issued and must use specific safety equipment during all operations. Personal safety equipment includes flight helmets (SPH-4C) with avionics, leather boots, a NOMEX flight suit and gloves. The gunner also uses a harness to attach himself to the helicopter as he leans out of the rear door during pursuit and shooting phases of the goat capture. The gunner may also wear insulating clothes (over the NOMEX clothes) to protect him from temperature changes and wind-chill when flying with the rear door off.

Stage 2: Flight-out

By 7 a.m. the capture team (the pilot and one or two gunners) is airborne. The flight into the backcountry usually takes 10-30 minutes. Simultaneously, personnel begin to arrive at the staging area at the Hurricane Ridge. At the staging area, the staging area manager gives his daily briefing and equipment is set up. This equipment includes supplies for handling, monitoring, medicinally treating, and transferring goats. In addition, traffic and crowd control equipment are set up.

Stage 3: Search and Selection

Goat Search and Capture Evaluation

In prior years, the capture team leader attempted to identify and prioritize goat search and capture areas in advance (see Appendix 2.3). These strategic plans were based on the location of known goat populations and the sensitivity of plant and soil resources. As time elapsed such preplanning was not always successful, as goat populations dispersed or were not always accessible. In 1989, predetermined search plans were abandoned.

Currently, decisions are more spontaneous and the capture team utilizes a daily strategy of systematic search and scanning. This allows goat sub-populations to be worked sequentially and avoids revisits soon after previous capture attempts (which can over-stress goat populations). These decisions are usually made by the capture team leader and are considered to be usually quite obvious to the capture team. There is no "second guessing" by park management of the search strategy.

Decision to Attempt Capture

If animals are spotted, this does not imply that the crew will attempt capture. Further conditions must be met. For example, in 1989, out of 138 animals observed, only 67 were captured (including goat fatalities). The criteria for deciding to attempt the capture of a particular goat are whether:

- the goat can be safely maneuvered to a location that improves landing ability and the potential ease of the gunner's movement across the terrain;
- whether the goat is alone or with others (goat captures are usually attempted on lone goats or ones that can be separated easily from others);
- the goat can be maneuvered for capture, netted or darted, and restrained in an area that will decrease the likelihood that the goat will be injured while trying to escape; and
- adequate aircraft performance and fuel are available to complete the capture.

Stage 4: Capture and Restraint

Pursuit and Darting/Netting

Once a goat has been identified for capture the team attempts to keep the actual chase to a very short time. In fact, after a goat has been spotted and chosen for capture, the in-flight portion of the capture generally ranges from 30 seconds to four minutes: "a few seconds to assess" the feasibility of darting or netting, "swooping" in for a clear shot, and two to three minutes to get a shot off. If the pursuit is not going well, the crew will abort the capture attempt.

A short time duration for goat pursuit and capture is an important criterion because of both animal and personnel safety. There are several reasons:

- goat chases in the backcountry frequently occur in very rugged terrain at high elevations. Low altitude flights along ridges, cliffs, and in the vicinity of trees are frequent. Flight maneuvers and flight paths frequently push the pilot to his physical and experiential limits and the helicopter to its performance limits;
- simultaneous and difficult demands are placed on the pilot and gunner. For example, the pilot must simultaneously monitor flight instruments, navigate a safe flight path, maintain communications with the gunner, and maintain visual contact with the goat; and
- goats can be injured by falls before or after netting or darting. High temperature and respiratory overload from long pursuits can kill the goats.

Communications between the pilot and the gunner are critical during pursuit. Both microphones and speakers are built into the flight helmets. To facilitate communication during pursuit, the gunner switches to hands-free "hot mike" mode, whereby he does not have to push a button to talk to the pilot. This allows the gunner to give the pilot instructions for pursuit (e.g., change of direction by the goat) and to maintain control and readiness of the firearms.

During pursuit, the gunner is the most exposed individual in the capture team. He is fastened to the helicopter with a harness and places a foot on the access step for support. At the same time that the gunner is leaning out the rear door, very important constraints exist on the timing and ability to fire the dart or net gun. These are a result of animal behavior, helicopter stability, capture method (dart gun or net gun), and the gunner's skills. During pursuit a gunner may change tactics and switch firearms several times before a goat is darted or netted. In order to avoid accidental discharge in the helicopter, each time a weapon is switched for another it must be unloaded and the other reloaded. A loaded weapon must at all times be pointed toward the outside with the muzzle parallel to the helicopter rotor plane. There are no safeties on these weapons.

There are two methods for immobilizing goats in the backcountry. The first is chemical immobilization. A Simmon ® dart rifle is used to deliver darts that contain Carfentanil citrate. A blank .22 caliber cartridge is used to propel the dart and rifle adjustments allow varying the range and velocity of impact. To avoid injury to a semi-drugged goat, attempts are made to keep the induction time as short as possible, although it can vary because of goat size, effectiveness of delivery, and physical state of goat.

The second is netting. A four-barreled Coda® net gun is used to deliver a 12 x 12 ft. square net with weights attached to each corner. Use of the net gun requires the pilot to fly the helicopter parallel to the goat. Firing must be very accurate because the rapidly spreading net can become entangled in helicopter skids or rotors. Safety procedures for use of the net gun require that both elbows be firmly resting on one's knees when holding the gun. This constrains the direction in which it can be fired and decreases the likelihood that misfiring can be directed into the rotor blades. Instead of the gun being aimed at the goat, it is held stationary and fired when the goat enters the "sight picture."

The advantages of each method depend on the location of pursuit and capture. The gunner must be prepared to use both at any time. Each method has its advantages and disadvantages, depending on the location of the goat:

- Dart guns are the easiest for the gunner to handle and aim. However, chemical immobilization requires a few minutes for induction during which the crew may not be able to control the animal's movement. During this time the goat is still mobile and can injure itself. Thus, the dart gun can only be used in certain areas where this possibility is minimized. Once the animal is immobilized, it is fully tractable.
- Net guns are very heavy. The criteria for use are very narrow. Firing of the gun can only occur at very specific times to avoid disabling the helicopter. When it works, it is very rapid. However, because the goat is not immobilized, the gunner must alight from the helicopter immediately to restrain the goat and avoid its becoming injured. Thus, this method is very hard on both the animal and the gunner.

Landing/Hovering

Once an animal is netted or darted, a site must be chosen for the gunner to alight from the helicopter and prepare the goat for transport. Optimally, landings should be near the goats so that the gunner is not required to cross much terrain.

Landings where both skids can be placed on the ground are a priority. However, because of the ruggedness of the backcountry areas, two-skid landings are rarely possible. Landings are frequently required on areas of steep slopes. Usually one-skid, toe-in or hover step-off are performed:

- Toe-in landings are those where the helicopter is rested on the toes of the skids. This maneuver requires holding a significant amount of hover power to prevent the helicopter from falling backwards. Lateral and longitudinal shift can occur during loading and unloading operations.
- One-skid landings occur when one full skid is on the ground and the other skid is suspended in the air. In this type of maneuver the center of gravity can shift laterally.
- Hover step-offs (helijumping) are often used during net gun captures.

In both types of landings, gusts of wind, up and down drafts, and loose rock can increase the danger of an accident. In the backcountry areas of Olympic National Park where these landings occur, rotor clearance from obstructions is often minimal.

In January 1990, the Office of Aircraft Safety, Department of Interior issued an Operating Procedures Memorandum for helicopter toe-in and one-skid landings (Appendix 2.4). New procedures prohibit such landings unless exemptions are obtained.

Alightment

The gunner waits for a signal from the pilot before alighting. Such signals are developed by the capture team before the start of each year's operations. Thus, the signals may change from year to year and when new individuals (e.g., a new pilot) join the capture team. The signal can be as little as the appropriate "look" of the pilot to the gunner. With the current capture team, the signal is made by a nod of the pilot's head. The communication must be nonverbal because the gunner unplugs his head set when preparing to alight.

When net guns are used, rapid restraint of the goat by the gunner is necessary to decrease the likelihood that the goat will be injured. Since this requires rapid alightment by the gunner, landings are frequently not possible. To maximize exit speed from the helicopter, the pilot performs a power hover over a suitable spot and at a suitable height so that the gunner can jump off the left skid.

Terrain Crossing

The terrain in which goat removal operations occur can be very rugged. The gunner must cross the terrain between the goat and helicopter while carrying 55 lbs. of capture and safety-related equipment.

Communication is maintained between the gunner on the ground and the pilot by portable radio and the helicopter radio. The gunner uses the portable radio to notify the pilot when the goat is ready for pickup. In case the goat is not visible to the gunner from the ground, the helicopter pilot can identify its location by hovering above it. Because of the terrain, transmission may be blocked, temporarily disrupting contact between the pilot and gunner.

Physical Restraint

Once the gunner is out of the helicopter, he must physically restrain and prepare the goat for transportation. This portion of the capture is the most labor intensive for capture team personnel and can take approximately 10-15 minutes. Frequently, the gunner must attempt physical restraint of the goat with limited working room and on steep slopes, loose rock, or hard snow.

The gunner must physically restrain the animal (the weight of a large male adult mountain goat is around 200 lbs). If the goat is darted and chemical immobilization occurs, the goat will be recumbent. If the goat is netted, it needs to be physically restrained. During one-person restraint, the gunner must rapidly but carefully approach the goat and quickly gain physical control of the head to avoid being injured by horns.

Stage 5: Medical Assessment and Preparation

Once blindfolded and restrained, the goats become very docile and much less dangerous to personnel. At this stage, medical data are obtained. These include vital signs (such as temperature) and examination for injuries (such as fractures).

After medical data are collected, the gunner must put the goat into a specially designed "goat-bag." Capture team personnel almost always work individually on the ground, unless the goat is very large and the other gunner is available. This activity is very labor intensive. If an animal has been injured, the gunner can decide to destroy the animal with his Service-ssued revolver according to Park Service regulations.

Stage 6: Goat Transport

After the goat has been "bagged," it is sling loaded to the helicopter. A 60-120 foot longline is used to attach the goat to the helicopter. Hovering helicopters are considered hazardous enough by Park Service management that 25 percent hazard pay is given to individuals working under a helicopter (capture team members are also given 25 percent hazard pay during "maximum performance flights" which occur in this project). Before the pilot and goat leave in the helicopter for the staging area, emergency survival gear (25-30 lbs.) are off-loaded to the gunner. Animal transport is skipped when a goat is injured or killed during a capture attempt or otherwise not capable of being transported to the staging area. If a goat is killed during a capture attempt, the crew resumes activities with Stage 3 (goat search).

An important loop in activities occurs if two gunners are active during daily operations (see Figure 2.3). While one gunner is engaged in restraining a darted or netted goat, the pilot and second gunner search for and pursue a second goat. If they are successful in netting or darting a goat within a reasonable length of time, the second gunner alights from the helicopter to restrain and prepare the goat for transportation. If it takes too long to capture a goat, they return to the first gunner and his captured goat. If the two captures occur in the same area, the pilot will:

- retrieve the first gunner's goat;
- retrieve the second gunner's goat; and
- transport the goats back to the staging area.

If the two gunners were not landed in the same area, the pilot may:

- retrieve the first gunner and captured goat, transport them both to a pre-arranged backcountry staging area;
- retrieve the second gunner and goat, transport them to the same backcountry staging area; and
- transport both goats to the Hurricane Ridge staging area.

During these flights the pilot must take care to fly at altitudes that prevent entanglement of the longline in trees, rocks, and so forth. The pilot also maintains radio contact with staging area personnel to provide information about the location and activities of the capture crew and estimated arrival time to the staging area.

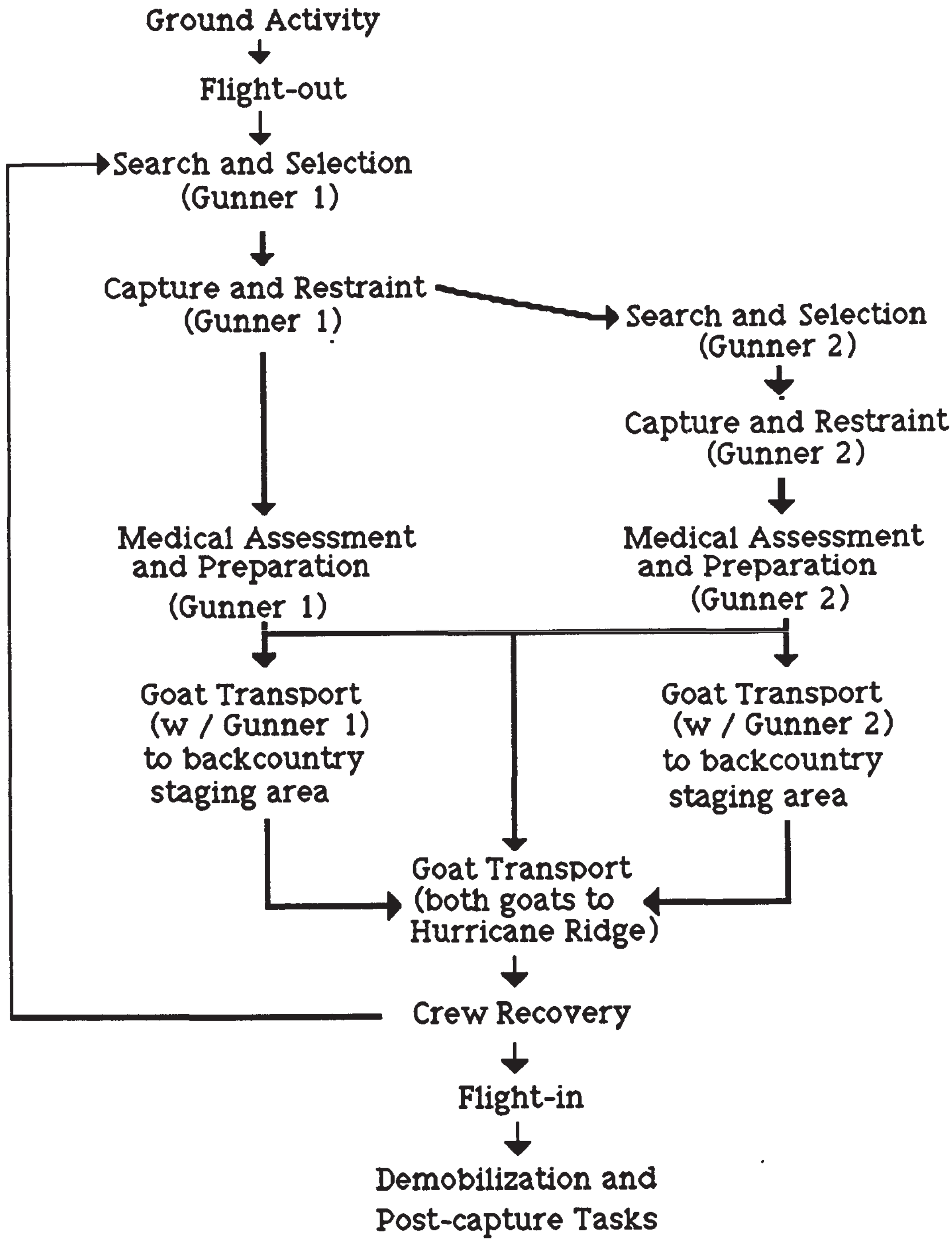


Figure 2.3. Stages of the technical task with two gunners

Upon arrival, staging area personnel detach the goat(s) from the helicopter. Staging area personnel qualify for 25 percent hazard pay when working under a hovering helicopter.

At this point, staging area personnel become responsible for captured goats. They perform a number of medical checks and prepare them for transfer to another agency. Appendix 2.5 contains a detailed list of these tasks.

Frequently the pilot will refuel at this stage. The fuel is available from a fuel truck that arrives each day from Forks. Routine safety checks are completed after each refueling; these are the same routine checks that are made before any flight.

Stage 7: Crew Recovery

During the time that captured goats are being transported to the staging area, a gunner has approximately 30 minutes of waiting time before he is picked up and a new round of captures begin. During this time, the gunner may spend a few minutes to retrieve and prepare his equipment for the next search. There are no formal rest periods during the day's activities, and so he can eat lunch, drink, and "catch his breath" while waiting for the pilot to return. Depending on the location of the capture and prior plans, the gunner can either stay and await pickup or walk to a predetermined rendezvous area.

Throughout the day, the pilot is in continual contact with personnel at the Hurricane Ridge Staging Area. Staging area personnel notify the pilot and capture crew of any impending weather changes that might require termination of the day's goat capture attempts. The decision to terminate a day's activities is made by the capture team.

Complications can arise at this stage because of the unpredictable and sudden weather changes that are characteristic of the Olympic Peninsula. Weather could prevent the pilot from returning for the gunner(s) in the backcountry. In such an event, the gunner(s) must either hike out or wait for the weather to improve, using limited survival gear. So far this problem has not arisen.

The decision to terminate the day's operations is made by the crew leader. This decision is based on several factors, including:

- success of locating and capturing goats;
- changes in weather;
- occurrence of any goat fatalities;
- fatigue of personnel; and
- total hours worked.

If a decision is made to terminate the backcountry capture of goats, the pilot and gunner(s) return to Hurricane Ridge (Stage 8). Otherwise they begin the capture process again and search for another goat (Stage 3).

Stage 8: Flight-in

After the gunner(s) are retrieved from the backcountry, the crew returns to the Hurricane Ridge staging area. This flight usually takes approximately 20 minutes. The capture team usually attempts to finish up capture activities and return to Hurricane Ridge by 1 or 2 p.m. (eight or nine hours since the flight-out in the morning).

Stage 9: Demobilization and Post-capture Tasks

Upon their return to Hurricane Ridge, the team's activities are not finished. An additional one to two hours of work must be completed before they are finished for the day. Thus, the capture team is frequently engaged in some aspect of work related to the project for 12-14 hours a day. In some unusual cases they may work a total of 16 hours in a day.

The helicopter pilot must return to Forks and perform routine safety and maintenance checks on the helicopter. Because the goat removal project places great stress on the aircraft, some maintenance activities are performed more frequently. For example, filters are cleaned twice as often as normal. Paper work includes the completion of a flight invoice that records daily aircraft use hours, and mileage.

Although the Office of Aircraft Safety has regulations that limit pilot work hours under their jurisdiction to eight hours a day, they are not applicable to Eagle Air Helicopters, Inc. employees. In some cases, pilots fly additional hours on other projects before they go off duty until the next day of goat removal activities.

The capture team gunner(s) must also complete additional activities before he is finished for the day. He must record data about the captured animals and reconcile his with the records of staging area and medical personnel (Appendix 2.6). In addition, he must clean capture equipment (e.g., recovered darts, protective clothing), store medical supplies and firearms, and dispose of medical waste. In addition, the gunner may assist staging area personnel handling "problem" animals, if necessary.

The staging area must be closed down and the staging area manager must fill out his logbook. To close down the area, personnel must remove traffic barriers, store equipment and supplies, and assist in the reconciliation of records with the capture team leader.

Literature Review

This section reviews prior social science research on safety and social risks in technical tasks. Specifically, this section:

- introduces the history and concept of "social risk;"
- develops an understanding of social factors that can cause or contribute to the occurrence of accidents; and
- summarizes characteristics of individual, group, and organizational behavior and performance in technical tasks that share similarities with the Olympic National Park Goat Removal Project.

Since the mid-1970s, social scientists have been actively involved in studies of risky activities and technologies. Research on accidents and their causes has revealed that the nature of organizations, the structuring of tasks, and the types of management systems that are present can have large effects on the levels of safety. Analyses of events such as the Mt. St. Helens explosion, Three Mile Island, Bhopal, Chernobyl, and the Challenger accidents have pointed to the importance of social factors in contributing to, and preventing or mitigating, accidents and exposure to disease and injury.

Over the past 15 years, several hundred books have been written on these topics by psychologists, anthropologists, sociologists, and geographers. Risks from natural disasters, occupational accidents, household accidents, and large system failures have been examined. While much research still needs to be done, a substantial base of prior studies and experience exists for analyzing any given risk problem. For example, numerous studies of social factors as contributory causes of accidents have been completed (Turner 1978; Bellamy 1983a; Perrow 1984; Bellamy 1985; Svenson 1986; LaPorte 1982).

Much of the research on social risk has been concerned with technical tasks that require complex interactions and high reliability of machines and people within an institutional and social context. Any attempt to improve safety must consider the technical task as a "total system" in which individual components interact (Hawkins 1987; National Research Council 1988). Such systems have been characterized as having four parts:

- mechanical components (e.g., helicopters, firearms);
- system personnel (e.g., pilot, ground crew);

- organizational and institutional infrastructure (e.g., helicopter operator, park rangers, management, administration, public interest groups); and
- social and economic factors (e.g., regulations, culture, environmental values, economics).

These features are represented in Figure 3.1. At each level and within the interactions among them, are factors that can cause or contribute to accidents in technical tasks. For example, group interactions can lead to inadequate or faulty plans and decisions. Similarly, improper or inadequate interactions of people with machines can lead to accidents.

Following Figure 3.1, the outer levels may also have significant influences on safety and reliability in technical tasks. Organizational, social, and economic factors form the context in which they operate. There is a growing literature on these broader organizational and social factors that can contribute to accidents (Turner 1978; Bellamy 1983a; Perrow 1984; Quintanilla 1987; Reason 1987b). In particular, management and political pressures can directly affect safety and reliability in performance.

This broader focus has proven useful in the design, evaluation, and management of safety and reliability in a variety of large scale technological systems, including nuclear power plants, chemical processing plants, offshore oil platforms, and transportation systems (Tuler et al. 1988; National Research Council 1988; Rasmussen 1987a). This broad perspective "has great potential for delivering results that yield useful recommendations for safety improvements" (National Research Council 1988).

How Accidents Happen

This section describes research on the social characteristics that may cause or contribute to accidents. Much of this work is concerned with "human error" and has been performed within the interdisciplinary fields of Human Factors and Aviation Psychology:

- human factors research is concerned with improving the relationships between humans and technical systems (e.g., effectiveness, efficiency, reliability, and safety). "Its goal has been to design systems that use human capabilities in appropriate ways, that protect systems from human frailties, and that protect humans from hazards associated with operation of the system" (National Research Council 1988:12). Such research covers a wide variety of topics, including instrument design, lifting of loads, alertness

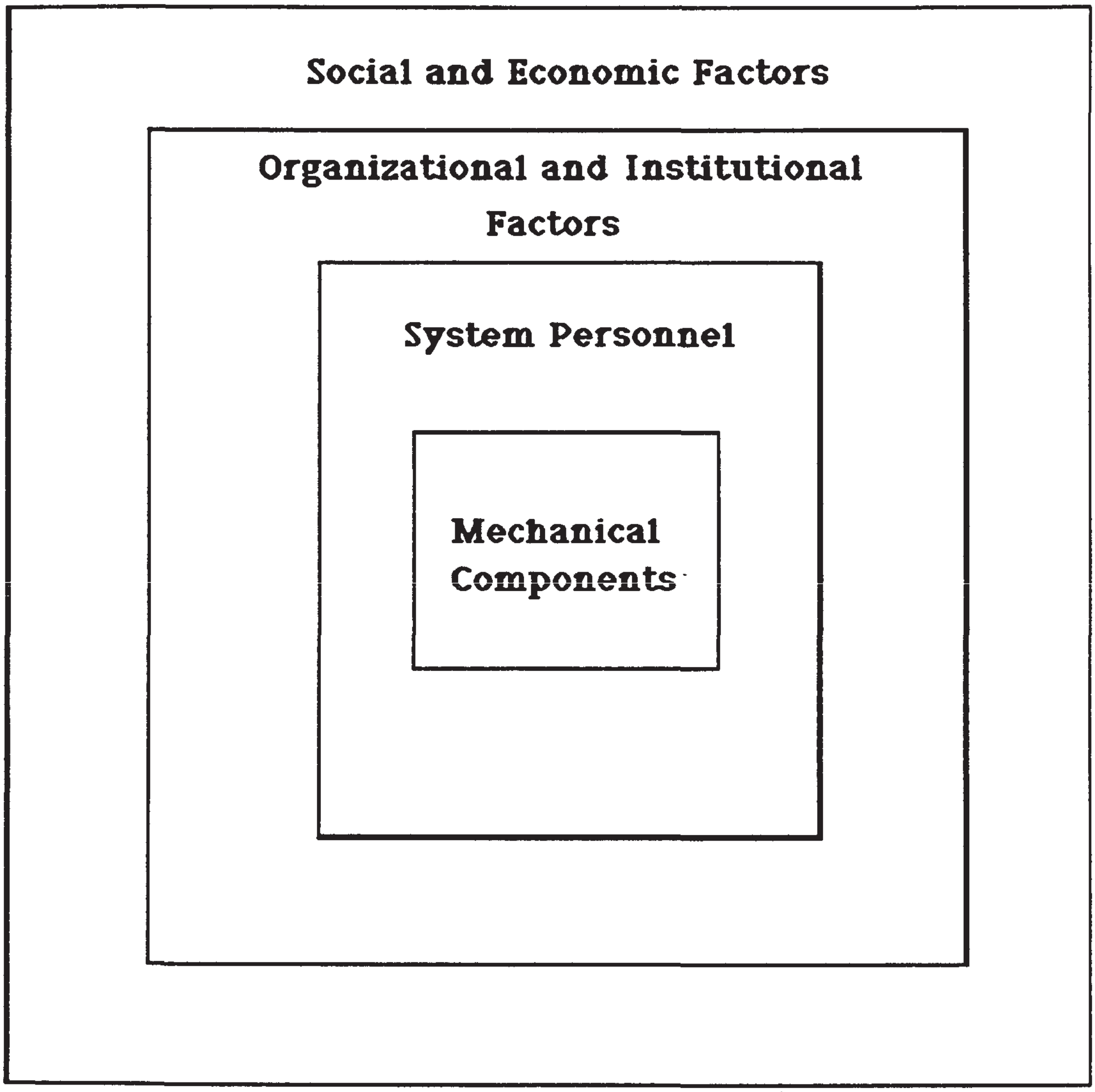


Figure 3.1. Interacting levels of technical tasks

From: National Research Council 1988

in monitoring and perceptual tasks, slips and falls, and training in decision and motor control tasks (Salvendy 1987). Currently much research effort is directed toward human information processing and cognition, and communication in different situations;

- aviation psychology "is an application of human factors principles to the aviation environment...Aircraft hardware systems are becoming increasingly reliable. The weak link continues to be the human operator whose reliability can be a function of several factors including the design of the crew station, crew training, the ability of the crew to communicate effectively, crew workload, and the level of fatigue and other imposed stressors" (Jensen 1989:122). Recent research has emphasized psychological and social aspects of safety in flight [e.g., communications, decision making capabilities, fatigue, and time stress (Koonce 1984; Jensen 1989)].

The concept of "human error" is important to the technical task of the Olympic National Park Mountain Goat Removal Project because "pilot error" is frequently used to explain helicopter accidents (Adams 1987; Adams 1989; Calahan 1990; Fox 1983; Fox 1987; U.S. Army 1988a; Hawkins 1987). For example, it has been estimated that 65-90% of annual helicopter accidents are attributed to "pilot error" (Adams n.d.; Skjenna 1981; Vyrnwy-Jones 1985). However, the accuracy of such estimates have been questioned because of inadequate reporting and measuring methods (Fox 1987).

Analyses of flight accident and mishap data suggest that human errors in helicopter aviation have certain charateristics:

- most helicopter pilot errors (84%) occur during takeoff, approach, and landing phases where obstacles, meteorology, power requirements, and visibility can create important hazards (Fox 1983);
- aeromedical accidents occur most frequently enroute (86%), during inclement weather (67%), and at night (2.5 times more frequently [Adams n.d.]);
- causes and contributing factors of pilot errors differ in fixed-wing naval aircraft and helicopter accidents (Borowsky and Wall 1983a);
- transfer of pilots to aircraft with different designs is an important contributory cause of mishaps and a threat to safety (Rayman 1982);
- increased flight experience was observed to increase the rate of helicopter pilot errors rather than lead to decreases in rates as expected (Borowsky and Wall 1983a);

- the two major contributory factors or causes of helicopter "pilot error" have been classified as: operational and technique errors (42%), and decision and judgment errors (41%[Adams 1989]);
- analyses of Bell Helicopter accidents cited poor judgement as a contributing factor in all accidents involving this make of helicopter (Fox 1987); and
- human-caused accidents may also occur on the ground. For example, downwash from hovering helicopters may create hazards to ground personnel (Skjenna 1981). Ground personnel may also be killed or injured from rotating propellers (Collins et al. 1982). Studies have also identified data for improper or absent routine maintenance activities and pre-flight safety checks in helicopter and fixed-wing aviation (Schofield and Giffen 1982; Borowsky and Wall 1983a).

Frequently, analyses of accidents use "human error" as a catch-all term for all unexplained causes of accidents. However, they frequently are not very helpful in understanding why certain events occurred and can focus blame on specific individuals when they are not necessarily at fault (Rasmussen 1982; Svenson 1986). Recent theoretical and applied work suggest that "human errors" are a result of interactions in the total technical task, including mechanical components, system personnel, organizational and institutional infrastructure, and social and economic factors (Rasmussen 1982; Rasmussen 1987c; Reason 1987a).

As a result, errors may be characterized as mismatches between humans and their tasks or machines (Tuler et al. 1988; National Research Council 1988; Rasmussen 1987b; Bellamy 1985). Mismatches occur as a result of human variability, technical variability or failure, and required interactions that are incompatible with human physical or psychological limitations or organizational constraints. Their characteristics may change as people develop their skills, knowledge, and experience.

In fact, many "human errors" or mismatches occur every day during people's normal activities--"Human activities play an important role in most accidents, typically not due to particulalry exotic errors or mistakes, but to slips and misunderstandings which are commonplace in normal human activity and which have their tragic effects only under particular circumstances" (Holmes 1987; Reason and Mycielska 1982).

By thinking of "human errors" as mismatches, they can be seen as the result of many interacting individuals and contributing factors. For example, project designers, supervisors, and operator and maintenance crews may each make independent and small errors that result in an accident. Thus, attempts to improve safety, reliability, and performance in technical tasks are fundamentally linked to the elimination or control of contributory factors. In addition, because mismatches may occur at any time, the best way to decrease their effects are to design systems that remove the opportunities for weaknesses to be expressed and provide a "buffer zone" for human variability in performance (Hawkins 1987; Rasmussen 1987a).

Factors that may contribute to mismatches are found in the social, organizational, physiological, and emotional aspects of the work environment [e.g., noise, fatigue, time pressures, emotional stress, communication protocols, and managment-employee relations (Rasmussen 1982, Embrey 1984, Rasmussen 1987d, Gael 1988). The importance of contributory factors is suggested by their frequent appearance in industrial accidents and during responses to natural disasters (Turner 1978; Bellamy 1985; Rasmussen 1987c). For example, Table 3.1 shows factors that may contribute to human errors in nuclear power plant emergency response systems.

Table 3.1. Factors contributing to errors in nuclear emergency response systems.

- administrative constraints in the sharing of information
- rigidity in plans, procedures, and command structure
- varying degrees of delay in communications
- organizational and personnel rivalries and conflicts
- excessive mental and physical workload and time pressure
- hazardous working conditions
- transitions from low to high activity and vice versa
- large population potentially affected
- public response unperdictable
- high volumes of indirect, abstract, and technical information
- uncertainties in information
- lack of direct control over plant components
- unfamiliarity of tasks and decisions
- simultaneous needs for limited and dispersed resources

From Tuler 1988

Similarly, an analysis of accidents found at least one of the items listed in Table 3.2 in all accidents involving Bell helicopters (Fox 1987) While the authors call them "root causes," they may be viewed as contibutors to specific acts that caused an accident.

Table 3.2. Basic causes of "human error"

1. Judgement 2. Mindset 3. Stress a. Physiological stress • health • workload • fatigue • medication • substance abuse/ injury b. Psychological stress • emotional • administrative	4. Training functions • flight procedures in type of rotary wing • time since update in type • flight and procedures in other type of rotary wing • flight and procedures in fixed wing, etc. 5. Personality functions • risktaker/nonconformist • previous accident/incidents 6. Preoccupation 7. Sensory input 8. Cultural background

From Fox 1987

In the following sections we review research from the social sciences that discusses such factors at the individual, group, and organizational levels of technical tasks. In general, the factors are impossible to isolate from each other; they are interrelated and may influence each other simultaneously. The topics have been chosen for their relevance and importance to the technical task of mountain goat removal at Olympic National Park.

Individual Characteristics

Individual behavior is related to many factors that influence physical/physiological or psychological characteristics of a person. Physical and physiological factors are related to such aspects of a person as strength, hearing, and visual perception. Psychological factors, for example, are related to a person's decision-making and judgment skills. In this section we summarize research on social characteristics of technical tasks that influence individual behavior and performance. Specifically, we focus on individual decision-making and judgments, attitudes and motivation, mental workload, stress, and fatigue.

Decisions and Judgments

The behavior of human decision makers operating in a variety of situations has been extensively studied (Slovic et al. 1988). The primary generalization from this research is that people often have difficulties making decisions, inferences, and judgments in complex situations (Slovic 1988). For example, in complex situations there is often one simple and obvious solution that is selected. It is, however, often incorrect or inefficient. Moreover, different decision strategies used by people at different times may greatly affect outcomes. Poor decisions can lead to the addition of small errors that can cause a future accident (Telfer 1989; Buch and Diehl 1984).

Empirical observations of human problem-solving and decision-making suggest that people do not always use all the information available to them (Simon 1955; Adams 1989; Tversky and Kahneman 1974; Svenson 1979; Svenson 1981; Perrow 1984; Fischhoff 1986; Rasmussen 1987b). Among the most important reasons are:

- information quality is often inadequate to fulfill requirements for appropriate decisions and judgments;
- people's capacity for processing large amounts of information is limited;
- time delays can be important and result even while responding to expected information (three-plus seconds for non-reflex responses);
- decisions are frequently made in situations that allow only limited attention to any particular item or issue.

In addition, decisions and judgments may be based on issues beyond those of "correctness" or "effectiveness." Additional factors include justifying procedures, distributing blame or success, and fulfilling role expectations. "Effective" choices may actually be of secondary importance relative to other goals. In aviation activities, decision making is influenced by many different characteristics of the pilot, the environment, and the aircraft.

Research on human decision-making indicates that predictable mistakes occur because humans develop biases and "rules of thumb" to simplify a complex world and guide their judgments. Some important ones are listed in Table 3.3; they have also been studied in the context of aviation mishaps (Wichman and Ball 1983b).

In general these processes work to people's advantage, but in certain unfamiliar situations they may lead to inappropriate choices or actions. "Over training" may create problems in novel situations where skills and unconscious reactions suddenly become irrelevant or even detrimental (Svenson 1979; Holmes 1987). On the other hand, because the biases and "rules of thumb" usually serve the important function of allowing people to operate in different situations; they cannot be dismissed as dangerous or useless.

The problems related to effective decision making and judgments are compounded in situations where a series of interdependent decisions are required, tasks and the situation can change rapidly, available information may be dependent on prior outcomes, and decisions alter the context of operations (Slovic et al. 1977; Brehmer 1987). These characteristics fit the dynamics of helicopter flight very well.

Table 3.3. Personal biases and "rules of thumb"

- overconfidence in estimations and plans
- underestimation of time constraints
- attempts to verify previously held beliefs by searching for and accepting supporting evidence and ignoring or forgetting contradictory evidence
- exaggeration of personal immunity from threats
- oversimplification of others' behavior
- limited examples used to make statistical inferences
- difficulties assessing probabilities and exponential processes
- ignorance of subtleties
- tendency toward conservatism
- ignoring side effects
- previous experiences often used as basis for future choices
- options which are not readily observable may not be considered
- complacency in familiar situations

Attitudes and Motivation

There has been some interest within aviation psychology to predict performance on the basis of personality and attitude characteristics. Personality traits refer to relatively enduring characteristics acquired by an individual during psychological development that can affect judgments and decisions (Helmreich 1984). Attitudes are less deeply held aspects of a person than personality traits and are thought to be modifiable by training. Interest in these issues stems in part because of their influence on motivation.

For example, Table 3.4 lists five hazardous thought patterns or attitudes that are thought to influence individual judgments (Skjenna 1981; Jensen 1982; Lester and Bombaci 1984; Adams n.d.). In addition, an Australian study has identified a sixth attitude called "deference" (Telfer 1989). It can appear as a result of age differences and in relationships with others, such as peers, managers, and customers. Deference can also appear in organizations that encourage a high degree of professionalization. However, few validation studies have been completed on the prevalence and impacts of these six attitudes (e.g., Telfer and Ashman 1986).

Some research suggests that certain personality traits and attitudes can be linked to pilot and flight crew performance (Skjenna 1981; Wichman and Ball 1983; Helmreich 1984; Lester et al. 1984; Alkov et al. 1985; Platenius and Wilde 1989; Adams 1989). There is considerable evidence that "attitudes about appropriate management of the flight deck influence the quality of management" and hence safety in aircraft flown by single pilots and small crews (Helmreich 1984:584).

Motivations and attitudes can play a potentially important role in helicopter aviation safety. For example, it has been suggested that helicopter pilots as a group may have personality traits that allow them to be easily influenced, feel greater pressure to complete missions, and possess unwarranted optimism that may lead to additional risks (Adams 1989). In addition, motivations such as "get-home-itis" can affect safety, just as can boredom or the lack of motivation, because it can lead to complacency and lack of attention (Hawkins 1987).

Table 3.4. Description of five hazardous thought patterns

1. Anti-Authority: **"Don't tell me!"**	This thought is found in people who do not like anyone telling them what to do. They think, "Don't tell me!" In a sense, they are saying "No one can tell me what to do." The person who thinks, "Don't tell me," may either be resentful of having someone tell him or her what to do or may just regard rules, regulations, and procedures as silly or unnecessary. However, it is always your prerogative to question authority if you feel it is in error.
2. Impulsivity: **"Do something--quickly!"**	This is the thought pattern of people who frequently feel the need to do something, anything, immediately. They do not stop to think about what they are about to do; they do not select the best alternative--the do the first thing that comes to mind.
3. Invulnerability: **"It won't happen to me."**	Many people feel that accidents happen to others but never to them. They know accidents can happen, and they know that anyone can be affected; but they never really feel or believe that they will be the involved. Pilots who think this way are more likely to take chances and run unwise risks, thinking all the time, "It won't happen to me!"
4. Macho: **"I can do it."**	People who are always trying to prove that they are better than anyone else think, "I can do it!" They "prove" themselves by taking risks and by trying to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible.
5. Resignation: **"What's the use?"**	People who think, "What's the use?" do not see themselves as making a great deal of difference in what happens to them. When things go well, they think, "That's good luck." When things go badly, they attribute it to bad luck or feel that someone is "out to get them." The leave the action to others--for better or worse. Sometimes, such individuals will even go along with unreasonable requests just to be a "nice guy."

From Lester and Bombaci 1984

One review of helicopter pilot characteristics suggests that they tend to be goal-oriented individuals, which adds largely self-induced motivational pressures to:

- make a flight when requested;
- complete the flight as planned;
- please people;
- meet schedules;
- make money; and
- impress peers (Adams 1989).

Mental Workload

Mental workload includes "those aspects of the interaction between a person and a task that cause task demands to exceed the persons' capacity to deliver" (Gopher and Donchin 1986:41-3) The concept of workload has been applied to both physical and mental tasks and these have been important research topics in human factors and aviation psychology (Rotondo 1978; Durnford 1984b; Hart and Sheridan 1984; Hart and Bortolussi 1984; Berg and Sheridan 1985; Cote et al. 1985; Gopher and Donchin 1986; Albery 1989; Tsang and Johnson 1989). However, there continues to be considerable debate over the exact definition of mental workload, theoretical models, effective measurement techniques, and their implications (Gopher and Donchin 1986).

Individuals can maintain high levels of performance while working on tasks even as demands and mental workload increase. As workload continues to increase, a point will be reached where the individual cannot continue to maintain the same level of performance. The result can be an abrupt deterioration in performance (Skjenna 1981; Moray 1979;[see Figure 3.2]).

Some of the factors that have been suggested as contributing to pilot mental workload in helicopter aviation are listed in Table 3.5. They include factors that increase levels of stress, affect operator capabilities, and increase task demands.

Such factors may play an important factor in helicopter aviation safety because of aircraft flight dynamics and operator requirements. In fact, many of the factors are the same as those identified as contributing to accidents and "human error."

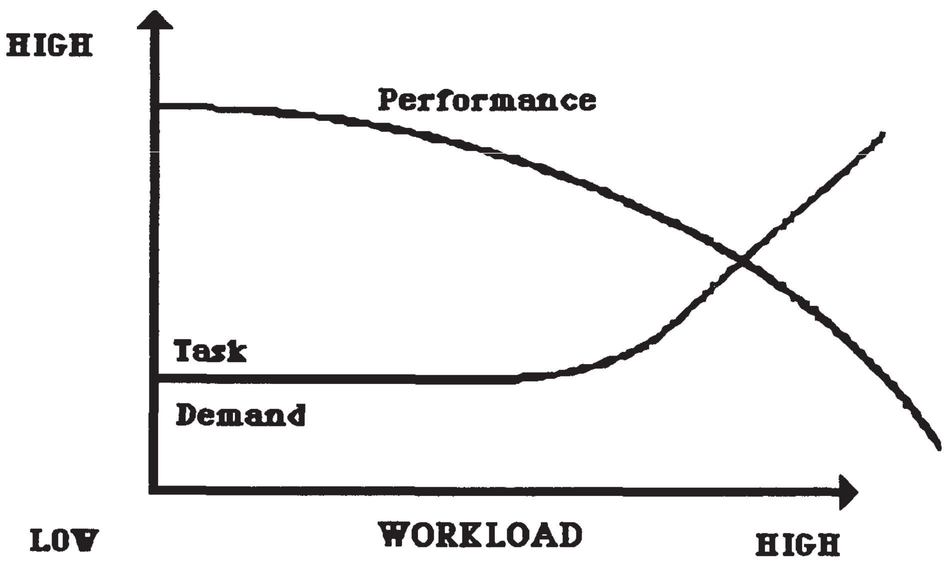


Figure 3.2. Individual performance as a function of mental workload

Table 3.5. Factors contributing to helicopter pilot mental workload

Pilot variables

- temperature (hot or cold)
- comfort (e.g., backache)
- inadequate nutrition, dehydration
- caffeine, alcohol, nicotine
- disorientation
- sleep cycle disruption, inadequate rest
- muscle fatigue, mental fatigue
- boredom
- anxiety, concern for safety
- anger and frustration
- sensory overload, sensory deprivation

Task variables

- vibration
- noise
- continuous need for concentration and monitoring
- time to complete task
- number, complexity, urgency, familiarity, variety of subtasks
- reaction effort required
- unavilability of resources

Stress

Human decision-making and behavior may be influenced by a variety of stress factors in the operating environment. Stress factors are things that alter a person's internal or external environment and that can lead to changes in performance. They have been documented and studied in a large number of contexts and include physical, physiological, psychological, and social factors (Hockey 1983; Hawkins 1987; Durnford 1984a; Dorner 1987; Skjenna 1981). Table 3.6 lists pilot stress factors that have been identified on helicopter flight.

Time pressure is very important and has been studied in a number of situations, including aviation, emergency response, and nuclear power accidents. Important effects of time pressure on individual decision-making and judgments are shown in Table 3.7. These effects may be important in helicopter aviation because "a helicopter demands continuous attention and pilots may be unable to satisfy this requirement. When a system malfunction or failure does occur, the pilot may not be capable of assimilating, processing, and acting on all of the information in time to assume control and recover successfully" (Adams 1989:227).

Most of the stress factors identified in Tables 3.6 and 3.7 may be present simultaneously in a situation. Their combinations depend on:

- background stress from day to day living;
- characteristics of the task;
- characteristics of the work environment; and
- characteristics of the equipment used.

Their importance results from their ability to:

- increase workload and decrease coping ability;
- impair decision-making and judgments;
- lead to avoidance behavior; and
- lead to injuries, such as acute or chronic back pain.

Aircraft pilots have been the subject of much study (Alkov et al. 1982; Durnford 1984a; Hart and Bortolussi 1984; Landstrom and Lofstedt 1987; Girodo 1988; Leibrecht 1989; Adams 1989; Simmel et al. 1989). Issues of interest include the effects of stress on judgments and decision-making (e.g., Telfer 1989). For example, the psychological stress and additional workload that an initial error may cause can lead a person to commit additional ones that can combine to cause an accident (Hart and Bartolussi 1984).

Table 3.6. Factors contributing to helicopter pilot stress.

Physical and physiological

- vibration
- noise
- temperature (e.g., hot, cold, protective clothing)
- comfort (e.g., backache)
- visual illusions (e.g., flicker)
- disorientation
- inadequate nutrition, dehydration
- caffeine, alcohol, nicotine
- muscle fatigue
- sleep cycle disruption, inadequate rest

Psychological and social

- mental workload
- mental fatigue
- boredom
- anxiety, concern for safety
- anger, frustration
- sensory overload, sensory deprivation
- time pressure
- previous errors
- domestic social problems
    - marital/family problems, separation from family
    - financial problems
    - legal problems
- paperwork, irksome tasks, reporting requirements
- liaison with supervisors

Table 3.7. Some effects of time stress on problem solving and decision making

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- impede the use of available information
- increase reliance on simpler decision rules
- increase risk averse behavior
- reduce use of information sources
- increase dependence on rules of thumb
- cause oversampling of data
- affect the logical analysis of inputs
- cause "tunnel vision" and perceptual narrowing
- decrease the use of comparative or evaluative decision strategies
- increase attention in tasks with closest deadlines regardless of importance
- increase weight to negative or most important factors
- consider fewer alternatives

From Tuler 1988

Helicopter pilots, crew, and passengers have also received specific attention. For example, one of the most problematic consequences of vibrations and cockpit design in helicopters is pilot lower back pain (Shanahan 1984; Froom et al. 1986). In addition, personnel who work around and in helicopters may be exposed to excessive amounts of noise and carbon-monoxide, leading to physiological stress that can hamper performance (Skjenna 1981).

Activities relevant to the technical task, but not necesasrily associated with helicopter flight, may also impose stress factors. For example, the wearing of fire, heat, and chemical protective clothing can lead to thermoregulatory stress (Fine et al. 1987; White et al. 1989; Post 1989; Faff and Tutak 1989; Allan 1984; Ramsey 1983). Task requirements such as mountain climbing and activities at high altitudes can lead to hypoxia and physiological stress that can degrade performance in physical activities (Skjenna 1981). Caffeine, alcohol and nicotine can have similar effects (Dellinger et al. 1985; Osborne and Rogers 1983; Morrow et al. 1990). In addition, dangerous situations can cause personal anxiety (Idzikowski and Baddeley 1983).

It has been suggested that stress factors contribute to human errors and accidents by leading to inadequate or inappropriate coping behavior (Alkov et al. 1982). For example, individuals experiencing marital problems may "act out" their anxieties in their work rather than internalizing their feelings--"(Navy) aviators who were 'acting out' as evidenced by their having problems with interpersonal relationships and trouble with their superiors and peers were more likely to be causally involved in their mishaps than those aviators who did not contribute. All of these symptoms would appear to be the result of inadequate stress coping" (Alkov et al 1982:246).

Fatigue

Feeling fatigued can be closely linked to experiences of workload and a variety of stress factors. However, fatigue is a difficult concept to define. While most people associate fatigue with feeling tired or not enough sleep, fatigue can also be associated with mental activity (Holding 1983; Monk et al. 1985). Subjective feelings of fatigue have been suggested as contributory causes to accidents and failures in a variety of mental and physical activities (Hawkins 1987; Hockey 1983; Borowsky and Wall 1983b; Krueger et al. 1985; Chidester 1990).

Prior research has suggested:

- linkages between fatigue and perceptual tasks, including visual sensitivity, concentration, and monitoring tasks;
- performance deterioration with the onset of fatigue. In particular, variability and range of responses tend to increase; and
- tasks that "permit the subject a choice of responses have indicated changed attitudes towards acceptance of risk and avoidance of effort, for mental and motor fatigue ..." (Holding 1983:164).

However, "discussions of the manifestations of fatigue ([in Navy aviation]; i.e., physiological fatigue, performance decay, and a feeling of tiredness) and results of previous research emphasize that, though certain fluctuations in mishap rates have been hypothesized to be related to fatigue, no studies have directly associated fatigue with mishap liablity" (Borowsky and Wall 1983b:535). In addition, the impact of individual differences with respect to sensitivity to fatigue in performance is not well documented or studied (Chidester 1990).

Some studies have found little correlation among factors commonly thought to lead to fatigue and degraded performance. For example, in one study of Navy avaition helicopter mishaps, fatigue was not statistically associated with (Borowsky and Wall 1983b):

- missions flown in the last 24-48 hours;

- hours continuously awake prior to mishap;
- hours continuous duty prior to mishap;
- hours duration of last sleep;
- hours worked in last 48 hours;
- hours slept in last 24/48 hours; and
- hours flown in last 24/48 hours.

In the same study, the authors found that there was a significant statistical relationship between mishap rate and:

- hours worked in the previous 24 hours in the helicopter community; and
- time of day. Mishap rate tended to be lower during the hours of 0900-1800. (These hours also correspond to daylight in most places when flight requirements may be less difficult than after sunset.)

A second study by the same researchers (Borowsky and Wall 1983a) found that increased helicopter flight hours (an indicator of experience, but not necessarily related to fatigue) led to increased incidences of:

- inadequate flight preparation;
- failure to maintain flying speed;
- misjudged altitude, distance, or position;
- violations of existing regulations, instructions; and
- poorer physical and mental conditions (e.g., stress, fatigue, vertigo).

In spite of the conflicting results of studies, fatigue is thought to be an important issue in aviation safety and a factor in previous accidents (Hawkins 1987). Consequently, there are a variety of recommendations for flight and work scheduling.

Group Characteristics

In many systems, groups of people must interact to perform a task. While necessary, their interactions can also create conditions that lead to accidents or mishaps. Research on small group behavior has often focused on group interactions that lead to "faulty" or incorrect decisions in different situations (Bellamy 1983b; Hirokawa and Scheerhorn 1986; Gouran 1986). These interactions can occur during the planning, operational, maintenance, and emergency response phases of technical tasks. This section summarizes research on group decision-making and the effects of time stress on group behavior.

Decision-making

Researchers have suggested several factors that may lead to faulty decisions in a group. They include:

- improper assessment of a situation;
- establishment of inappropriate goals and procedures;
- improper assessment of alternative decisions;
- establishment of faulty information on which to base a decision; and
- faulty reasoning.

Individuals can enable faulty decisions by paving the way for errors in group decision-making (Hirokawa and Scheerhorn 1986). In particular, faulty group decision-making can often be traced to the influences of specific group members on communication and different social factors, such as deferment to peers. Individuals also can prevent faulty decisions by counteracting negative influences (e.g., convince others to reject flawed beliefs, perceptions, and inferences) and by influencing a group to accept correct conclusions before negative influences occur (Hirokawa and Scheerhorn 1986).

Faulty decisions by groups may be a result of different types of behavioral phenomena (Fischhoff 1986; Tuler 1988). They include:

- the "risky shift" phenomena in which a group chooses more risky alternatives than its individual members;
- group polarization, whereby the choice of a group is more extreme than the individual choices;
- groupthink, where a group arrives at a concensus decision without adequately evaluating all alternatives;
- false consensus, where individuals of a group falsely believe that a consensus has been reached; and
- pluralistic ignorance, where group members believe they are alone in their beliefs.

In some cases, pressures for group consensus may be very strong. They result from the characteristics of the group and the environment in which they interact. The characteristics fall into several catagories (Swap 1984):

- composition (e.g., group size, individual personalities);
- leadership characteristics (e.g., centralization of authority, style of leadership);

- task characteristics (e.g., demands and requirements of task, timing of task demands, interdependencies among different tasks); and
- decision rules and processes (e.g., ability to reverse decisions, criteria used for making decisions, social context of group decision-making).

The form of consensus generated by groupthink is of particular concern because it may also contribute to more risky decisions (e.g., "risky shift"). The major factors that contribute to such behavior include the requirements of group activities, member personalities, and the size and isolation of a group. In groups experiencing groupthink, "the powerful forces of perceived 'togetherness' act in concert to render the possibility of failure unthinkable--and if not unthinkable, then certainly unspeakable" (Reason 1987b:124). For example, accidents in nuclear power plants have occurred after frequent statements that they were impossible. Similarly, the low possibilities of catastrophic oil tanker spills calculated by industry groups lead to a general lack of planning for their occurrence and readiness for accident response.

In some cases, familiarity among members of a group may result in negative consequences, such as groupthink. However, research also suggests that familiarity is important in group behavior because it can decrease misunderstandings between individuals and improve the reliability of communications.

Issues of familiarity have been studied with respect to flight crews in fixed-wing aircraft. In particular, communication problems among crew members have resulted in a number of aircraft accidents (Kanki and Foushee 1989; Kanki et al 1989). In general, researchers find that:

- "prior experience with flight crewmembers enhances performance and the communication process mirrors that benefit" (Kanki et al 1989:57);
- familiarity leads to the development of conventional and stable communication behaviors. "When predictability increases, coordination attempts are more likely to succeed because the assumptions and expectations crewmembers have of each other are more reliable" (Kanki et al 1989:60); and
- effective communications depend on verbal and body language, and understanding is increased by familiarity in noisy environments (Hawkins 1987).

Stress

As in the case of individual behavior and decision making, group performance may also be hampered by different types of stress (Holsti 1971; Dorner 1987; Bellamy 1985; Svenson and Edland 1986; Rasmussen 1987b). Many of the stress factors that can influence group behavior are similar to those that can influence individual behavior. Research on stress and group behavior has tended to focus on the effects of time pressure and personal anxiety on group decision-making capabilities.

For example, research suggests that time stress can lead to increased differences in the role and status of group members (Bellamy 1985). The result may be that information is withheld purposefully or mistakenly. Time constraints may leave less time to correct this behavior because of fewer opportunities for interaction.

Empirical research suggests that time stress also leads to a tendency to avoid delegation of authority (Holsti 1971; Dorner 1987). It may also create conflicts between individual personalities, procedures, or the relevance of specific information (Putnam 1986; Rasmussen 1987d). These factors may create dangerous situations in technical tasks where important decisions are made in isolation and there is little time to resolve misunderstandings and conflicting goals, such as the desire to stop a small leak in an oil refinery and the desire to avert a major explosion in an oil refinery. These issues can be especially important in groups whose members are unfamiliar with each other.

Another source of stress occurs when group activities create high levels of personal stress and anxiety. Conflicts among individuals and rivalries among groups can exacerbate this problem and create large barriers to the collection and understanding of information and the selection of alternatives (Bellamy 1985). When differences of opinion exist, the act of making a decision may exacerbate the personalization of issues.

Constraints resulting from both personal anxiety and time stress may also increase already frequent pressures for group agreement. These same pressures may decrease the ability of a group to reverse prior decisions, even in the face of contradictory evidence (Svenson and Edland 1986). In fact, groups often attempt to confirm rather than disprove hypotheses, resulting in easier acceptance of controversial or uncertain decisions.

Organizational Characteristics

The decision-making and problem-solving behavior within an organization and the interaction among organizations can be very important for safety in technical tasks. This section summarizes the influences that organizations have on individual and group behavior and how risks can be managed through training.

Constraints on Behavior

Much research has focused on the effects of different organizational characteristics on individual behavior (Turner 1978; March 1981; Crecine 1986; Cohen, March, and Olsen 1972; March and Weissinger-Baylon 1986; LaPorte and Consolini 1988). For example, misperceptions and poor choices may result from rigid organizational beliefs and practices, restrictions of the social and cultural environment, political interests, institutional constraints, and communication constraints. In turn, such misperceptions or poor choices are made within an organization and may consequently influence its behavior and effectiveness.

Interactions among individuals within an organization are partly a result of how the individuals believe the organization functions. These understandings arise through an organizational culture that can influence the way people interpret and infer things about the world around them (e.g., professionalization). In addition, dynamics depend partly on the work situation (e.g., management-employee relations, job requirements) and organizational structure. A list of such factors that appear in the research literature is shown in Table 3.8.

Hazard Management

In many instances, organizations must manage hazards associated with technical tasks, such as NASA's need to maintain safety of the space shuttle missions. "Hazard management" is concerned with the prevention, mitigation, and recovery of technological and natural accidents through the management of potential mismatches and social risk factors. This is an area of research that can provide planning and training methods widely applicable to technical tasks. Techniques include the use of lectures and other learning materials, computer-based simulations, and "real-life" exercises. They are intended to reduce the:

- improving situational awareness;
- improving knowledge of rules, alternative actions, and possible consequences;
- enhancing coordination;

- improving correspondence between plans and implementation; and
- ensuring that individuals and organizations are capable of coping with time constraints and unexpected situations.

Table 3.8. Organizational factors contributing to accidents

- Pressure
    - authority, peer, heavy responsibility
- Job requirements
    - ill-defined job requirements
    - lack of resources
    - expectations too high or impossible
    - multiple tasks--selective attention by workers and management
- Conflicts among personnel
    - personality, procedural, substantive
- Conflicting assumptions related to tasks or roles
    - management vs. designer
    - management vs. operating personnel
- Rigid organizational beliefs, assumptions, and rules
- Rules and procedures not maintained
- Communication systems not adequate or unavailable
- Quality of work environment
    - lack of job satisfaction
- Industrial actions
    - slow-downs, strikes
- System (or co-workers) considered unreliable or untrustworthy
- Mindsets
    - attitudes toward safety, professionalism, productivity
- Lack of coordination, trust, understandings among organizations

Planning by an organization is a key activity for any hazardous activity. One of the most important lessons to be learned from prior experience is that activities should be undertaken only when operational capabilities for people and their equipment are not to be exceeded (U.S. Army 1988b). Such lessons can be as simple as having enough drinking water to avoid dehydration. However, there are many examples of inadequate planning for normal as well as emergency situations that have led to accidents. These occur in all types of activities, including nuclear power plant, aviation, and military operations.

Personnel training is important preparation for any hazardous activity and has been a focus of research in many areas including aviation psychology. Traditionally, flight training in actual aircraft or simulators was designed to provide knowledge of the aeronautical system, such as instrumentation usage, landing techniques, and emergency procedure techniques. Training programs have also been developed for commercial fixed-wing aircraft crews to enhance communication and coordination (Blake and Mouton 1978; Margerison et al. 1987). Although task requirements have evolved from psychomotor skills to more mental processing, these new requirements are left to experience rather than formal training. In addition, it has been stated that helicopter pilot instrument equipment, procedures, and training are 30 years behind those for fixed-wing aircraft pilots (Adams 1989).

Recently more effort has been paid to training pilots for making effective judgments in normal as well as emergency and novel operating conditions (e.g., Adams n.d.; Buch and Diehl 1984; Connolly et al. 1989). These methods, called aeronautical decision-making training, have been formalized, established, and validated for fixed-wing aircraft in the United States, Canada, France, and Australia (Telfer 1989). They are based on the belief that "judgment training is possible because judgment is like a personal attitude which is acquired through practice as an individual grows and can be modified" (Fox 1987:7).

The keystone of the FAA's Aeronautical Decision Making Training program to reduce pilot error is the recognition and definition of the hazardous pilot attitudes that may increase judgmental errors (FAA 1986). The objectives of the program are:

- to teach pilots how to recognize hazardous thought patterns and override them; and
- to teach pilots improved processes for making decisions and judgments. They include improving knowledge, vigilance, selective attention capabilities, risk identification, risk assessment, and problem-solving abilities.

Although the FAA developed an aeronautical decision-making manual for helicopter pilots in 1986, it has never been validated or mandated (Adams 1987). However, it is based primarily on extensively tested materials developed for fixed wing aircraft and the idea of knowing one's own abilities and those of the crew. The

FAA estimates that fixed-wing pilot human errors were reduced 10-50 percent using this method (Fox 1987).

Summary of Literature Review

There has been considerable research, both theoretical and empirical, on individual, group, and organizational behavior. Much of this work is concerned with the variety of factors that can influence behavior and decision-making in positive or negative ways. The social sciences have devoted much attention to these issues and they provide a useful perspective from which to assess and improve safety in technical tasks.

It is apparent that humans are capable of completing complex tasks in difficult environments. However, the evidence shows that humans are also variable in their capabilities. Such variability can interact with task requirements and technical components in such a way that accidents and mishaps occur. As tasks and the interactions of machines and people are made more complex and completed in even more difficult situations, the likelihood of accidents or mishaps grows. In fact, any person can contribute to or cause an accident at anytime, regardless of their skills and experiences.

The research has identified a number of factors that contribute to variability in human behavior and decision-making. These factors may be rooted in the physical, physiological, psychological, or social characteristics of an individual and organization. They include factors related to strength, perceptions and sensations, motor coordination, mental capacities, and interpersonal relationships. Many of them have been described here.

However, research on "human error" and their causes are not capable of explaining exactly why or when they may occur. Because of variability among individuals' behaviors and decision-making, it is impossible to eliminate all sources and causes of errors. Consequently, it is impossible to predict when all accidents and mishaps can occur. In fact, it has been observed that the only way to avoid potentially harmful effects of "human errors" is to make systems "goof proof" so that they do not fail in ways that can cause large accidents.

A result of such an awareness has been the development of improved training techniques and safety devices. Safety devices have not been discussed in this report. However, they may include such efforts as improving instrument warning devices, crashworthiness of helicopters and the survivability of crash victims (e.g., Skjenna 1981; Fox 1983). Training techniques include the use of simulators and real life exercises and focus on motor skills as well as judgment and decision-making. They are the focus of much concern in the aviation community and their positive effects have been documented in a number of cases.

Potential Social Risks of the Technical Task

As described earlier, the technical task of goat removal involves several distinct stages. The specific requirements of each stage potentially create a complex and dangerous set of activities. Figure 4.1 shows how social factors can influence safety and reliability at each stage of the technical task. For example, social factors can create sources of stress and high workload, lead to difficulties in interpersonal relationships, and influence organizational planning. Three important levels can influence and shape performance:

- individual factors, including "subculture" attitudes and personal characteristics;
- interpersonal factors, including group planning activities and communications; and
- organizational factors, including liaison among agencies and agency mission requirements.

In this section we describe these factors and how they may influence safety in the technical task.

Individual Factors

Individuals participating in goat removal are subject to a number of factors that can affect performance. They can be a product of general human characteristics, such as susceptability to high workloads, stress, and fatigue. For example, high levels of pilot workload are a regular occurrence because of extreme aircraft maneuvers required during goat pursuit and capture. In particular, helicopter flights in the project require:

- high-speed flight at very low elevations in mountainous terrain;
- control in the presence of updrafts and downdrafts;
- maintenance of visual contact with a goat during pursuit;
- near continuous intercom and radio communications;
- periodic instrument checks, including monitoring of fuel levels; and
- frequent one-skid, toe-in, and step-out landings.

These factors can affect safety at various stages of the technical task that require helicopter flights. Additional individual factors that can affect performance include:

- cumulative fatigue from long working hours with early starts;
- high pilot workload during one-skid, toe-in, and hover step-off landings;
- frustration due to weather related delays or cancellations;
- frustration and low morale as a result of goat mortality; and
- complacency in operations as a result of routinization and prior successes.

Technical Task Stages	Social Risk Factors
Ground Activity	lack of management, planning assistance, perceived need for technical task, potential loss of wages, recipient agency "requires" goats, groupthink
Flight-out	complacency, fatigue, hunger
Search and Selection	groupthink, lack of capture success, communication problems, lack of management assistance in planning, recipient agency "requires" goats
Capture and Restraint	high mental workload (gunner and pilot), concern for safety, fatigue, anxiety, hunger, communication problems, goat mortality, organizational information sharing
Medical Assessment	gunner out of contact with pilot, fatigue, goat mortality
Goat Transport	gunner not in contact with pilot, fatigue, hunger, complacency, high pilot workload
Crew Recovery	concern for gunner safety, fatigue, groupthink, complacency, communication problems
Flight-in	recipient agency "requires" goat, fatigue, complacency, "get-home-itis"
Demobilization and Post Capture Tasks	"get-home-itis," complacency, goat mortality, information sharing between organizations, fatigue

Figure 4.1. Social risk factors by stage of the technical task

Frustrations due to cancellations may influence future decisions to cancel operations. Similarly, concern over rates of goat mortality may influence behavior during pursuit and capture stages. Feelings of fatigue can affect judgments and operations at all stages in a negative manner. Since the use of net and dart guns require unique skills, quick reflexes, high levels of concentration, and use of good judgment, fatigue can increase risk.

In addition, an organizational culture of professionalism may lead capture team personnel to perform the tasks in spite of personal anxiety and concern for safety. For example, "a sampling of agency personnel showed that 84 percent of those polled agreed that 'preservation is the major purpose of the National Park Service'" (Foresta, 1984:104). At the same time, personnel may feel that the project is an improper response to the issue of mountain goat impact on the Olympic National Park ecosystem.

Anxiety may lead to improper decisions or judgments during critical stages of the technical task. Personnel may feel varying degrees of anxiety and concern for their safety because:

- operations are getting increasingly difficult and occur in more rugged areas;
- in case of stranding in remote backcountry areas of the park, the gunner must be prepared to wait in the backcountry or walk out with minimal amounts of food and survival equipment;
- capture team members may be out of radio contact with the helicopter pilot or staging area. Lack of communication during accidents may be life-threatening;
- emergency evacuation can be slow and difficult while survival may be dependent on fast recovery and medical attention; and
- although training in specialized animal handling and restraint techniques is required, proficiency and safety result only after experience in handling animals of different sizes and age classes.

Interpersonal Factors

The technical task requires the interaction of a number of individuals at all stages. It is critical that personnel in the Olympic Mountain Goat Removal Project interact in ways that maintain safety and improve performance. For example,

- trust in abilities is essential among the capture team at all phases of flight, alightment, and recovery;
- the capture team must remain alert to the debilitating effects on others (and themselves) of fatigue and stress throughout the project duration; and
- delegation of authority is critical to prevent high workloads on the capture team with non-critical tasks (includes activities at the staging area).

At all stages of the technical task there are important requirements for reliable and clear communication. Effective communication is critical for the safe and effective pursuit, capture, and recovery of goats. In addition, inadequate communications among personnel during planning stages prior to the technical task can also affect safety. For example, during 1989 planning, top management provided little guidance on what to do, how to do it, and when. The capture team was required to decide, which increased pressure and their responsibility.

During many of the activities of mountain goat removal, interactions can be complicated because individuals are from different organizations. For example, the gunner and pilot must work together closely. However, because they are trained and based in different organizations, their attitudes, favored procedures, communication expectations, and skills may differ. In some cases, such differences may lead to personality conflicts and an inability to accomplish goals.

Organizational Factors

Organizational factors can influence behavior and safety at all stages of the technical task. One of the most critical factors is the sense of mission and professionalism that is instilled in personnel. For example, the National Park Service includes the "preservation of intact ecosystems" as an important part of its mission (Foresta, 1984:101). At the same time, personnel are responsible for the management and possible eradication of exotic species that adversely impact park resources. Organizational values for wildlife can lead to contradictions with the desire to remove mountain goats from the park.

Organizations may affect safety and performance in the technical task through their attention to planning. In particular:

- the scheduling of goat capture missions can increase pressure on the capture team to fly in marginal weather conditions. For example, the 1989 schedule was condensed to four weeks (down from 8 in 1988). Weekend missions were not allowed to avoid disruption of summer visitors. This allows maximum utilization of staff and minimized impact on summer activities;
- the use of carfentanil may be life threatening. The chemical immobilization agent, Carfentanil, is extremely powerful (10,000 times more powerful than morphine to humans) and has the highest level of security issued by the U.S. Drug Enforcement Agency. Special procedures must be followed when handling this drug, including the use of gloves and the presence of two people. Appendix 2.2 describes the drug, special handling requirements, and emergency procedures for accidental human exposure. Human exposure at any time requires immediate life support, evacuation, and medical care if a person is to be saved. In addition, helicopter accidents in remote areas of Olympic National Park require immediate response and search and rescue operations; and
- cancelled missions require that alternative plans be made for the efficient and productive use of staff. Staff participation may impair the completion of other staff responsibilities. For example, the prolonged commitment of the Elwha Subdistrict Ranger District to the project seriously impaired its supervision in 1989.

Interaction between different organizations may also influence the context in which the technical task takes place. For example, the threat of litigation from animal and plant advocacy groups may influence the activities of the NPS. Without the threat of litigation, the organization might not require the hazardous technical task of mountain goat removal.

Contractual conflicts and needs can lead to negative feelings that may impact safety and working relationships. For example, past contracts with Eagle Air Helicopters, Inc. did not provide contingency plans for payment in case of weather related cancellations. Such problems may lead to the possibility of lost wages and conflicts between capture team personnel about flight cancellations or delays.

The liaison with agencies receiving goats may lead to negative feelings and the exposure of the capture team to unnecessary risks. For example, in 1989 coordination with the Washington Department of Wildlife was seen as being difficult, placing undue demands on the capture team to deliver goats at specified times.

Potential Hazards of the Technical Task

This section describes hazards as they appear in different stages of the technical task. Hazards to individuals result from failures in completing the technical task (e.g., technical failures, human errors, or mismatches between technical task requirements and personnel capabilities). There are two principal types of hazards to personnel participating in the mountain goat removal project:

- physical hazards, including abrasions, sprains, fractures, broken bones, accidental drug overdose consequences, and death; and
- social hazards, such as a loss of confidence in management or peers, loss of wages or career opportunity, loss of self-image, impacts on family, stress, and anxiety.

Physical hazards can occur at any stage of capture-related activites. Examples are shown in Figure 4.2. Many of the technical task stages have hazards that occur in any wildlife capture and translocation program and are not unique to the goat removal project. These include minor or moderate injuries from slips and falls, back pain from long hours of helicopter flight, helicopter accidents as a result of being caught in inclement (i.e., low visibility) weather, and automobile accidents during ground transportation activities. However, there are hazards unique to this project. They include:

- physical harm from jumping out of a hovering helicopter;
- possible helicopter accidents during toe-in and one-skid landings;
- falls while crossing rugged terrain;
- helicopter crashes during dangerous flying conditions;
- accidents while using the net gun;
- injury while restraining a goat; and
- accidental induction of the chemical immobilization agent to oneself or another during preparation, capture, and handling of wastes.

The most important of the physical hazards to personnel are death or severe injuries that can result to capture team members. These may occur during helicopter accidents and their greatest risk is during pursuit and landing/hovering operations. Because most of the operations occur in the backcountry, any search and rescue attempts will be difficult and delayed, which can exacerbate the consequences.

Hazards also arise from the handling of dart and net guns during flights. During this stage the gunner is very exposed to physical harm because of his position in the helicopter: leaning out of the rear door secured by a harness. If safety equipment fails or was not secured properly, the gunner can fall from the aircraft. In addition, the firearms do not have safety devices, and Carfentanil is extremely dangerous to humans. The use of these firearms can also lead to helicopter accidents. For example, cartridges or nets can fly into or damage rotors and cause an accident.

Technical Task Stages	Hazards
Ground Activity	anxiety from delays, lost wages, accidental exposure to carfentanil, helicopter accident
Flight-out	pilot backache, thermal stress, slip / fall by ground crew member
Search and Selection	stress from not finding suitable goats, helicopter accident from fuel mismanagement
Capture and Restraint	sprained ankle during alignment, frustration because of goat death or miss, helicopter accident, wind chill, interpersonal conflict over failed attempt
Medical Assessment and Preparation	back strain while loading goat into goat-bag, depression over need to destroy goat
Goat Transport	helicopter accident, carfentanil exposure, injury to gunner while sling loading goat into helicopter, groundcrew injury from helicopter
Crew Recovery	hearing loss, helicopter accident, hypothermia, frustration because cannot retrieve goat
Flight-in	back ache, helicopter accident, hearing loss
Demobilization and Post Capture Tasks	helicopter accident, troublesome paperwork, demoralization at lack of success, automobile accidents

Figure 4.2. Hazards by stage of the technical task

Social hazards arise at different times during specific project activities or as a result of long-term participation in the program. In particular, physical harm or the threat of physical harm may lead to social hazards. Examples of social hazards are also shown in Figure 4.2. They include:

- loss of wages and income (for example to Eagle Air Helicopters, Inc. by providing a dedicated helicopter to the project and not being reimbursed for work losses due to cancellations);
- potential loss of career options as a result of becoming expert in wildlife translocation projects;
- changed relations with peers from either failure or success in project;
- conflict with management because of differences in program decisions;
- contradictions in image of self (e.g., professional dedication vs. concern for physical harm);
- inter-organizational conflicts that result in inability of organizations and/or personnel to work together;
- frustration, worry, and stress (over frequency of cancellations, goat injuries and deaths); and
- value conflicts over participation in the program.

While actual or threatened physical hazards may lead to social hazards, social hazards can cause physical harm by influencing behavior and performance during future activities. For example, loss of trust in other capture crew or management can result in wrong decisions at later times that can directly lead to physical harm. Similarly, loss of hearing from exposure to helicopter noise can make critical communications more difficult in the future, especially when hearing loss is gradual and the person is not aware of his disability.

In addition, the effects of social hazards and factors can be to increase risk-taking behavior that can result in physical harm. For example, to overcome explicit or perceived criticism for previous "misses," the crew may attempt future captures in unsafe situations.

Recommendations

This report provides an analysis of the technical task of mountain goat removal from Olympic National Park and a summary of social science research relevant to the improvement of safety and performance in technical tasks. An understanding of these two areas supports recommendations that can be applied to improve personnel safety, reliabilty, and performance in the technical task of the Olympic National Park Mountain Goat Removal Project.

Our analysis of the social science literature and the technical task suggest that specific changes might be useful to enhance safety, reliability, and performance. There are two major concerns. One is that the technical task demands performance that clearly pushes personnel and equipment to their physical, mental, and mechanical limits. It is not a task with significant buffer or "forgiveness." The second is that the operation is highly dependent upon the few specific individuals involved. No matter how talented they are, the result is a system that is <u>not</u> institutionalized or stable.

Because improvements in some areas can be made prior to summer 1990 operations, we provide immediate short-term suggestions as well as suggestions that may be useful over the long-term (during following years). We provide suggestions for improving the technical task by:

1) altering the technical task to reduce social risk factors;
2) altering the social environment to reduce social risk factors;
3) monitoring social risk factors associated with the technical task; and
4) additional options, such as the role of training.

Short-Term Suggestions

These suggestions can provide improvements to safety and performance during operations in the summer of 1990.

Altering the Technical Task

<u>1) We suggest that the capture team formalize criteria for time durations of mountain goat pursuit.</u> Pursuit of mountain goats requires high speed flight in mountainous terrain at low elevations. Such flight requirements may place high levels of workload and stress on the capture team. Research suggests that fatigue, stress, and high levels of workload can negatively affect judgments and actions. Thus, performance and safety may be negatively affected. Specific limits on

allowable durations of pursuit may help to decrease workload and stress. Such limits may also help decrease negative influences that may result from unsuccessful capture attempts.

2) We suggest that capture team protocols be developed for pre-flight briefings to enhance coordination and attention to safety needs. The technical task of mountain goat removal demands hazardous activities that require careful attention to safety details. The routinization of pre-flight tasks and the expectations of capture crew from working closely together may cause lapses in attention to important safety requirements. This possibility is supported by research that suggest accidents and complacency can become more likely in situations with much familiarity and experience. To offset behaviors that can lead to accidents, the capture team should consider procedures whereby activities are double-checked to ensure safety.

3) We suggest that the capture team develop formal criteria for deciding when to terminate a day's operations. Currently the capture team leader is responsible for deciding when to terminate a day's operations. He bases his decisions on personal feelings of fatigue, hours worked, and success in capturing goats. Research suggests that such informal methods may not provide adequate attention to the situation of other capture team members. For example, interpersonal relationships may in some cases prevent other members from expressing a need to terminate the day's operations. To offset the possibility of such negative social factors, we suggest that specific decision criteria should be developed.

4) We suggest that the capture team leader be provided with an assistant to reduce Demobilization and Post-Capture Task workload. Daily capture operations in the backcountry may last up to 8 or 9 hours. After the capture team returns to Hurricane Ridge the capture team leader must perform additional tasks that may last 1 or 2 hours. The literature suggests that long hours or work over an extended period can lead to fatigue and negative influences on performance and safety. To reduce the workload of the capture team leader and increase his off-hours, attention should be given to ways by which an assistant could reduce his responsibilities for post-capture tasks.

5) We suggest that the choice of capture equipment (dart or net gun) remain a technical decision of the capture team. The capture team must use specialized

capture equipment in a unique program. Thus, they are best able to assess their equipment needs and possible equipment modifications. Research suggests that safety is improved when equipment and individuals are adapted to each other and to the task. Because the capture team is most familiar with the special needs, all decisions about capture equipment should remain the responsibility of the capture team.

6) We suggest that the capture team formalize verbal and nonverbal signals prior to operations each summer. High levels of workload during the technical task require that specific methods of communication be developed between capture team members. Currently, the capture team develops verbal and nonverbal signals through experience in the technical task. In some cases, the signal can be as little as a nod of the head. Research suggests that misunderstandings can arise when individuals interact under time pressure, stress, and high levels of workload. In addition, research suggests that communication problems among individuals can influence safety. In particular, lack of familiarity among crew members can lead to misunderstandings or non-receipt of messages. Communciation research has shown that performance can be improved by the use of formalized signals and increased personnel familiarity. In some cases it may also be important to formalize communciation signals and protocols with staging area personnel.

7) We suggest that the capture team investigate alternative methods for reducing pilot workload during backcountry flights. The pilot of the helicopter must fly in difficult conditions that approach the limits of his skill and the capabilities of the aircraft. The literature on accidents in aviation suggests that safety is enhanced when a system contains a "buffer zone" for safety and can be "forgiving" to failures. Current operations may not allow the pilot adequate margins of safety. We suggest that all possible alternatives to reduce pilot workload be investigated. For example, they may include the use of instrumentation to warn of low fuel levels or power hover techniques to replace toe-in and one-skid landings.

Altering the Social Environment

8) We suggest that the contract with Eagle Air Helicopters, Inc. be renegotiated so that operator payment is not affected by flights cancelled or delayed due to inclement weather. In prior years, contracts with Eagle Air Helicopters, Inc. required the provision of an aircraft, pilot, and fuel truck for each day of planned

operations. However, frequent cancellations due to inclement weather lead to loss of income for the helicopter operator. Conflicts over decisions to cancel operations may occur in some cases. Research suggests that safety and performance is influenced by the quality of organizational cooperation and working relationships. To prevent negative influences we suggest that the contract with Eagle Air Helicopters, Inc. be rewritten to provide fair compensation and income to the pilot and operator when flights are canceled or delayed.

9) We suggest that liaison with recipient agencies be redesigned and formalized to reduce pressures on the capture team. In prior years of the project, liaison with recipient agencies has sometimes been inadequate. In some cases, recipient agency personnel were not prepared for goat transfer and placed unnecessary pressure on the capture team to deliver goats. Research suggests that such factors may influence judgments and behavior by causing stress and anxiety. Such factors can negatively influence safety and reliability. Thus, we suggest that formal criteria and protocols with recipient agencies to decrease production pressures on the capture team be developed and strictly enforced. Alternative transfer strategies may also be considered, such as the use of a centralized team to collect and transfer the captured mountain goats.

10) We suggest that the capture team should be included in any decisions that impact the technical task at any level. The capture team is best able to understand the requirements of the technical task and the risks they face. Decisions that directly or indirectly impact the technical task may influence their safety. Research suggests that worker participation in the design and evaluation of tasks can positively influence safety, reliability, and performance. Thus, we suggest that any decisions to alter the technical task include the participation of the capture team.

Monitoring Social Risk Factors

11) We suggest that the capture team pay special attention to individual needs for adequate rest periods and good nutrition. Currently the capture team leader is responsible for monitoring team members' performance. The technical task is designed so that gunners may rest and eat while waiting to be recovered by the pilot after goat transport to the staging area. The pilot may rest and eat while refueling. Research suggests that effective and safe judgments and behavior depend on alert individuals. However, alertness and judgments may be negatively influenced by

inadequate rest and improper nutrition. We suggest that formal rest and eating periods be incorporated into the stages of the technical task.

12) We suggest that evaluations of project personnel should be based on criteria of safety and effectiveness. Personnel participating in the technical task must pay careful attention to safety. Evaluations based on quantitative measures of performance, such as the rate and number of captured goats may lead to less attention to safety. Research suggests that pressures from job evaluations and supervisors can lead to stress and anxiety that may hinder attention to such details. Thus, we suggest that personnel evaluations be based on criteria of safety and effectiveness rather than the rates or numbers of goats captured.

13) We suggest that data collection and task monitoring be included in annual project evaluations. Prior rates of goat captures and technical task effectiveness may be useful in the identification of realistic expectations in future goat capture attempts. Moreover, analysis of annual data can assist in the understanding of hazards faced by capture team members and provide a basis for making decisions on the future directions of the project. Thus, we suggest that data on the characteristics of goat captures and the performance of capture team members be collected and monitored.

Additional Options

14) We suggest that training programs be developed to familiarize personnel with accident response. Much of the technical task is performed in remote areas of Olympic National Park. Accident response to helicopter accidents and human exposure to Carfentanil are real possibilities that should be planned for. However, research suggests that organizations are often ill-prepared for response to unfamiliar accidents that require rapid response. Training of response personnel with accident scenarios have proven to be useful for familiarizing personnel with response requirements. We suggest that a training program be implemented that will provide response training to a variety of accident scenarios. All personnel that may participate in accident response should be trained, including park dispatchers, search and rescue crews, and hospital personnel.

15) We suggest that consideration be given to duty hour limits for pilots participating in the project. After returning from Olympic National Park the pilot

may have additional non-flight duties to complete. Cumulative fatigue from long hours of work may result. Research suggests that fatigue may have negative influences on pilot judgments and flight behavior. Thus, safety may be negatively influenced. We suggest that the contract with Eagle Air Helicopters, Inc. specify limits on duty hours.

Long-Term Suggestions

In this section we develop suggestions for improving safety in the technical task during the long-term (e.g., in following years). Although we do not list them again, all of the short-term suggestions should be carried over into following years' activities.

Altering the Technical Task

16) We suggest that the capture team investigate alternative operational techniques to improve safety in the technical task. Current operations approach the limits of capture team skills and helicopter performance capabilities. Research on technical tasks in hazardous environments suggests that systems that fail to leave adequate margins of safety may experience severe accidents. Efforts should be made to provide and enhance "reserve" margins of safety for project personnel, equipment and aircraft, and in the interface between them. For example, power hovers or alternative hauling techniques may be available that will reduce hazards to the capture team.

Altering the Social Environment

17) We suggest that decision-making criteria and procedures be formalized. The current capture team has developed decision making criteria through experience with the technical task. In addition, verbal and nonverbal communication signals have been developed. If new personnel enter the technical task, formal decision and communication procedures should be made available to improve safety and performance. Prior research suggests that lack of familiarity with group decision making and communication can lead to improper or unsafe actions. Formal procedures can best be developed by the current experienced capture team.

18) We suggest that quantitative goals not be established. Neither the capture team nor management should develop quantitative goals for goat captures, missions, etc. in the technical task. Such goals may contribute to unnecessary pressures on the capture team. Research suggests that social pressures and stress factors from production requirements can negatively influence safety. Thus, we suggest that goals be based on the need for safe and reliable operations over the long term.

Monitoring Social Risk Factors

19) We suggest that the capture team develop a formal reporting system for near misses and mishaps during all stages of the technical task. Knowledge of performance in the technical task and an understanding of near misses and mishaps can assist in the modification of the technical task to improve safety. Research suggests that investigations of accidents and near misses are improved with formal recordkeeping. Such data have proven useful for many technical task improvements in safety and reliability. We suggest that a formal reporting system be used only when near misses or mishaps occur. To avoid unnecessary additional work, the reporting system should be integrated into current recordkeeping procedures.

20) We suggest that the capture team provide annual evaluations of technical task risk to the Park Superintendent. Responsibility should be given to the capture team leader to develop and submit such annual reports. They can assist the Park Service to monitor risk in the technical task and provide formal evaluations to be used in NPS decisions.

Additional Options

21) We suggest if the project is to be conducted beyond 1990, a second capture team should be trained. The current technical task relies on the participation of one individual (the current capture team leader) and several pilots. While effective in the short-term, the program is vulnerable to a number of disruptions. These include cancelled operations, a lack of "institutional memory" (because most program knowledge resides with this individual), and difficulty in recovery after an accident or mishap. Research suggests that such system weaknesses can lead to increased risk. A second capture team would make the program more resilient to these potential disruptions, and can reduce personnel fatigue and stress.

22) We suggest that task and judgment training be formalized and performed periodically. Research suggests that formal training can improve safety and performance in techncial tasks. Available programs exist for pilot judgment training which may prove useful. All members of the capture team should undergo similar training in order to understand the requirements imposed on each. This may help to improve pilot and gunner coordination. Periodic training programs should be used to improve skills, learn new techniques, improve interactions among

individuals, and heighten awareness of potential problems from routinization of tasks and inappropriate senses of safety.

<u>23) We suggest that individual and team training be formalized.</u> The technical task can now be performed only by one capture team. We suggest that additional teams not be trained as units, but that individuals be trained in different groups. In this way, new personnel will be able to enter the experienced capture teams and the project may be safely institutionalized.

Conclusion

The Olympic National Park Mountain Goat Removal Project is defined as a technical task. It is comprised of stages that require the interactions of a number of individuals and machines. The individuals are from different organizations that must coordinate their schedules and requirements. The combination of activities that comprise the technical task demand high levels of expertise, physical stamina, and mental capacities to ensure personnel safety and reliable performance. In this report, a variety of social factors were discussed that can contribute to hazards in different stages of the technical task. In particular, mistakes or failures at several stages can contribute to the occurrence of risks that may injure or kill project personnel.

We apply the social sciences to the analysis of the technical task. The social sciences have devoted much attention to issues of individual, group, and organizational behavior. They provide a useful perspective from which to assess and improve safety in technical tasks.

In particular, the literature suggests that human variability can interact with task requirements and technical components in such a way that accidents and mishaps occur. As tasks and the interactions of machines and people are made more complex and completed in even more difficult situations, the likelihood of an accident or mishap grows. To accomodate the always present possibility that "human errors" may occur, systems should be designed to be "goof proof" and provide "buffer zones" that mitigate potentially dangerous consequences of mishaps and accidents. Systems that push the bounds of human and mechanical capabilities also push their luck.

Social science research has assessed the social factors that can cause or contribute to accidents. Additional research suggests how they might be overcome and the safety and reliability of technical tasks improved. Such research forms the basis for our set of suggestions that can be applied to improve safety in the technical task of mountain goat removal from Olympic National Park.

Bibliography

1. Adams, R. Root causes of helicopter pilot error accidents. Advanced Aviation Concepts, Inc., Robbinsville, NJ (no date).

2. Adams, R. An international program to reduce pilot error accidents (aeronautical decision making training). Advance Aviation Concepts, Inc., Jupiter, FL (1987).

3. Adams, R. Special considerations for helicopter safety, in Aviation Psychology , Jensen, R., Eds. (Gower Technical, Brookfield, 1989).

4. Albery, W. B. The effects of sustained acceleration and noise on workload in human operators. Aviation, Space, and Environmental Medicine 60, 943-948 (1989).

5. Alkov, R. A., Borowsky, M. S. and Gaynor, J. A. Stress coping and the U.S. Navy Aircrew Factor Mishap. Aviation, Space, and Environmental Medicine 53, 11, 1112-1115 (1982).

6. Alkov, R. A., Gaynor, J. A. and Borowsky, M. S. Pilot error as a symptom of inadequate stress coping. Aviation, Space, and Environmental Medicine 56, 244-247 (1985).

7. Allan, J. R. Thermal control problems in military helicopters. In Aeromedical support in military helicopter operations , AGARD (NATO, Neuilly Sur Seine, France, 1984).

8. Bellamy, L. Survey of affective and social influences on system reliability. University of Aston, Birmingham, England (1983a).

9. Bellamy, L. Neglected individual, social, and organizational factors in human reliability assessment. In Proceedings of the Fourth National Reliability Conference National Centre of Systems Reliability, Birmingham, England (6-8 July,1983b).

10. Bellamy, L. How people's behavior shapes your plant operation, Process Engineering, pg. 27-28 (July, 1985).

11. Berg, S. and Sheridan, T. B. Effect of time span and task load on pilot mental workload. Man-Machine Systems Laboratory, Massachusetts Institute of Technology, Cambridge, MA (1985).

12. Blake, R. R. and Mouton, J. S. The new management grid. Houston: Gulf (1978).

13. Borowsky, M. S. and Wall, R. Flight experience and naval aircraft mishaps. Aviation, Space, and Environmental Medicine 54, 5, 440-446 (1983a).

14. Borowsky, M. S. and Wall, R. Naval aviation mishaps and fatigue. Aviation, Space, and Environmental Medicine 54, 6, 535-538 (1983b).

15. Brehmer, B. Models of diagnostic judgments. In New Technology and Human Error , Rasmussen, J., Duncan, K. and Leplat, J., Eds. (John Wiley and Sons, NY, 1987).

16. Buch, G. and Diehl, A. An investigation of the effectiveness of pilot judgment training. Human Factors 26, 5, 557-564 (1984).

17. Calahan, M. Personal communication (1990).

18. Caughley, G. The Deer Wars: The story of deer in New Zealand . (Heinemann Publishers, Exeter, NH, 1983).

19. Chidester, T. R. Trends and individual differences in response to short-haul flight operations. Aviation, Space, and Environmental Medicine 61, 132-138 (1990).

20. Cohen, M., March, J. and Olsen, J. A garbage can model of organizational choice. Administrative Science Quarterly 17, 1-25 (1972).

21. Collins, W. E., Mastrullo, A. R., Kirkham, W. R., Taylor, D. K. and Grape, P. M. An analysis of civil aviation propeller-to-person accidents: 1965-1979. Aviation, Space, and Environmental Medicine 53, 5, 458-462 (1982).

22. Connolly, T. J., Blackwell, B. B. and Lester, L. F. A simulator-based approach to training in aeronautical decision making. Aviation, Space, and Environmental Medicine 60, 50-52 (1989).

23. Cote, D. O., Krueger, G. P. and Simmons, R. R. Helicopter copliot workload during nap-of-the-earth flight. Aviation, Space, and Environmental Medicine 56, 153-157 (1985).

24. Crecine, J. Defense reource allocation: Garbage can analysis of C3 procurement. In Ambiguity and command: Organizational perspectives on military decision making, March, J. and Weissinger-Baylon, R., Eds. (Pitman Publishing, Inc., Marshfield, MA, 1986).

25. Dellinger, J. A. and Taylor, H. L. Measuring the effects of neurotoxicants on flight simulator performance. Aviation, Space, and Environmental Medicine 56, 254-257 (1985).

26. Dorner, D. On the difficulty people have in dealing with complexity. In New Technology and Human Error , Rasmussen, J., Duncan, K. and Leplat, J., Eds. (John Wiley and Sons, NY, 1987).

27. Durnford, S. J. Stressful mission profiles, part 1. In Aeromedical support in military helicopter operations , AGARD (NATO, Neuilly Sur Seine, France, 1984a).

28. Durnford, S. J. Stressful mission profiles, part 2 - Workload and fatigue. In Aeromedical support in military helicopter operations , AGARD (NATO, Neuilly Sur Seine, France, 1984b).

29. Embrey, D. Human reliability. Paper presented at the 1984 Summer School of the Italian Physical Society. Parbold, England: Human Reliability Associates, Ltd. (1984).

30. Faff, J. and Tutak, T. Physiological responses to working with fire fighting equipment in the heat in relation to subjective fatigue. Ergonomics 32, 6, 629-638 (1989).

31. Federal Aviation Administration. Investigation of hazards of helicopter operation and root causes of helicopter accidents. Report no. DOT/FAA/PM-86/28 (July, 1986)

32. Fine, B. J. and Kobrick, J. L. Effect of heat and chemical protective clothing on cognitive performance. Aviation, Space, and Environmental Medicine 58, 149-154 (1987).

33. Fischhoff, B. Judgment and decision making. In The Psychology of Human Thought , Sternberg, R. and Smith, E., Eds. (John Wiley and Sons, NY, 1986).

34. Foresta, R. A. America's National Parks and Their Keepers . (Resources for the Future, Washington, DC, 1984).

35. Fox, R. G. Relative risk: The measure of safety. Presented at the 28th Corporate Aviation Safety Seminar Flight Safety Foundation (17-19 April 1983).

36. Fox, R. G. Helicopter accident trends. Presented at the AHS-FAA-HAI National Specialists Meeting "Vertical Flight Training Needs and Solutions Arlington, TX (17-18 September 1987).

37. Froom, P., Barzilay, J., Caine, Y., Margaliot, S., Forecast, D. and Gross, M. Low back pain in pilots. Aviation, Space, and Environmental Medicine 57, 694-695 (1986).

38. Gael, S., Eds. The Job Analysis Handbook for Business, Industry, and Government. (John Wiley and Sons, NY, 1988).

39. Girodo, M. The psychological health and stress of pilots in a labor dispute. Aviation, Space, and Environmental Medicine 59, 505-510 (1988).

40. Gopher, D. and Donchin, E. Workload: An examination of the concept. In Handbook of Perception and Human Performance , Boff, K. R., Kaufman, L. and Thomas, J. P., Eds. (John Wiley and Sons, NY, 1986).

41. Gouran, D. Inferential errors, interaction, and group decision-making. In Communication and group decision-making, Hirokawa, R. and Poole, M., Eds. (Sage Publications, Beverly Hills, CA, 1986).

42. Hart, S. G. and Bortolussi, M. R. Pilot errors as a source of workload. Human Factors 26, 5, 545-556 (1984).

43. Hart, S. G. and Sheridan, T. B. Pilot workload, performance, and aircraft control automation. Paper reprinted from AGARD Conference Proceedings No. 371. Neuilly Sur Seine, France: NATO (1984).

44. Hawkins, F. H. Human Factors in Flight . (Gower Publishing Co., Brookfield, VT, 1987).

45. Helmreich, R. L. Cockpit management attitudes. Human Factors 26, 5, 583-589 (1984).

46. Herman, L. Personal communication (1990).

47. Hirokawa, R. and Scheerhorn, D. Communication in faulty group decision-makingIn Communication and group decision-making, Hirokawa, R. and Poole, M., Eds. (Sage Publications, Beverly Hills, CA, 1986).

48. Hockey, R., Eds. Stress and Fatigue in Human Performance. (John Wiley and Sons, NY, 1983).

49. Holding, D. Fatigue. In Stress and Fatigue in Human Performance , Hockey, R., Eds. (John Wiley and Sons, NY, 1983).

50. Holmes, J. A lethal ingredient: Human error.Insight, pgs. 52-53. (9 March, 1987).

51. Holsti, O. Crisis, stress, and decision making. International Social Science Journal 23, 53-67 (1971).

52. Idzikowski, C. and Baddeley, A. Fear and Dangerous Environments. In Stress and Fatigue in Human Performance , Hockey, R., Eds. (John Wiley and Sons, NY, 1983).

53. Janda, C. Personal communication (1990).

54. Jensen, R. S. Pilot judgment: Training and evaluation, Human Factors, 24:61-73 (1982).

55. Jensen, R. S., Eds. Aviation Psychology. (Gower Technical, Brookfield, 1989).

56. Kanki, B. G. and Foushee, H. C. Communication as group process mediator of aircrew performance. Aviation, Space, and Environmental Medicine 60, 402-410 (1989).

57. Kanki, B. G., Lozito, S. and Foushee, H. C. Communication indices of crew coordination. Aviation, Space, and Environmental Medicine 60, 56-60 (1989).

58. Koonce, J. M. A brief history of aviation psychology. Human Factors 26, 5, 499-508 (1984).

59. Krueger, G. P., Armstrong, R. N. and Cisco, R. R. Aviator performance in a week-long extended flight operations in a helicopter simulator. Behavior Research Methods, Instruments, and Computers 17, 1, 68-74 (1985).

60. Landstrom, U. and Lofstedt, P. Noise, vibration and changes in wakefulness during helicopter flight. Aviation, Space, and Environmental Medicine 58, 109-118 (1987).

61. LaPorte, T. R. On the design and management of nearly error free organizational control systems. In The Accident at Three Mile Island: The Human Dimensions, Sills, D., Wolf, C. and Shelanski, V., Eds. (Westview Press, Boulder, CO,1982).

62. LaPorte, T. R. and Consolini, T. High reliability organizations: Challenges to organizational theory. Paper presented at the American Political Science Association, Washington, D.C. (September 1988).

63. Leibrecht, B. C. Health hazard assessment: Reducing health risks in army aviation. In U. S. Army Aviation Journal, pgs. 4-5. (January,1989).

64. Lester, L. F. and Bombaci, D. H. The relationship between personality and irrational judgment in civil pilots. Human Factors 26, 5, 565 (1984).

65. Machlis, G. Personal communication (1990).

66. March, J. Decisions in organizations and theories of choice. In Perspectives on Organization Design and Behavior , Van De Ven, A. H. and Joyce, W., Eds. (John Wiley and Sons, NY, 1981).

67. March, J. and Weissinger-Baylon, R., Eds. Ambiguity and Command: Organizational Perspectives on Military Decision-Making. (Pitman Publishing Inc., Marshfield, MA, 1986).

68. Margerison, C., Davies, R. and McCann, D. High-flying management development. Training and Management Development Journal 41, 2, 38-41 (1987).

69. McCurry, M. Personal communication (1990).

70. Monk, T. H., Fookson, J. E., Kream, J., Moline, M. C., Pollack, C. P. and Weitzman, M. B. Circadian factors during sustained performance: Background and methodology. Behavior Research Methods, Instruments, and Computers 17, 1, 19-26 (1985).

71. Moray, N. Mental workload: Theory and measurement. (Plenum Press, NY, 1979).

72. Morrow, D., Leirer, V. and Yesavage, J. The influence of alcohol and aging on radio communication during flight. Aviation, Space, and Environmental Medicine 61, 12-20 (1990).

73. National Research Council. Human factors research and nuclear safety (National Academy Press, Washington, D.C., 1988).

74. Oborne, D. J. and Rogers, Y. Interactions of alcohol and caffeine on human reaction time. Aviation, Space, and Environmental Medicine 54, 6, 528-534 (1983).

75. Olympic National Park. Mountain goat management in Olympic National Park: Environmental Assessment. (Olympic National Park, Port Angeles, WA 1987).

76. Perrow, C. Normal Accidents . (Basic Books, Inc., NY, 1984).

77. Platenius, P. H. and Wilde, G. J. S. Personal characteristics related to accident histories of Canadian pilots. Aviation, Space, and Environmental Medicine 60, 42-45 (1989).

78. Post, R. E. Heat stress. In U. S. Army Aviation Digest, pgs. 20-21. (March, 1989).

79. Putnam, L. Conflict in group decision-making. In Communication and Group Decision-making , Hirokawa, R. and Poole, M., Eds. (Sage Publications, CA, 1986).

80. Quintanilla, S. A. R. New technologies and human error: Social and organizational factors. In New Technology and Human Error, J. Rasmussen, K. Duncan, and J. Leplat, Eds. (John Wiley and Sons, NY, 1987).

81. Rafulski, P. Personal communication (1990).

82. Ramsey, J. Heat and cold. In Stress and Fatigue in Human Performance, Hockey, R., Eds. (John Wiley and Sons, NY, 1983).

83. Rasmussen, J. Human errors: A taxonomy for describing human malfunction in industrial installations. Journal of Occupational Accidents, 4:311-333 (1982).

84. Rasmussen, J. Approaches to the control of the effects of human error on chemical plant safety. Paper presented at the International Symposium on Preventing Major Chemical Accidents, American Institute of Chemical Engineers (February 1987a).

85. Rasmussen, J. Cognitive control and human error mechnisms. In New Technology and Human Error, J. Rasmussen, K. Duncan, and J. Leplat, Eds. (John Wiley and Sons, NY, 1987b).

86. Rasmussen, J. Definition of human error and a taxonomy for technical system design. In New Technology and Human Error, J. Rasmussen, K. Duncan, and J. Leplat, Eds. (John Wiley and Sons, NY, 1987c).

87. Rasmussen, J. Mental models and the control of actions in complex work environments. RISO Report No. RISO-M-2656. Roskilde, Denmark: Riso National Laboratory (1987d).

88. Rayman, R. B. Negative transfer: A threat to flying safety. Aviation, Space, and Environmental Medicine 53, 12, 1224-1226 (1982).

89. Reason, J. A framework for classifying errors. In New Technology and Human Error, J. Rasmussen, K. Duncan, and J. Leplat, Eds. (John Wiley and Sons, NY, 1987a).

90. Reason, J. Collective planning and its failures. In New Technology and Human Error, J. Rasmussen, K. Duncan, and J. Leplat, Eds. (John Wiley and Sons, NY, 1987b).

91. Reason, J. and Mycielska, K. Absent Minded? The psychology of mental lapses and everyday errors . (Prentice Hall, Inc., Englewood Cliffs, NJ, 1982).

92. Rotondo, G. Workload and operational fatigue in helicopter pilots. Aviation, Space, and Environmental Medicine 49, 2, 430-436 (1978).

93. Salvendy, G., Eds. Handbook of Human Factors. (John Wiley and Sons, NY, 1987).

94. Schofield, J. E. and Giffen, W. C. An analysis of aircrew procedural compliance. Aviation, Space, and Environmental Medicine 53, 10, 964-969 (1982).

95. Shanahan, D. F. Back pain in helicopter flight operations. In Aeromedical support in military helicopter operations . AGARD (NATO, Neuilly Sur Seine, France, 1984).

96. Simmel, E. C., Cerkovnik, M. and McCarthy, J. E. Sources of stress affecting pilot judgment. Aviation, Space, and Environmental Medicine 60, 53-55 (1989).

97. Simon, H. A. A behavioral model of rational choice. Quarterly Journal of Economics 69, 99-118 (1955).

98. Skjenna, O. W. Cause Factor: Human. A treatise on rotary wing human factors. Minister of National Health and Welfare, Canada (1981).

99. Slovic, P. Judgment and decision making in emergency situations. Unpublished manuscript. Decision Research, Eugene, OR (January, 1988).

100. Slovic, P., Fischhoff, B., and Lichtenstein, S. Behavioral decision theory. Annual Review of Psychology, 28:1-39 (1977).

101. Slovic, P., Lichetenstein, S. and Fischhoff, B. Decision making. In Steven's Handbook of Experimental Psychology , Atkinson, R. C., Herrenstein, R. J., Lindzey, G. and Luce, R. D., Eds. (John Wiley and Sons, NY, 1988).

102. Svenson, O. Process descriptions of decision making. Organizational Behavior and Human Performance 23, 86-112 (1979).

103. Svenson, O. Are we all less risky and more skillful than our fellow drivers. Acta Psychologica, 47:143-148 (1981).

104. Svenson, O. A psychological perspective on accident evolutions and how to arrest them in nuclear power plants. Paper presented at the Society for Risk Analysis Annual Meeting, Boston, MA (9-12 November 1986).

105. Svenson, O. and Edland, A. Choice reversals and decisions under time stress. Report no. 23. Cognition and Decision Research Unit, Dept. of Psychology, University of Stockholm, Sweden (February, 1986).

106. Swap, W. Group Decision Making . (Sage Publications, CA, 1984).

107. Telfer, R. Pilot decision making and judgment In Aviation Psychology , Jensen, R., Eds. (Gower Technical, Brookfield, 1989).

108. Telfer, R. and Ashman, A. Pilot judgment training: An Australian validation study. New Castle: University of Newcastle, Australia (1986).

109. Tsang, P. S. and Johnson, W. W. Cognitive demands in automation. Aviation, Space, and Environmental Medicine 60, 130-135 (1989).

110. Tuler, S. Individual, group, and organizational decision making in technological emergencies: A review of research. Industrial Crisis Quarterly 2, 109-138 (1988).

111. Tuler, S., Kasperson, R. E., Ratick, S. The effects of human reliability on risk in the transportation of spent nuclear fuel. Unpublished report. Center for Technology, Environment, and Development, Clark University, Worcester, MA (1988).

112. Turner, B. Man-Made Disasters . (Wykeham Publications, Ltd., London, 1978).

113. Tversky, A. and Kahneman, D. Judgment under uncertainty: Heuristics and biases. Science 185, 1124-1131 (1974).

114. U. S. Army. Human Error: Major Cause of Army Aviation Accidents. In U. S. Army Aviation Digest, pgs. 8-12. (March, 1988).

115. U. S. Army. Risk Management: Flying the mission anyway--the best way. In U. S. Army Aviation Digest, pgs. 12-13. (June, 1988).

116. Vyrnwy-Jones, P. A review of Army Air Corps helicopter accidents, 1971-1982. Aviation, Space, and Environmental Medicine 56, 403-409 (1985).

117. White, M. K., Vercruyssen, M. and Hodous, T. K. Work tolerance and subjective response to wearing protective clothing and respirators during physical work. Ergonomics 32, 9, 1111-1123 (1989).

118. Wichman, H. and Ball, J. Locus of control, self-serving biases, and attitudes towards safety in general aviation pilots. Aviation, Space, and Environmental Medicine 54, 6, 507-510 (1983).

Appendices

Appendix 2.1

Appendix 2.1

1989 CAPTURE PROJECT ORGANIZATION

PROJECT LEADER
Chuck Janda

LIAISON OFFICER
Paul Crawford

CAPTURE TEAM LEADER
Rich Olson

STAGING AREA MANAGER
Art Sandison
Katie Reavey

TECHNICAL SPECIALIST
CAPTURE

Gary Gissell

TECHNICAL SPECIALISTS
ANIMAL HANDLING

Doug Houston
Bruce Moorhead
Cat Hawkins
Ruth Scott

SECURITY MANAGER

Dave Austin

TRAFFIC CONTROL

Paula Thurston
Kelly Bush

PROJECT LEADER

The Project Leader (Chief Ranger) is responsible for approving all operation plans, determining project strategy and priorities, managing the project budget, providing management direction to the Capture Team Leader and field personnel, maintaining liaison with the Superintendent, other park divisions and cooperating and assisting agencies, providing for public information, and conducting an operations review at the conclusion of the project.

LIAISON OFFICER

This position is supervised by the Project Leader.

The Liaison Officer is responsible for coordinating activities between the capture project and other agencies, primarily the Washington Department of Wildlife (WDW). The Liaison Officer serves as the Project Leader in the absence of the Chief Ranger.

1. Establish and maintain communication between the Project Leader, Capture Team Leader and cooperating agencies; provide a point of contact for assisting/cooperating agency representatives.

2. Advise cooperating agencies regarding the schedule of project activities; communicate anticipated logistical requirements to those agencies receiving animals.

3. Monitor project operations to identify current or potential intra- or inter-organizational problems.

4. Maintain a current list of cooperating and assisting agencies, personnel assignments and radio and telephone contact procedures.

5. Participate in planning meetings.

6. Compile and disseminate information regarding current project status, personnel assigned and attainment of project objectives.

CAPTURE TEAM LEADER

This position is supervised by the Project Leader.

The Capture Team Leader is responsible for supervising and directing all field activities of the project including animal capture, transport, medical treatment and preparation for transfer and translocation.

1. Accomplish the necessary operational and logistical planning required to achieve the project objectives.

2. Arrange, organize and manage required project staff.

3. Purchase necessary equipment, supplies, materials and services.

4. Conduct staff orientation, training and certification.

5. Conduct daily operational briefing for all personnel.

6. Supervise and direct daily capture operations.

7. Develop emergency action procedures for the staging area.

8. Ensure that all capture and aircraft activities are conducted according to approved protocols, OAS regulations and standard operating procedures.

9. Ensure adherence to all agency safety rules, regulations and policies; provide for frequent reviews of safety related issues and communicate the results of these reviews to the Project Leader.

10. Ensure that supervisory personnel span-of-control considerations are not exceeded.

11. Document all field activities.

12. Complete all necessary administrative requirements regarding scheduling of personnel, timekeeping, procurement, property management, etc.

13. Provide for frequent communication with the Project Leader and Liaison Officer; keep them informed of the project status and any problems or incidents requiring management attention.

14. Maintain security over firearms, drugs and controlled substances used in the project; comply with all required inventory record keeping provisions of DEA registration certificate.

15. Complete performance evaluations for all field personnel.

16. Incorporate the results of daily staff debriefings into field activities; compile information for use in an operations review at the conclusion of the project.

TECHNICAL SPECIALIST (CAPTURE)

This position is supervised by the Capture Team Leader.

The Technical Specialist-Capture is a member of the project capture team and participates in search, capture, restraint and aircraft transportation of animals between backcountry areas and the staging area.

1. Maintain personal gear, including all required safety equipment in a state of readiness for daily operations.

2. Upon notification by the Capture Team Leader. contact the designated pilot of the capture aircraft to communicate decisions regarding daily operations.

3. Prior to the start of capture operations, assist in preparation of the assigned aircraft to capture configuration; store all equipment in the forward section of the aircraft in designated locations.

4. Obtain preflight briefing from Capture Team Leader: conduct cross-checks of all capture, communication and personal safety equipment.

5. Conduct all animal capture, restraint and helicopter transport according to approved protocols and standard operating procedures.

6. Maintain security over all controlled substances and containminated wastes; dispose of materials through Capture Team Leader.

7. Participate in daily operation debriefings.

Capture Team Qualification Requirements

1. Gunner:
    - basic helicopter safety training (8 hours)
    - orientation to aerial wildlife capture operations (2 hours)
    - animal capture/restrain training (40 hours)
    - agency firearm qualification (4 hours)
    - aerial net gun deployment procedures and protocol (4 hours)
    - avionics and aircraft radio user training (1 hour)

2. Animal Restraint:
    - basic helicopter safety training (8 hours)
    - orientation to aerial wildlife capture operations (2 hours)
    - animal capture/restraint training (40 hours)
    - one-skid landing training (4 hours)
    - avionics and aircraft radio user training (1 hour)
    - LORAN C user training (1 hour)
    - basic navigation and flight following procedures training (2 hours)

STAGING AREA MANAGER

This position is supervised by the Capture Team Leader.

The Staging Area Manager is responsible for managing all activities and safety at the Hurricane Ridge staging area and base heliport. The Staging Area Manager has been delegated broad authority from the Capture Team Leader to control activities at the staging area.

1. Supervise and direct all personnel assigned to the staging area.

2. Determine routine work assignments for all personnel; ensure that workload is divided equitably among available personnel and that all personnel are fully productive.

3. Conduct daily safety briefings for all personnel assigned to staging area.

4. Ensure that all personnel use required personal protective equipment and techniques when appropriate.

5. Establish staging area layout at the start of daily operations; maintain perimeter barricades, flagging, traffic cones, signing, etc.

6. Manage staging area parking plan and the movement of all vehicles in and around the staging area.

7. Provide for support needs of personnel; meal breaks, water, etc.

8. Direct aircraft landings/takeoffs; provide landing advisories to aircraft on final approach to heliport.

9. Enforce all safety rules regarding activities around aircraft landing areas; keep all unauthorized personnel away from touchdown pad.

10. Supervise aircraft support vehicle (fuel truck) and driver; supervise refueling operations and enforce no smoking restrictions.

11. Monitor project radio communications; respond to radio traffic from Communications Center and capture team.

12. Provide routine progress reports to Liaison Officer and/or Project Leader through Communications Center.

13. Maintain readiness of emergency equipment at staging area; initiate emergency action procedures when required.

14. Maintain liaison with cooperating agency personnel; incorporate these persons into animal handling process at staging area.

15. Promptly check, refurbish and shuttle capture equipment between staging area and capture team using capture aircraft.

16. Provide security over staging area drug kits and controlled substances; ensure that drug containminated wastes are segregated and properly handled.

17. Expedite animal processing and crating procedures; ensure that crated animals are monitored.

18. Coordinate activities of any media representatives at staging area; request assistance from Liaison Officer or Project Leader if required.

19. Manage daily demobilization of staging area; secure all equipment and supplies; transfer containminated wastes to Capture Team Leader.

20. Maintain unit log; provide daily debriefing of activities to Capture Team Leader.

ASSISTANT STAGING AREA MANAGER

This position is supervised by the Staging Area Manager.

The Assistant Staging Area Manager is responsibile for the same duties as the Staging Area Manager; except that the following additional duties are assigned:

1. Serve as check-in recorder for all personnel assigned to staging area; maintain crew time reports for all personnel.

2. Maintain the inventory of the staging area drug kits and medical supplies.

3. Assist in administration of medical protocol.

4. Collect individual animal data cards at the conclusion of each day's operation; check that all required information has been obtained.

5. Dispose of containminated wastes from daily operations as directed by the Capture Team Leader.

6. Maintain the inventory in the staging area equipment cache; check all emergency equipment at the staging area daily.

7. Tell funny jokes to the Capture Team Leader to keep his morale up.

TECHNICAL SPECIALIST (ANIMAL HANDLING)

These positions are supervised by the Capture Team Leader. Routine direction is provided by the Staging Area Manager.

The Technical Specialists-Animal Handling are responsible for animal assessment, medical and injury treatment, crating and monitoring prior to transfer of animals to the receiving agency for vehicle transport away from the staging area.

1. Obtain daily briefing from Staging Area Manager.

2. Maintain all assigned equipment and supplies in a state of readiness; secure all equipment around aircraft landing areas.

3. Observe all safety instructions provided by Staging Area Manager.

4. Divide workload among all assigned personnel; work to promote rapid and efficient handling of incoming animals.

5. Assess animal condition immediately upon their arrival at the staging area.

6. Triage animals with serious injuries or medical complications.

7. Administer routine medical protocol.

8. Administer extended care or emergency medical protocols, as required.

9. Perform euthanasia on seriously injured animals; place carcass in crate and protect for later necropsy.

10. Document medical protocol as it is administered; collect data to support population studies.

11. Recover and refurbish capture equipment; transfer to Staging Area Manager.

12. Crate animals for vehicle transport.

13. Monitor the condition of crated animals.

14. Maintain liaison with cooperating agency personnel; incorporate these persons into medical and handling procedures, where feasible.

15. Maintain security over staging area drug kits and controlled substances.

16. Use personal protective equipment and proper clinical techniques when handling hazardous substances.

17. Consolidate containminated wastes for transfer to Staging Area Manager.

18. Provide frequent reports on overall animal condition and any serious capture-related injuries to Staging Area Manager for communication to capture team; advise Staging Area Manager of any animal medical problems which require the personal attention of the Capture Team Leader.

19. Keep Staging Area Manager appraised of any logistical problems or hazardous conditions.

20. Participate in daily debriefings.

TRAFFIC CONTROL

These positions are supervised by the Security Manager.

Traffic Control personnel are responsible for controlling vehicles in the vicinity of the staging area and protecting the safety of park visitors.

1. Obtain daily briefing from Security Manager.

2. Assist in maintaining staging area layout.

3. Carry out the staging area traffic and parking plan.

4. Keep unauthorized vehicles and persons away from staging area and helicopter landing areas.

5. Use proper procedures in controlling vehicle traffic.

6. Provide services and information to park visitors.

7. Advise Security Manager of problems or hazardous conditions.

8. Assist in emergency action procedures.

9. Participate in demobilization of staging area and in daily debriefings.

SECURITY MANAGER

This position is supervised by the Staging Area Manager.

The Security Manager is responsible for maintaining control over vehicles and bystanders in the vicinity of the staging area.

1. Obtain daily briefing from Staging Area Manager.

2. Assist Staging Area Manager in establishing and maintaining staging area layout; frequently check that all barricades, flagging, traffic cones and signing are in their proper locations.

3. Enforce the staging area traffic and parking plan.

4. Maintain order around the staging area; keep all unauthorized persons away from the staging area and helicopter landing areas: ensure that bystanders do not congregate within the roadway.

5. Supervise traffic control personnel; ensure these persons have personal protective equipment and use proper procedures in controlling traffic around the staging area.

6. Promptly advise Staging Area Manager of any serious safety or security problems; work with Staging Area Manager to immediately correct these problems.

7. Maintain security over government equipment and vehicles.

8. Provide services to park visitors such as emergency assistance, road and trail directions, etc.; provide information on the capture project, park features and facilities, etc.

9. Maintain liaison with Hurricane Ridge naturalist personnel and the staff of the Heart of the Hills entrance station.

10. Be flexible and adjust activities as traffic and visitation levels change.

11. Document all serious complaints and incidents.

12. Monitor project radio communications.

13. Be prepared to assist in emergency action procedures.

14. Assist in daily demobilization of staging area.

15. Participate in daily debriefings.

Appendix 2.2

Appendix 2.2

NADA #139-633
Approved by FDA

Wildnil

Carfentanil Citrate
Sterile Injection

CII

WARNING:
CARFENTANIL IS AN EXTREMELY POTENT DRUG AND MUST BE HANDLED WITH EXTREME CARE TO AVOID RISK TO USERS. AVOID ACCIDENTAL ADMINISTRATION TO HUMANS. PLEASE READ HUMAN WARNING SECTION CAREFULLY.

Caution: Federal law restricts this drug to use by or on the order of a licensed veterinarian.

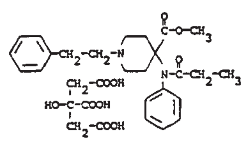
Do not administer 30 days before or during hunting season. Do not use in domestic animals intended for food.

The licensed veterinarian referred to under the CAUTION statement shall be engaged in zoo and exotic animal practice, wildlife management programs or research.

DESCRIPTION:
Wildnil (Carfentanil citrate) is methyl 4- (1-oxoproply) phenyl-aminol-1-(2 phenylethyl)-4-piperidinecarboxylate-2 hydroxy-1, 2, 3-propanetricarboxylate (1:1). Each mL contains: Carfentanil citrate 4.46 mg (Equivalent to 3 mg Carfentanil), sodium chloride 8 mg, methyl paraben 1.8 mg, propyl paraben 0.2 mg in water for injection.

Wildnil (Carfentanil citrate) is a synthetic opiate with a clinical potency 10,000 times that of morphine, (Mather, L.E., Clin., Pharm. 8, 1983, pp 422-446). Wildnil (Carfentanil citrate) is a Schedule II Controlled drug substance.

STRUCTURAL FORMULA:



PHARMACOLOGY:
Wildnil (Carfentanil citrate) has a morphine-like analgesic mode of action and produces rapid immobilization following intramuscular injection.

INDICATIONS:
Wildnil (Carfentanil citrate) is for immobilization of free ranging or confined members of the family Cervidae (deer, elk, moose).

CONTRADICTIONS AND PRECAUTIONS:
Do not use Wildnil (Carfentanil citrate) in animals that display clinical signs of severe cardiovascular or respiratory disease or impairment. Available data are inadequate to recommend use of Wildnil in pregnant animals. Avoid use during breeding season. **Never use Wildnil (Carfentanil citrate) unless antidote or antagonist is on hand.**

WARNINGS:
WILDNIL (CARFENTANIL CITRATE) MUST NEVER BE USED UNLESS ADEQUATE AMOUNTS OF THE REVERSAL AGENT, DIPRENORPHINE, IS IMMEDIATELY AVAILABLE.

Veterinarians using Wildnil should be familiar with clinical procedures such as measurement of pulse and respiration, prevention of aspiration, relief of bloat, obstetrics, control of shock and hemorrhage, recognition of hyperventilation and heat exhaustion, the immobilization of fractures, etc. In cases of severe excitement during induction or delayed recovery, continued observation is necessary to correct any of the above and to insure the animal does not injure itself.

Adequate ventilation – especially in cages or crates – is mandatory; keep head and neck in position to insure patent air passage and to prevent aspiration of stomach contents.

In animals that are recumbent for a considerable length of time, care should be taken to avoid eye damage; shading to prevent retinal burning is advisable and a bland ophthalmic ointment is beneficial. Predatory birds such as magpies have been known to peck at the eyes of recumbent animals. Following Wildnil administration, a brief period of visual adjustment occurs and it may be necessary to direct animals away from hazards such as water, ravines, trees, etc.

Care should be used not to dart animals in the abdomen (intraperitoneally) or against bone. The ideal locations are the heavy muscles of the shoulder or croup. Use a heavy initial dose and avoid subsequent fractional doses. Injection into fat depots results in slow absorption; use needles of adequate length.

As with any anesthetic or immobilization procedure in wild or exotic species, extreme care must be exercised when the drug is used during high environmental temperatures or following extended pursuit or any other activity that may result in elevated body temperatures. Supplies and equipment to shade the animal and control hyperthermia should be available when using Wildnil (Carfentanil citrate) during periods of hot weather. High ambient temperatures increase risk when using Wildnil. Spraying and/or shading animals is useful to lower body temperature. Never use when the temperature is over 100°F and restrict use to days when temperature is less than 85°F. High humidity and/or extreme altitude cause stress.

Lateral recumbency is hazardous in all ruminants. When using Wildnil (Carfentanil citrate), one must be prepared to employ proper procedures to handle problems resulting from lateral or sternal recumbency. Lateral recumbency may call for immediate position correction and injection of the antidote Diprenorphine. Animals in or near water may require immediate assistance to prevent drowning or aspiration.

Prolonged periods of lateral recumbency in heavy animals have caused radial paralysis. Adequate padding may be helpful and Diprenorphine should be administered as soon as feasible.

Animals that exhibit hyperexcitability, anxiety and hyperventilation should either: Be given one additional dose of Wildnil to quiet them to prevent excessive hyperventilation and alkalosis or administered Diprenorphine as an antidote.

The transporation of animals given Wildnil requires careful surveillance to prevent excessive struggling, injury or death. Do not transport more than one animal in a sling, stall or crate.

ADVERSE REACTION:
Seven drug related fatalities were reported during clinical trials that involved the immobilization of 509 members of the family Cervidae (deer, elk, moose). Mortalities were attributed to hyperthermia, acute capture myopathy and/or narcotic recycling in 3.8%

(6/158) of moose and less than 1% (1/295) of the elk immobilized in clinical trials.

Other reported adverse reactions were as follows: tachycardia, tachypnea, excitement during induction, respiratory depression, erratic breathing, thrashing, struggling, hiccuping, paddling, torticollis, grinding teeth, muscle spasms, opisthotonus, lingual paralysis, penile prolapse, excessive salivation, regurgitation of rumen contents and delayed renarcotization. Signs of acute toxicity may include extreme respiratory or cardiovascular depression. Antagonist or antidote should be administered immediately to effect.

HUMAN WARNINGS:
TREATMENT OF ACCIDENTAL HUMAN EXPOSURE
Wildnil (Carfentanil citrate) is an extremely potent drug and is to be used ONLY by individuals experienced in handling potent immobilizing agents in zoos, exotic animal and wildlife practices, wildlife management procedures and biological research.

As with all potent drugs capable of producing rapid immobilization in wild animals, Wildnil (Carfentanil citrate) must be treated with extreme respect and caution. Human safety is critical.
Since Wildnil (Carfentanil citrate) may be employed in locations distant from emergency medical facilities, users must ALWAYS observe the following precautions:

1. User should seek professional medical attention *immediately* if the drug is accidentally ingested or injected.
2. At least two people in the field team should be able to recognize signs of toxicity if accidental exposure should occur. They should be familiar with emergency, cardiopulmonary resuscitation procedures plus have FIRST AID KITS containing resuscitation aids available.
3. WORK IN PAIRS when loading syringes or darts with Wildnil (Carfentanil citrate). Wear rubber gloves when loading syringes to avoid accidental spills on hands.
4. DO NOT SPRAY, squirt or spill the drug when filling syringes.
5. WASH AT ONCE with large volumes of water if Wildnil (Carfentanil citrate) comes in contact with skin or mucous membranes.
6. PRACTICE GOOD MEDICAL TECHNIQUES. Do not become careless. Do not hold used needles in mouth. Always insure that darts and syringes contain proper dose.
7. *ALL REASONABLE EFFORTS SHOULD BE MADE TO LOCATE AND RETRIEVE* any loaded darts that missed the target animal.
8. RESPECT all dart guns, darts and power delivery syringes as though they were cocked and loaded.

INFORMATION FOR PHYSICIANS:
Wildnil (Carfentanil citrate) is a powerful synthetic opiate. Accidental human exposure may produce severe central nervous system depression resulting in respiratory depression or failure followed by coma. Depending on route of administration, effects may be noted in 2 to 30 minutes. Treatment should start immediately by administering appropriate opiate antagonist, providing airway support, plus cardiopulmonary resuscitation techniques.

Wildnil
Carfentanil Citrate
Sterile Injection

CII

DOSAGE AND ADMINISTRATION:

a. RECOMMENDED DOSE RANGE FOR CERVIDAE:

SPECIES	DOSE (MG/KG)
Moose (Alces americana)	.006 - .014
Elk (Cervus elaphus)	.005 - .020
Axis Deer (Axis axis)	.005 - .010
Sitka Deer (Odocoileus hemionus sitkensis)	.005 - .011

For members of the family Cervidae, a dose range of .005 - .020 mg/kg has been found to be safe and effective. Immobilization is usually achieved 2 to 10 minutes following administration. The lower end of the dose range is suggested for those animals of quiet temperament, under confinement, that have not been pursued prior to administration of the drug, or in poor physical condition. The upper dose range is suggested for animals of excitable temperament following extensive pursuit or in instances where an extremely short time to effect is desirable.

Some exotic species of deer (Elds, Pampas, Muntjac, and Indian hog deer) may require a higher dose for immobilization. The highest dose required for immobilization in clinical trials was 0.064 mg/kg in Muntjac deer.

The most effective dose rate will vary due to conditions of use. The upper end of the dose range may also be appropriate for animals being pursued by vehicle or aircraft when an extremely quick knockdown time is desired or when individuals are known to be highly excitable. In all instances, all factors including nutritional, reproductive and health status of an animal as well as environmental conditions (temperature, cover and terrain) must be evaluated by the user and best professional judgement used.

b. ADMINISTRATION:
Inject required dose deep into a large muscle mass of the neck, shoulder, back or hindquarter. Intrathoracic, intra-abdominal or subcutaneous injection is to be avoided. To ensure proper dosage for animals weighing less than 50 kg, remove required calculated dose of Wildnil (Carfentanil citrate) with a tuberculin syringe. Dilute to appropriate volume with sterile water for injection prior to administration.

c. ANTIDOTE:
Diprenorphine is antidotal and rapidly reverses the effect of Wildnil (Carfentanil citrate). Administer 7mg of Diprenorphine for each milligram of Wildnil (Carfentanil citrate). The calculated dose of antagonist may be administered intravenously or one half intravenously and one half intramuscularly or subcutaneously. Intramuscular or subcutaneous administration will delay absorption of the antagonist and may reduce tendency for renarcotization. Reversal of effects of Wildnil (Carfentanil citrate) are usually observed in 2 to 10 minutes.

STORAGE:
Store at controlled room temperature (59-86°F) in a facility consistent with appropriate Drug Enforcement Agency regulations regarding schedule II class drugs. Protect from prolonged exposure to excessive heat.

HOW SUPPLIED:
Wildnil (Carfentanil citrate) is supplied in a 10 mL multiple use vial. Each milliliter contains 3 milligrams of Carfentanil citrate.

Developed and Manufactured by:
Janssen Pharmaceutica Beerse, Belgium for:
Wildlife Laboratories, Inc. 1401 Duff Drive #600, Fort Collins, Colorado 80524

OLYMPIC NATIONAL PARK

Protocol for Treatment of Accidental Human Exposure to Carfentanil

Carfentanil is a synthetic opiate with an estimated clinical potency 10,000 times that of morphine. Carfentanil is used to affect chemical immobilization in the capture of mountain goats and other wildlife species within the park. Highly toxic to humans, Carfentanil requires careful handling and secure storage. This protocol details the procedures for treatment of accidental human exposure to Carfentanil.

INDICATIONS:

1. Accidental exposure to Carfentanil through-

   -- Spilled chemical on broken skin
   -- Ingestion
   -- Direct injection
   -- Ocular exposure
   -- Mucous membrane exposure

2. For other, less threatening exposure; ie. chemical spilled on unbroken skin-

   -- Flush affected area liberally with water.
   -- Contact medical control and monitor patient.
   -- Administer Naloxone if necessary.

SIGNS AND SYMPTOMS OF CARFENTANIL POISONING:

-- Lethargy
-- Sedation
-- Slurred speech
-- Weakness
-- Nausea/vomiting
-- Difficulty in breathing
-- Disorientation
-- Constricted pupils
-- Muscle rigidity

TREATMENT AND CARE:

1. Determine/estimate amount of Carfentanil absorbed.

2. If absorption is from surface contact, wash area with large quantities water.

3. Should accidental injection take place in a limb, a tourniquet may be applied proximal to the injection site to delay distribution of the drug. If this treatment is used, the tourniquet must be released in less than one hour.

4. Place patient on flat surface in supine position, preferably on sid

3. Maintain patency of airway; provide respiratory support with bag valve mask if needed.

4. Monitor/record respiration and pulse rate.

5. Assess pupil reactivity to light.

ANTIDOTE:

Administer Noloxone (Narcan) which is supplied in .4mg/ml x 1ml pre-filled syringes; or 1mg/ml x 10ml bottles.

Initial Dose - 2mg IM in deltoid muscle (side of upper arm) using 22ga. x 1 or 1-1/2" needle.

Repeat Doseage - 2-5mg every 2-4 minutes as needed for above symptoms. Repeat doseages may be given in deltoid or IV.

FURTHER CARE:

1. Establish contact with medical control, expedite transport.

2. Establish IV of Lactated Ringers, if available.

3. Administer supplemental oxygen, if available.

4. Watch for vomiting; turn patient to side to avoid aspiration of vomitus.

5. Assist ventilation using bag valve mask, if available.

6. Initiate CPR if no pulse is detected.

SIDE EFFECTS OF NOLOXONE:

Essentially none.

CONTRAINDICATIONS FOR USE OF NOLOXONE:

-- Loss of consciousness not thought to be due to Carfentanil posisoning.

NOTE: IF IN ANY DOUBT ABOUT CAUSE OF IMPAIRED CONSCIOUSNESS ADMINISTER NOLOXONE - IT WILL NOT HURT PATIENT.

In the rare case of <u>no</u> effect with Noloxone give Diprenorphine (M50-50) IM or IV at a doseage of 7mg for each 1mg of Carfentanil injected or absorbed.

Richard Gibson, M.D.
Park Medical Sponsor

Howard Yanish
EMS Coordinator

Appendix 2.3

Appendix 2.3

Proposed 1989 Goat Capture Project Strategy

Logic used in determining Strategic Priorities:

Boundary Units

The seven goat management units which abut the park boundary were excluded from this analysis. If management intends for capture to take place in these populations in 1989, a priority will have to be established.

Population Trend

Populations known or suspected to be increasing were rated higher than populations which are stable. Stable populations were rated higher than those which are declining.

Vegetation Priority

Three broad zones were designated based on the presence of sensitive or endemic plant species or the susceptibility of vegetation to goat effects. Priority 1 areas were rated the highest; Priority 3 areas lowest.

Strategic Priority

All non-boundary units assigned Priority 1 for vegetation were compared to population trends to determine ranking. This process continued for Priority 2 vegetation areas, and so on. The ranking hierarchy is as follows:

1. Vegetation Priority 1/Population Trend Increasing
2. " /Population Trend Stable
3. " /Population Trend Decreasing
4. Vegetation Priority 2/Population Trend Increasing
5. " /Population Trend Stable
6. " /Population Trend Decreasing
7. Vegetation Priority 3/Population Trend Increasing
8. " /Population Trend Stable
9. " /Population Trend Decreasing

Though there are 9 possible categories, uncertainties regarding population trends within some management units resulted in only 7 total Strategic Priorities identified.

All units with identical Strategic Priorities were listed together in alphabetical order.

Management Unit	Boundary Unit	Population Trend	Vegetation Priority	Strategic Priority
1. Anderson		0	3	7
2. Appleton		-	2	5
3. Barnes		0	2	4
4. Blue	X	-	1	N/A
5. Carrie		0	2	4
6. Constance	X	+	1	N/A
7. Chimney		+	3	6
8. Claywood		0	1	1
9. Dana		-	2	5
10. Divide		0	3	7
11. Ferry		0/+	2	3
12. Hughes	X	-	2	N/A
13. Klahhane		-	1	2
14. Lacrosse		0	3	7
15. MacCartney		0	1	1
16. Mystery	X	0	1	N/A
17. Olympus		+	3	6
18. Royal	X	0/-	1	N/A
19. Sawtooth	X	0/+	3	N/A
20. Steel		0	3	7
21. Stone	X	0	3	N/A

Population Trend:

+ = Estimated Increasing - = Est. Decreasing 0 = Est. Stable

Vegetation Priority:

1 = Highest occurrence of endemic, rare, sensitive plants 2 = Moderate occurrence
3 = Occurrence low or unknown

1989 Capture Project

Strategic Priorities

Priority 1 Areas

Claywood
MacCartney

Priority 2 Areas

Klahhane

Priority 3 Areas

Ferry

Priority 4 Areas

Barnes
Carrie

Priority 5 Areas

Appleton
Dana

Priority 6 Areas

Chimney
Olympus

Priority 7 Areas

Anderson
Divide
Lacrosse
Steel

Boundary Areas Excluded

Blue
Constance
Hughes
Mystery
Royal
Sawtooth
Stone

Appendix 2.4

Appendix 2.4

United States Department of the Interior
OFFICE OF THE SECRETARY
OFFICE OF AIRCRAFT SERVICES
3905 VISTA AVENUE
P.O. BOX 15428
BOISE, IDAHO 83715-9998

113A-2

In reply refer to:

OAS OPERATIONAL PROCEDURES MEMORANDUM (OPM) NO. 90-5

SUBJECT: HELICOPTER TOE-IN, SINGLE-SKID AND STEP-OUT LANDINGS

Effective Date: January 1, 1990

Supersedes: None - Initial Release.

Distribution: A, B, and C

Expiration Date: December 31, 1990

.1 Purpose. This OPM establishes policy and operational guidelines for the use of helicopter toe-in, single-skid, and step-out landings. This OPM applies to all helicopters -- DOI fleet, other Government agencies, contractor, and military.

.2 Authority. This policy is established by the Director, Office of Aircraft Services (OAS) in accordance with the provision of Departmental Manual 350 DM 1.A(2).

.3 Definitions.

A. Toe-In Landings. Toe-in landings are those landings that are used to drop off or pick up passengers or cargo by resting the helicopter on the toes of the skids. This requires holding a significant amount of hover power (within 15% of hover power) to keep the helicopter from falling backwards. When the helicopter is operated in this manner, there is the potential of significant lateral and longitudinal CG shift during loading/offloading operations. When the helicopter is balanced on the forward 1/3 or less of the skid tube, main rotor blade clearance is another significant concern (1/2 of flat surface/flat pitch blade clearance). These landings are normally used where landing areas are on slopes which exceed the capability of the helicopter. Identification criteria for toe-in landings are:

(1) Inability to reduce below hover power by 15%
(2) Forward 1/3 or less of skid tube in contact with surface
(3) 1/2 or less of flat pitch/flat surface blade clearance exists

B. Single-Skid Landings. Single-skid landings are those landings that are used to drop off or pick up passengers or cargo while holding the helicopter with one full skid on the ground and the other suspended in the air. When in contact with the ground, the center of gravity can shift laterally. This type of landing is normally used in sloping terrain or when the helicopter cannot land and reduce the power to flat pitch.

C. Step-out Landings. Step-out landings are those landings that are used to drop off or pick up passengers and cargo (other than rappel/short haul) while holding the helicopter in a hover. The helicopter is not in contact with the ground and the center of gravity can shift laterally and longitudinally. This type of landing is normally used in lieu of toe-in/single-skid landings in terrain where the helicopter cannot land and reduce power to flat pitch.

D. Hover Landings. Hover landings are landings which do not meet the definition of toe-in, one-skid, or step-out landings. These landings are characterized by the necessity to maintain a substantial amount of hover power while the landing gear is in contact with the surface. This is normally due to the nature of the surfaces such as swampy ground, tundra/muskeg, snow, lava rock, etc. During these landings, the potential CG shifts are not as hazardous as in the previously mentioned landings (i.e., toe-in, one-skid); however, the pilot remains alert and on the controls as opposed to a flat surface/flat pitch landing stability.

.4 Policy. Due to the hazardous nature of these types of landings; toe-in, single-skid, and step-out landings are prohibited. Hover landings are not prohibited.

.5 Exceptions. If a bureau determines the need to perform this type of landing to accomplish a program, a request for an exception shall be submitted to the Director, OAS. Requests for exception will be submitted from the bureau State, Regional or Area office directorate. This request will include a risk assessment and the concurrence of the bureau directorate accepting operational responsibility for this hazardous operation. Once the exception has been granted, the pilot will be approved by OAS for this type landing only for the specific project requested. Bureau personnel involved on the project will be trained by OAS in established procedures to minimize center of gravity and power change requirements with the approved pilot.

Robert L. Peterson

Director

Appendix 2.5

Appendix 2.5

Staging Area Procedures 1989

TASKS AND PRIORITIES IN ANIMAL HANDLING AND MEDICAL PROTOCOL

Names listed under tasks are assigned roles. Some tasks are not assigned to specific individuals, but will be directed by Doug, Bruce, or Cat. Medical protocol/data gathering will be performed on one animal at a time (to be determined by Doug and/or Bruce). The other animal(s) will be properly positioned, left in the flight bag(s), and monitored by one individual (or more as needed for restraint). Data gathered on each animal is a critical part of ensuring comprehensive treatment and enabling followup on the animals; Bruce will have primary responsibility for maintaining complete data sheets and coordinating followup procedures with State personnel.

At the beginning of each day, before first animal(s) arrive:

1. Explain and coordinate animal treatment roles with State personnel.
   Cat (Doug).
   Explain and coordinate followup procedures and data sheets with State.
   Bruce.

2. Have transport crates iced and ready in place at staging area.
   State personnel

3. Preload standard injections.
   Cat/Kate

When animal(s) arrive:

1. Control/elevate animal's head and position animal sternally.

2. Perform gross assessment of (each) animal, ensure regular respiration, and maintain an open airway.

3. Remove ropes, bag, and, for drugged animals only, disconnect front from rear hobbles, while providing the necessary amount of restraint.

4. Overview; assess animal. Doug (Bruce)
   Check limbs and wounds
   Sex
   Lactating?

5. Medical and data protocol.

Bruce	Doug	Cat/Kate
Data	Wounds	Antibiotics
Temperature	Age/teeth	Eye ointment
	Girth	

Doug/Bruce/Cat (whoever is free): Assist State personnel with ear tag, radio collar. Take blood & nasal swab if necessary.

6. Crate animal.

a) Bruce:
Check capture record forms to ensure all tasks have been completed.

b) Doug (Cat):
Direct crating operation.

Two people at head of animal (one to operate door, one to control head, remove front hobbles, hornguards, and blindfold, and direct forequarters into crate).
Three or more people at rear of animal (one to operate door, two or more to remove rear hobbles and direct hindquarters into crate).

c) Cat/Kate:
Administer antagonist if this has not been done at an earlier stage.

Repeat medical and data protocol for other animal(s), then move crate(s) into trailer.

Check crated animals at half hour to 1 hour intervals thereafter for condition, evidence of stress, etc.

Appendix 2.6

Appendix 2.6

CAPT# ____ GOAT CAPTURE RECORD CRATE# ____

OLYMPIC NATIONAL PARK

DATE ___/___/___ CAPT. TIME ________ RECORDER ______________

CAPT. LOCATION ______________________ LAT/LONG ________/________

EARTAG NPS#: ______________ Old New State#: ______________

Color Collar Radio ______________________________

SEX M F AGE #Horn Rings ___ #Yrs ___

Incisors 1. ___/___ 2. ___/___ 3. ___/___ 4. ___/___ (P or M)

Lactating? Y N Girth ________ cm Est. Wt. ________ kg lbs

CAPTURE METHOD Drug Netgun Manual

Carfentanil 0.9 cc/IM No. Doses ___ Induction: Partial Complete

M50-50 1. 9.5 cc/IM Time Adm ____ Time Recovery ____ ET ____

______ 2. ______ IM ____ ____ ____

PHYS. CONDITION A-OK B-Minor Injuries C-Serious Injs. D-Died

Rectal Temp. (F°/Time) T1 ___/___ T2 ___/___ T3 ___/___ T4 ___/___

Respir. (Breathes-Min/Time) ___/___ ___/___ Pulse (Rate-Min/Time) ___/___

Injuries Capt./Old ______________________________

Obs. Stress/Bloat ______________________________

MEDICAL PROTOCOL

1. Standard

<u>Penicillin</u> (IM): 15cc-AM 10-AF 5-Ylg <u>Mu-Se</u> (IM): 2cc-AM 1.5-AF 1-Ylg

<u>Clostridial</u> (SbQ): 2.5cc-Goat <u>Ivermectin</u> (SbQ): 3cc-AM 2-AF 1-Ylg

<u>Minor Wounds Treated</u>: Betadine Hetacin <u>Eye Ointment</u>: Gentocin

2. Extended

<u>Valium</u> (IM/IV) 3cc-AM 2-AF 1-Ylg <u>Dopram</u> (IV) 2.5cc-Adult

Other: ______________________________

3. Emergency

<u>Ringers lactate</u> (IV) 1-2 liters-goat <u>Solu-Delta-Cortef</u> (IV) 2 vials-AM 1-AF

<u>Sodium bicarb</u> (IP) 1cc-lb. body wt <u>Euthanasia T-61</u> (IV) 30cc-goat

RELEASE

Date/Time ___/___ State ____ Contact/Phone ______________

Rel. Location ______________________________

Followup Info. Date ______ #Obs ___ Phys. Condition: OK D ? ______

COMMENTS 6/89 BM