Type B Accident Investigation Report of the April 23, 1997, Helicopter Accident at Raton Pass

May 1997

Western Area Power Administration
U.S. Department of Energy

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This report is an independent product of the Type B Accident Investigation Board appointed by Michael S. Cowan, Chief Program Officer, Western Area Power Administration.

The Board was appointed to perform an investigation of this accident and to prepare a report in accordance with DOE Order 225.1, *Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in this report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

On April 24, I established a Type B Accident Investigation Board to investigate the April 23, 1997, helicopter accident at Raton Pass. The Board's responsibilities have been completed with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1, *Accident Investigations*.

I accept the findings of the Board and authorize the release of this report for general distribution.

Michael S. Cowan

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Michael S. Cowan

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EXHIBITS, FIGURES, AND TABLES

ACRONYMS

AGL	Above Ground Level
AIP	Aviation Implementation Plan
CFR	Code of Federal Regulations
CSO	Corporate Services Office
DOE	U.S. Department of Energy
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FOSM	Flight Operations Standards Manual
FOTM	Flight Operations Training Manual
FSS	Flight Service Station
I-25	Interstate 25
LTE	Loss of Tail Rotor Effectiveness
MSL	Mean Sea Level
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
RPM	Revolutions Per Minute
VFR	Visual Flight Rules

EXECUTIVE SUMMARY

INTRODUCTION

On April 23, 1997, a helicopter belonging to the Western Area Power Administration (Western) crashed near the summit of Raton Pass in southern Colorado. On April 24, 1997, Michael S. Cowan, Western's Chief Program Officer, appointed a Type B Accident Investigation Board to investigate the accident in accordance with DOE Order 225.1, *Accident Investigations*. The Board began its investigation on April 28, 1997, completed the investigation on May 21, 1997, and submitted its findings to the appointing official on May 27, 1997.

ACCIDENT DESCRIPTION

The accident occurred at approximately 4:10 p.m. on Wednesday, April 23, about one-half mile north of the Colorado-New Mexico border along Interstate Highway 25 (I-25). At the time of the accident, the helicopter was enroute from Farmington, New Mexico, to Fort Collins, Colorado. The weather in the Pass was 500-foot overcast with periods of rain and fog throughout the day. As the aircraft approached the Pass, its airspeed was approximately 80 knots. Just after the aircraft crested the ridgeline that runs through the Pass, the Pilot encountered a cloud bank that was approximately one mile ahead. Upon seeing the cloud, the Pilot executed an immediate hard right climbing turn. During the turn, airspeed slowed to 20-30 knots. Suddenly, the aircraft entered an uncommanded right yaw (horizontal rotation) that was caused by loss of tail rotor effectiveness. As the aircraft spun out of control, it descended and crashed approximately one-quarter mile west of I-25. The aircraft impacted the side of a hill, became airborne while continuing a right turn, hit the ground facing north, and rolled on its right side where it came to rest. There was no post-crash fire; however, the aircraft was destroyed. The Pilot shut down the aircraft and exited through the passenger door, which was above him. After exiting the aircraft, he made three telephone calls, including a 911 call. He then proceeded down the hill to I-25, where he was picked up by a person who had heard the 911 call on a scanner and transported the Pilot to a hospital. The Pilot was treated for bruises and minor cuts and released from the hospital at 8 p.m.

ROOT AND CONTRIBUTING CAUSES

The Board determined the root or fundamental cause of the accident to be the Pilot's lack of experience and training for the terrain and weather he encountered at the time of the accident.

In addition, four contributing causes[1] were identified:

- Lessons learned from previous aviation accidents involving unqualified, inexperienced, and/or inadequately trained pilots were not sufficiently implemented.

[1]Factors that significantly increased the likelihood of the accident without directly causing it.

- Oversight of the aviation program was not applied with sufficient discipline, focus, and consistency.

- Roles, responsibilities, and authorities of aviation program officials were not clearly defined and understood.

- Management has not fostered an atmosphere that demands a high level of accountability in the aviation program.

CONCLUSIONS

There is a need to provide greater discipline and direction to a program that appears uncertain about itself. Aviation program policies were established but not implemented. Western had developed operations and training manuals that reflect the rigorous standards required for an aviation program operating in a high-risk environment. These manuals described a high-quality program. However, the policies contained in the manuals were inconsistently applied. For example, basic pilot qualifications were not enforced when the Aviation Safety Officer was given additional duties as a backup pilot.

Aviation program roles, responsibilities, and authorities were not clearly understood. Reviews of aviation manuals and other documents, along with statements from Western's pilots, revealed a lack of consistency in delineating the roles and duties of aviation officials. It was unclear what was expected of such key officials as the Chief Pilot and the Aviation Safety Officer. Some statements to the Board indicated that the position of Chief Pilot exists in name only; that Western's program operates without a true Chief Pilot. Moreover, the role of the Aviation Safety Officer was unclear. He is charged with duties about which he has limited awareness, including duties associated with oversight and review.

Oversight within the aviation program was not consistently applied. It appears that a great deal of internal oversight was accomplished by self-monitoring. Two pilots, including the one involved in the accident, were allowed to fall out of currency. The Chief Pilot did not ensure that the Aviation Safety Officer received an annual Western proficiency flight check. Furthermore, the Aviation Safety Officer did not conduct a comprehensive audit program. He appeared to be unfamiliar with established aviation policies. Consequently, he was unable to ascertain if existing policies and procedures were effective. Additionally, the Aviation Manager believed himself to be occupied with too many non-aviation responsibilities, and thus unable to perform effective supervision and oversight of the program he is charged with directing.

The Pilot lacked the qualifications and currency required to act as an unsupervised pilot-in-command. The Pilot was hired as the Aviation Safety Officer. The position did not require him to fly. However, before and after being hired he was asked to fly power line patrol and perform other pilot duties, despite the fact that he did not meet Western's pilot qualifications. Furthermore, at the time of the accident the Pilot had not met currency requirements to have flown 100 hours in the last 12 months and had not received a proficiency flight check within the preceding 12 month period, as required. The Board determined that requisite experience and training would likely have prevented the helicopter accident. To prevent a recurrence of

similar accidents, significant deficiencies in aviation management must be corrected and judgments of need from previous accidents must be implemented.

Type B Accident Investigation Report of the April 23, 1997, Helicopter Accident at Raton Pass

1.0 INTRODUCTION

1.1 BACKGROUND

On April 23, 1997, at approximately 4:10 p.m., Western Area Power Administration (Western) helicopter N618DE, a Bell 206L-1 LongRanger piloted by Western's Aviation Safety Officer, crashed near the summit of Raton Pass, about one-half mile north of the Colorado-New Mexico border. The Pilot received minor injuries and was not hospitalized. The helicopter was destroyed.

On April 24, 1997, Michael S. Cowan, Western's Chief Program Officer, appointed a Type B Accident Investigation Board to investigate the accident in accordance with DOE Order 225.1, *Accident Investigations* (Appendix A).

Western, an agency of the U.S. Department of Energy (DOE), markets Federal hydropower and operates and maintains approximately 17,000 miles of power transmission lines, 260 substations, and various related facilities in 15 central and western states. Western's Corporate Services Office (CSO) is in Golden, Colorado. Local programs are administered through five strategically located offices in Western's territory.

1.2 ACCIDENT SITE DESCRIPTION

The aircraft crashed at Wootton Ranch on a small mesa in the mountainous and wooded area of Raton Pass. The accident site was at approximately 7,500 feet mean sea level (MSL). Raton Pass is a major geographic landform separating the plains area towns of Raton, New Mexico, and Trinidad, Colorado. The mountain peaks extend to approximately 8,000 feet MSL at the summit of the Pass. Interstate Highway 25 (I-25) crosses through the pass north and south between New Mexico and Colorado.

1.3 SCOPE, CONDUCT, AND METHODOLOGY

The Board commenced its investigation on April 28, 1997. The Board completed its investigation on May 21 and submitted its findings to the Chief Program Officer on May 27. The purpose of the investigation was to determine the causes of the accident, including deficiencies, if any, in aviation safety management systems, and to help Western promote safety and reduce the potential for similar accidents.

The Board conducted its investigation using the following methodology:

- Facts relevant to the accident were gathered through an accident site visit, interviews, and through document and evidence reviews.

- Events and causal factors charting[1] and barrier analysis[2] were used to provide supportive correlation and identification of the accident's causes.

- Based on analysis of the data, judgments of need for corrective actions to prevent recurrence were developed.

2.0 FACTS AND ANALYSIS

2.1 ACCIDENT DESCRIPTION AND CHRONOLOGY

2.1.1 Background and Accident Description

At the time of the accident, the Pilot was enroute from Farmington, New Mexico, to Fort Collins, Colorado, following completion of a power line patrol mission in northwest New Mexico and northern Arizona. He was the sole occupant of the aircraft.

Other than the pilot's statement of the events leading up to and during the accident, no direct account of the accident was available. The Board has reconstructed the most probable sequence of events from the Pilot's statement, physical evidence at the crash site, and witness statements.

At approximately 1 p.m. on April 23, the Pilot departed the Farmington, New Mexico, airport enroute to Fort Collins, Colorado, under a visual flight rules (VFR) flight plan. The planned route was from Farmington, by way of Santa Fe, to Las Vegas, New Mexico, for landing and to refuel. The next leg of the flight was planned to Pueblo, Colorado, over Raton Pass, for landing and to refuel. The last leg of the flight was planned from Pueblo to the Fort Collins Downtown Airport, where the flight was scheduled to terminate.

Shortly after 12 p.m., the Pilot received a weather briefing in Farmington from an Albuquerque Flight Service Station (FSS) briefer. The briefer indicated that the weather would be good VFR all across the route with some virga (precipitation not contacting the ground) between Santa Fe and Las Vegas. The briefer twice indicated the only area of concern was around Raton Pass. The Pilot recorded (handwritten notes) forecast and terminal area weather information applicable to the flight. The Pilot also received a notice to airmen (NOTAM) from the briefer regarding a demonstration flight near the Pueblo airport.

[1] Charting depicts the logical sequence of events and conditions (causal factors) that allowed the events to occur.

[2] Barrier analysis reviews hazards, the targets (people or objects) of the hazards and the controls or barriers that management control systems put in place. Barriers may be administrative, physical, or supervisory/managerial.

The first leg of the flight ended at approximately 3:10 p.m. at the Las Vegas airport. The Pilot closed the flight plan for that leg of the flight. He requested refueling from airport line service, which he supervised.

At approximately 3:30 p.m., the Pilot departed the Las Vegas airport for the flight to Pueblo. He activated this leg of the flight plan shortly after takeoff and followed I-25. His route of flight was north over Raton Pass.

Approximately four miles north of the town of Raton, the Pilot crossed a ridge line at the top of the Pass, where he "encountered" a cloud bank approximately one mile directly ahead along the route of flight. The Pilot stated he never entered the cloud. At that point, over the middle of the highway, he elected to make a hard right climbing turn to avoid the cloud and rising terrain that was to his right. According to the Pilot, the indicated airspeed before executing the turn was 80 knots, which he told the Board was too fast for the conditions. He said that airspeed decreased to 20-30 knots while in the turn. The Pilot said that, while in the turn, he "lost directional control," and the aircraft began to spin (rotate horizontally) to the right. At this time the aircraft was approximately 300 feet above ground level (AGL).

The aircraft crashed approximately one-quarter mile west of the initial flight path. The aircraft impacted the side of a hill, became airborne while continuing a right turn, hit the ground facing north, and rolled on its right side where it came to rest. The Pilot indicated the aircraft was still rotating at the time of initial impact (Exhibits 2.1, 2.2, 2.3, 2.4). There was no post-impact fire.

The Pilot initially tried to open the pilot's side door, then realized that the door was against the ground. Realizing the engine was still running, he grabbed the collective with both hands and shut down the engine. He stated that initially he could not find the overhead console to shut off electrical power to the aircraft, but then found it. He was not sure whether he shut off the fuel valve switch. When the Board reached the accident site, the fuel valve and battery switches were found in the "off" position.

The emergency locator transmitter (ELT) did not activate during the crash. Subsequent bench tests verified that it was functional. The ELT cabling and antenna were not damaged in the crash.

Weather Factors

Weather conditions at the time of the crash were obtained from witness statements and a Colorado Department of Transportation weather recording station near the bottom of the pass. Witnesses indicated the weather between 4 p.m. and 5 p.m. was, at times, thick fog with precipitation (drizzle). When fog was not present, the ceiling was estimated to be 500 feet AGL. The temperature was about 35 degrees Fahrenheit.

The observed weather at the time of the accident was consistent with information the Pilot had obtained from the Albuquerque FSS briefer prior to the first leg of the flight. When

Exhibit 2.1
Accident site. Note aft portion of the tail boom,
with tail rotor in foreground.

Exhibit 2.2
Ground scar from main rotor blade impact. Depth
(8 inches) indicates engine was running at the time of impact.

Exhibit 2.3
Scored tail rotor drive shaft. Drive shaft
was powered during impact.

Exhibit 2.4
Tail rotor drive shaft. Twisting indicates
drive shaft was powered at time of impact.

referring to the Pilot's intended route of flight, the briefer told the Pilot that the weather around Raton Pass "may be your most limiting factor there."

Prevailing winds were from the south (tailwind to the aircraft's heading). The Pilot approached the ridge line along the road at approximately 300 feet AGL. The cloud that the Pilot encountered was obscured by the ridgeline prior to his crossing the summit. The Board determined that the weather at Raton Pass during the period preceding the accident was a factor in the accident.

2.1.2 Chronology of Events

See Figure 2.1 for a summary of the chronology of significant events.

2.1.3 Emergency Response and Investigative Readiness

After shutting down the engine, the Pilot exited the passenger door, which was above him. He then walked around the airframe to assess damage to the aircraft. He retrieved a cellular telephone from the aircraft, which he used to call Western's Aviation Manager and report the accident. He also dialed 911 and reached the Las Animas County Sheriff's Department to report the accident. The Sheriff's Department transferred him to the Colorado State Patrol (Trinidad office), and he reported the accident to both law enforcement agencies.

The Pilot removed the rear passenger door from the aircraft and retrieved a bag containing additional cellular telephone batteries and another bag containing personal items. He went to the nose of the aircraft, reached through a hole in the plexiglass, and retrieved two books containing microwave grid coordinates and credit cards.

The Pilot walked away from the crash site, proceeding downhill. He climbed a six-foot-high barbed wire fence, crossed railroad tracks, climbed a dirt road, crossed another barbed wire fence, and climbed a hill to the highway.

When he reached the highway, the Pilot was assisted by a Security Employee for Santa Fe Trail Ranches. The Security Employee was at a service station, where he overheard the 911 call on a police scanner. He proceeded south on I-25 and parked opposite the crash site. The Security Employee assisted the Pilot and took him to the Mount San Rafael Hospital emergency room in Trinidad. The Pilot was examined and treated for a leg injury, which required sutures. He also requested blood and urinalysis samples (results were negative) for the accident report. He was released from the emergency room at approximately 8 p.m.

The Board also interviewed a Las Animas County Sheriff's Deputy who responded to a dispatch call at approximately 4:45 p.m. and immediately went to the crash site, where he saw the Security Employee pick up the Pilot. The Deputy retrieved the aircraft maintenance log, a flight helmet, and a headset from the wreckage. He returned these

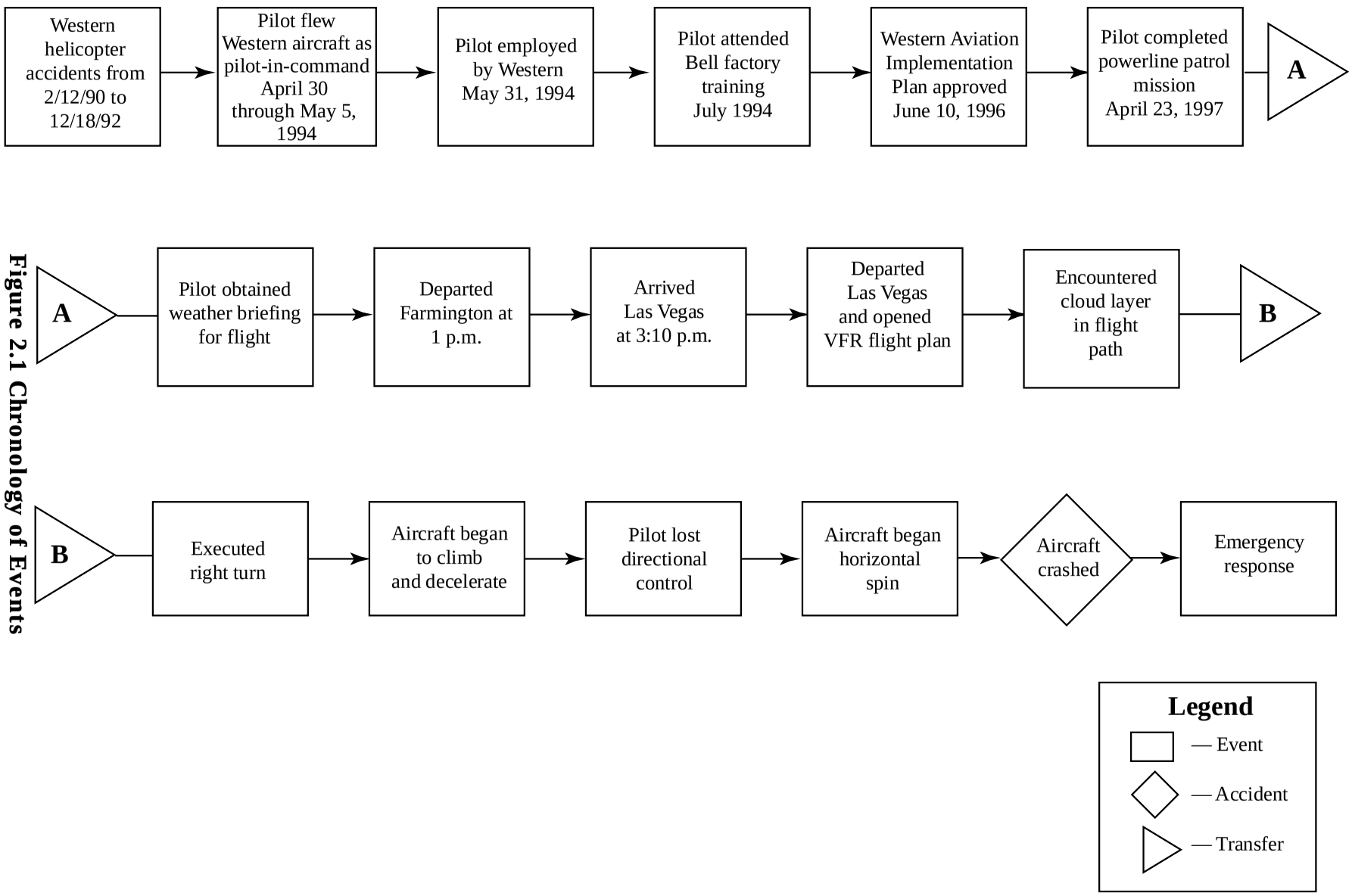


Figure 2.1 Chronology of Events

items to the Pilot at the hospital. While at the wreckage site he smelled fuel, but did not see anything leaking.

The site was located in a remote area generally inaccessible to the public and was not secured prior to the Board's arrival. However, the resident owner of the property "kept an eye" on the wreckage.

2.2 HAZARDS, CONTROLS, AND MANAGEMENT SYSTEMS

2.2.1 Aviation Safety

The following facts relate to aviation safety issues that may have had an impact on the accident:

Loss of Tail Rotor Effectiveness

Based upon the Pilot's description of the accident and onsite examination of the wreckage, the Board examined loss of tail rotor effectiveness (LTE) as a possible contributing factor in the accident. LTE is a flight characteristic that occurs under certain conditions in various models of helicopters, including the Bell 206 series, which can result in a rapid uncommanded right yaw (horizontal rotation) and loss of control of the aircraft. LTE may occur in certain relative wind conditions at slow airspeeds. A detailed discussion of LTE can be found in Appendix B.

In response to questions from the Board relating to LTE, the Pilot stated, "I had insufficient control with my tail rotor." The Pilot indicated there was nothing mechanically wrong with the helicopter.

Aircraft Maintenance

The Board reviewed aircraft maintenance records for N618DE. The review included examining overhaul, alteration, inspection, and other maintenance records. There were no discrepancies found during the review. The Board found that Western's maintenance and inspection program is well-established and meets or exceeds Federal Aviation Administration (FAA) and manufacturer requirements.

Summary

The Board concluded that, at the time of the accident, the aircraft experienced LTE, which resulted in the Pilot losing control of the aircraft. The Board based its conclusion on the Pilot's interview with the Board, discussions with the National Transportation Safety Board (NTSB), examination of the wreckage at the accident site, discussions with a representative of Bell Helicopter, Inc., wind conditions at the time of the accident, and published literature documenting factors related to LTE.

Previous Western Aircraft Accidents

Western experienced four aircraft accidents over a 34-month period between February 1990 and December 1992. Three involved rotary-wing aircraft and one involved a fixed-wing aircraft. Each accident report contained conclusions that also apply to this accident, indicating they have not been adequately addressed.

Findings from previous accidents include:

- The pilot had not received initial flight training as required by Western.
- There was no formal aerial-patrol training identified by Western for new pilots.
- Training programs had not been developed for crew members prior to the accident.
- The pilot did not obtain the FAA weather briefing.
- The weather forecast from available sources indicated gusty winds.
- The Montrose District's Flight Operations Manual did not include current policies and procedures.
- Western did not have a policy for pilots to follow when evaluating weather conditions.
- Western did not have a policy to orient new pilots on transmission line patrol procedures.
- The pilot flew several missions prior to receipt of required initial flight training.
- Western did not have a policy to train observers in aircraft safety and transmission line patrol.
- Colorado Helicopters reduced its baseline requirements for pilot qualifications to hire the pilot.
- The pilot had minimal, if any, prior experience in class C external load, and no experience in this type of construction.
- The pilot was not reviewed, observed, or trained in safe flying techniques for Class C loads.
- DOE/EH should verify that all departmental elements ensure that aviation operations are in compliance with the applicable Federal Aviation Requirements (FARs).
- Ensure that all crew members meet minimum qualifications for pilot-in-command.

- Qualified aviation staff should conduct facility inspections and provide field oversight of operations to ensure compliance and conformity with DOE and FAA requirements.

- Vest the authority and responsibility for aviation operations in someone knowledgeable in aviation reporting directly to the Assistant Administrator, who is responsible for aviation.

2.2.2 Pilot's Qualifications, Experience, and Currency

Pilot's Experience Prior to Joining Western

The Pilot was an experienced Naval aviator with a background in pilot standardization, squadron operations, and maintenance management. He served 18 years in the military, with service in the United States Navy and Marine Corps.

The Pilot was experienced in rotary- and fixed-wing aircraft and had accumulated approximately 3,400 hours of flight time (2,700 hours in helicopters and 700 hours in airplanes) before being hired by Western. He had flown numerous low level and combat training missions and stated that about 400 hours were flown in mountainous terrain, mostly in the Desert Southwest.

After leaving military service in 1988, he was employed as a civilian program analyst at the Naval Air Systems Command. He was recalled to active duty in January 1990 and flew fixed-wing aircraft in support of fleet logistic support missions.

Pilot's Flying Experience With Western

The Pilot was hired May 31, 1994, as an Aviation Safety Officer. His job responsibilities were amended October 2, 1994, to include duties as a backup pilot. The Pilot flew as pilot-in-command prior to and shortly after joining Western. Up to the time of the accident he accumulated approximately 172 hours of flight time. This included power line patrol, transporting passengers, ferrying aircraft, maintenance flights, and training flights with other Western pilots. According to the Pilot's statement, he flew between 40 and 50 hours as pilot-in-command in mountainous terrain with Western. The Pilot had never flown power line patrol prior to joining Western.

Pilot Qualification and Currency

Western's Flight Operations Standards Manual (FOSM) qualifications for helicopter pilot-in-command include: 3,000 hours in helicopters; 1,000 hours in make and model; and 1,000 hours mountain flying experience, where applicable. At the time of the accident the Pilot had approximately 2,850 hours in helicopters and 400 hours flying in the mountains. The Pilot indicated to the Board that he did not meet Western's qualifications when he came to Western.

Western's FOSM qualification requirements to act as pilot-in-command require 100 hours as pilot-in-command in category during the previous 12 months. This is commonly referred to as a currency requirement. The Pilot had flown approximately 72 hours in helicopters during the 12 months prior to starting the mission on April 22.

Pilot's Position Responsibilities

The Aviation Safety Officer is responsible for developing and managing Western's aviation safety program and aligning it with appropriate DOE, Western, and FAA policies. Current responsibilities include serving as backup helicopter pilot, maintaining credentials and currency to fly rotary-wing aircraft, and remaining current with fixed-wing aircraft operations as they relate to Western's mission and needs. In addition, he is the principal aviation management official responsible for internal program oversight.

Summary

The Pilot's qualifications met Western's requirements for the position of Aviation Safety Officer. However, his job description was changed in October 1994 to include the duties of backup pilot. Although the Pilot accumulated more than 2,700 hours of helicopter flight time before joining Western, he had not flown helicopters for six years. His experience level and currency did not meet Western's pilot-in-command requirements. The Pilot's mountain experience was primarily obtained in the United States Desert Southwest. The weather conditions in this environment normally differ significantly from those experienced in the Colorado mountains. The Board believes the Pilot lacked sufficient experience flying in the combination of terrain and weather conditions normally encountered in the Colorado mountains.

2.2.3 Mission Procedures

Prior to the accident, the Pilot was asked to serve as a backup pilot for the Montrose office. The mission was flying power line patrol out of Farmington, New Mexico. Before beginning the mission, the Montrose pilot flew several hours in the mountains observing the backup pilot's procedures. The two pilots also spent time on the ground covering aspects of the mission and discussing various safety and flight planning procedures applicable to the mission.

On the morning of April 22, the Pilot met with his assigned power line patrol observer at the Montrose airport at 7:30 a.m. before flying to Shiprock to begin power line patrol. The Pilot and observer performed power line patrol duties from Shiprock to Page, Arizona. The weather was good, and the Pilot and observer did not encounter any unusual circumstances. They completed the first day of line patrol and returned to the Farmington airport at approximately 5 p.m. The Pilot had dinner and went to bed at 9:30 p.m. He reported not having any alcohol that evening.

The following morning, April 23, the Pilot watched The Weather Channel prior to leaving his hotel room for the Farmington airport. The Pilot and observer proceeded to a point near Shiprock Substation where they intended to begin line patrol. In accordance with Western's aviation procedures, the Pilot notified the Montrose Dispatch Center that they were beginning power line patrol. Dispatch reported being able to hear the Pilot, but the Pilot was not receiving dispatch. At that point, the Pilot landed. After establishing communication with Montrose dispatch, the Pilot and observer proceeded on power line patrol.

The power line patrol was completed at a point about five to six miles north of the Farmington airport. The Pilot and observer returned to the airport before noon. The Pilot completed post-flight inspection of the aircraft, debriefed the observer, and refueled the aircraft. Without eating lunch, he began preparations for the flight to Fort Collins, Colorado.

At approximately 12:10 p.m., the Pilot called the Albuquerque FSS for a weather briefing and to file a VFR flight plan. A portion of the weather briefing dealt with possible adverse conditions in the area of Raton Pass. The FAA provided the Board with a cassette tape containing the Pilot's discussion with the Albuquerque FSS. The following is a portion of the dialogue between the briefer and the Pilot:

Briefer: "I'd say right now with what's out there I'd say the hardest place for you might be in the vicinity of Raton Pass with the low clouds in the eastern plains. You know, it depends on how soon it breaks up . . . . If it breaks up more by the time you get there you may not have any trouble at all. I was going to say that might be your most limiting factor there."

Pilot: "OK."

Briefer: "Looks like good VFR all across the route. Like I say the worst of it's that low ceilings right around Vegas heading north out of there through the Pass. That might be the most limiting factor and you may have to dodge around a few rain showers out there if you want to but, heck, they're saying that Cheyenne by 09Z tonight which is about 3 in the morning, light snow 500 overcast so."

Pilot: "Yeah, so I got to do this today. Because that front's going to come in 'til Saturday."

The weather briefer indicated that winds would be generally out of the south along the Pilot's flight leg from Las Vegas to Raton Pass, indicating a tailwind for the route of flight. The first leg of the flight from Farmington to Las Vegas, New Mexico, was uneventful, and the Pilot landed at the Las Vegas airport at approximately 3:10 p.m. He supervised refueling of the aircraft and departed the Las Vegas Airport at approximately 3:30 p.m. Shortly after departing, he contacted Albuquerque FSS to activate the flight plan. In the course of the conversation, the flight specialist asked the Pilot if he wanted more advisories. The Pilot declined.

Summary

The Pilot completed the power line patrol mission in accordance with Western's aviation procedures. Each segment of the mission was planned, beginning with the flight from Montrose on April 22. The observer who flew with the Pilot indicated that there was nothing unusual about the power line patrol. It is significant that the Pilot did not obtain an updated weather advisory when activating the flight plan out of Las Vegas, despite being previously advised that Raton Pass may be a limiting factor.

2.2.4 Policies and Procedures

Aviation Documents

Western's Aviation Implementation Plan (AIP) and the FOSM establish the basic flight policies and operating procedures required to conduct Western's flight operations. The manual is currently being revised, its first revision since 1993.

On November 5, 1993, Western issued its FOSM. It states: "The rules, regulations, and procedures in this manual establish the basic flight policies and operating practices required to conduct flight operations in accordance with the Federal Aviation Regulations (FAR) as they apply to operations conducted by Western Area Power Administration (Western) under Title 14 Code of Federal Regulations (CFR) Parts 135 and 91."

For safety and program structure, the intent of the FOSM is to organize Western's program in accordance with 14 CFR 135. Significant elements of the CFR requirements are: Management Personnel, Flight Operations, Flight Crewmember Requirements, Crewmember Flight Time and Duty Period Limitations and Rest Requirements, Crewmember Testing Requirements, Crewmember Training, and Maintenance.

The Flight Operations Training Manual (FOTM) establishes standards and requirements for a training program for crew members, check airmen, flight instructors, and other applicable operations personnel employed by Western.

Each pilot's Aviation Training Record contains information pertaining to certification and ratings, medical certificates, aeronautical experience, duties and responsibilities, flight/duty time, check rides/evaluations, and training.

Hiring Procedures

The Pilot was hired May 31, 1994, as an Aviation Safety Officer in response to aviation audits and a judgment of need from a previous Western aircraft accident. The hiring procedures were according to standard Federal personnel practices, including development of a vacancy announcement for the position, background checks of applicants, and interviews of the final candidates. There was no mention of piloting responsibilities in the vacancy announcement or in the Pilot's initial position description.

Prior to beginning employment with Western, the Pilot was asked to fly with the Aviation Manager on several occasions as an orientation to Western aircraft and power line patrol operations. The pilot also flew on power line patrol as pilot-in-command. The Aviation Manager sat in the back seat of the helicopter, with no access to flight controls in the event a problem occurred. An observer occupied the left front seat. The Pilot stated that he believed these orientation flights to be a test of his capabilities.

On October 21, 1994, the Pilot's job description was revised to include backup piloting duties. The FOSM does not contain any reference to backup pilots. Backup pilot duties were defined as essentially all the duties of Western line pilots, including line patrol, ferrying aircraft and passengers, maintenance flight tests, and other assigned duties.

The Aviation Manager stated that he hired the Pilot as an Aviation Safety Officer and not as a pilot. However, because the Aviation Safety Officer had significant experience in rotary-wing aircraft operations in the military, the Aviation Manager requested an amendment to his job description to include backup pilot duties. The Aviation Manager and Chief Pilot believed the Pilot could achieve proficiency by flying with other Western pilots and would be "brought along slowly." On the other hand, the Aviation Manager stated to the Board that he would not hire a line pilot with the Aviation Safety Officer's experience and flight hours because of the hazardous nature of Western's missions.

Oversight

According to his position description, the Aviation Safety Officer was responsible for internal oversight of Western's aviation program. Specifically, he was charged with providing Western with aviation oversight by conducting internal safety evaluations, continuously monitoring existing aviation field activities, and ensuring that safety standards were uniformly applied and accepted. The Aviation Safety Officer stated that he conducted oversight of power line patrol procedures through in-flight observation. In addition, he stated that he reviewed flight and duty time records to ensure that pilots were not exceeding maximum limits, and also provided oversight of the passenger/comment feedback system.

Documents, records, and interviews clearly indicate that oversight of significant elements of the aviation program was inadequate. Examples of insufficient oversight include:

- Prior to the accident, the Pilot was not aware of Western's qualification requirements for pilot-in-command. Western requires that new hires receive training on the FOSM, which includes information on pilot qualifications. There is no record of the Pilot receiving formal training on the FOSM or its contents since coming to Western.

- The Pilot stated that since coming to Western he had not received formal weather training. The FOTM requires that new hires receive "Basic Indoctrination Training," which includes formal classroom training in meteorology.

- The FOSM and FOTM have not been revised since they were issued in 1993, despite changes in the operations and training programs.

- Forms contained in the FOTM are not being used to record training. In addition, a form developed by the Chief Pilot for use in recording annual proficiency flight checks is not included in the manual.

- Western has instituted policies and procedures within the aviation program without formally establishing them in the FOSM. For example, the Pilot did not meet currency requirements of 100 flight hours within the previous 12 months. However, aviation management considered him current because he flew with a Western pilot prior to conducting the April mission. This informal currency procedure is not a part of Western's program in the FOSM.

- Eleven of 12 aviation navigation charts found in the wreckage were out of date. Two of the out-of-date charts applicable to the flight, the Albuquerque and Denver sectionals, were found in an open position, which indicated they were in use at the time of the accident.

Summary

Western's aviation program manuals were not revised to reflect changes in the aviation program as they occurred. This indicates laxity in implementing the aviation program. The Board also questions the Aviation Manager's decision to modify the Pilot's position description to include backup pilot duties. Based on the Pilot's experience, the stringent qualifications and flight hours required of line pilots, and the significant risk to life and property, this was a serious error in judgment. The distinction between pilot and backup pilot was artificial. The Board found several issues that pointed to informality in management oversight of the aviation program. There appeared to be a lack of awareness of Western's pilot-in-command requirements; a disregard for currency requirements; lack of aviation management oversight to ensure pilots were qualified; and lack of formal, structured, and consistent training.

2.2.5 Human Factors and Training

Pilot's Behavior

The Pilot's attitude with regard to safety, especially weather conditions, was described by several co-workers as ultra-conservative. The Aviation Manager told the Board he believed the Pilot would never allow himself to fly in the conditions he encountered at Raton Pass.

One pilot told the Board, "He will fly miles around a thunderstorm or any weather that he's encountered, and I know for a fact because I get the feedback from the line patrol or the microwave technicians that he's flown with . . . " Another pilot said, "He's a pretty methodical guy, and if he is going to err, he's certainly going to err on the side of extreme caution, and he's demonstrated that to me on a couple of occasions . . . "

The Pilot's conservative approach to flying has been criticized. On one occasion, his flight preparation was so methodical that several passengers refused to wait for him and canceled the flight. On another occasion, he made a precautionary landing when a fuel

boost pump warning light came on; he was criticized for refusing to fly to a nearby airport. According to the FAA-approved flight manual, the aircraft could be flown if one of its two fuel boost pumps was inoperative. The Aviation Manager also told the Board that the Pilot's conservative attitude was criticized.

The aircraft was due in Fort Collins the evening of April 23 for a 50-hour maintenance check. Another pilot had flown to Fort Collins and was waiting to ferry the aircraft to Huron, South Dakota. There was evidence of deteriorating weather in the Fort Collins area. If the Pilot had not reached Fort Collins that evening, it is likely he would not have been able to get there for several days. The Board believes these factors influenced the Pilot's decision to complete the trip on April 23.

Western's Training Requirements

Flight operations training for Western's pilots includes initial new hire training, initial equipment training, transition training, upgrade training, recurrent training, and requalification training. Initial training includes a segment on "Duties and Responsibilities," which covers sections of Western's FOSM. It also covers "Flight Control," which includes, among other topics, weather and NOTAM information. An additional section entitled "Aircraft Performance" covers the effects of temperature, pressure altitude, and density altitude, as well as general performance criteria. Meteorology is one of the eight significant topics covered.

Category Requirements

The following are specific category requirements:

- All new hires must complete initial new hire training.

- All pilots must complete recurrent training for the position and aircraft type "for which they are currently assigned" within the eligibility period.

- Pilots who have become unqualified because they have not received recurrent training and/or an annual proficiency flight check must complete requalification training.

- Pilots who are reassigned to a different duty position and/or aircraft type must complete either initial equipment, transition, upgrade, or requalification training, depending upon the aircraft type and duty position for which they were previously qualified.

Pilot's Training

The FOTM clearly specifies that a pilot-in-command must satisfactorily complete a proficiency flight check once every 12 calendar months in at least one of the aircraft types in which the pilot-in-command is to serve. The only Western flight proficiency check the Pilot received was on October 13, 1995.

Entries in the remarks section of the Pilot's log book indicate that he received mountain operations training on two occasions. He flew March 19, 1996, with the Montrose helicopter pilot for 3.9 hours, and again on March 25, 1996, with the Chief Pilot for 3.6 hours. He also flew in various mountainous areas of Colorado before his power line patrol assignment in New Mexico.

The Aviation Training Record indicated the Pilot received training at the Bell Helicopter factory and from a contract pilot. Training at Bell Helicopter included ground and flight procedures in the Bell 206L in July 1994, August 1995, and October 1996. The contract pilot provided training on Western's Bell 412.

The Pilot said he had not received formal weather training from Western, which indicated, along with the lack of documentation in his training record, that he had also not received the initial new-hire training. The Pilot successfully completed a written test on June 6, 1995, covering FAR Parts 61 and 91, the Bell 206 flight manual, and FAR Part 133, external loads.

Summary

There is no evidence that the Pilot received initial new-hire training as outlined in the FOTM. This training includes formal structured classroom instruction in several subjects, such as Western's policies and procedures, aviation manuals, and meteorology. The Board believes aviation management should ensure that all pilots receive initial and recurrent training as prescribed in Western's program.

2.2.6 Management Systems

DOE Order 440.2

This Order establishes the framework for an effective aviation program to reduce or eliminate accidental losses and injuries in Departmental and contractor aviation operations. The Order requires development of an AIP that defines key elements of an aviation program.

Western Notice N 440.1

This Notice communicates that an AIP for Western was developed as required by DOE Order 440.2. The Notice states that aviation policy, responsibilities, and procedures are now contained in the AIP instead of a Western directive.

Western's Aviation Program Responsibilities

The AIP includes aviation program responsibilities for the Administrator, Chief Program Officer, Regional Managers, Aviation Manager, Aviation Safety Officer, Chief Pilot, Aviation Maintenance Manager, Pilot-in-Command, and Aerial Observers. It also incorporates Western's aviation procedure manuals. The AIP was approved June 10, 1996, by the DOE Office of Field Support, subject to Western providing DOE with copies of its procedure

manuals and any revisions as they occur. Updated manuals have not been provided to DOE. They are currently being revised.

Aviation Program Assessment

Recently, two assessments of Western's aviation program were conducted. The first assessment was conducted at the request of the Aviation Manager. This assessment was termed a "self-assessment" because it was conducted at Western's request and the results of the audit were for Western's internal use and not subject to external review. This assessment was conducted March 17-21, 1997.

The second assessment was conducted by the DOE's Office of Oversight (EH-21) and was an external assessment. The external assessment was part of an overall review of DOE's aviation program. The external assessment was conducted at the beginning of April 1997.

While the self-assessment identified strengths in Western's aviation program, including a streamlined management structure and a strong maintenance program, significant program deficiencies were identified. These included management performance, program policies and procedures, internal oversight, and training.

The external assessment outbriefing for senior management noted opportunities for improvement. However, Western management stated that the external team determined the program was safe, effective, and professional. The outbriefing from the external review led management to believe Western's program was doing well, and there were no major problems.

These two assessments provided Western with results and conclusions that differed significantly. They sent Western's management a mixed message regarding the health of Western's aviation program.

2.3 BARRIER ANALYSIS

A barrier is defined as anything that is used to control, prevent, or impede a process and is intended to protect a person or object from hazards. The barrier analysis conducted by the Board addressed pilot, administrative, and management barriers. These barriers either failed or were missing. Successful performance of any of these barriers would have prevented, or mitigated the severity of, the accident. The barriers that failed are summarized in Table 2.1.

Table 2.1 Performance of Barriers

Barrier	Purpose	Performance
Roles, Responsibilities, and Authorities.	To ensure that personnel understand their roles, responsibilities, and authorities within the aviation program.	Barrier failed because the roles, responsibilities, and authorities were not clearly understood. There was unclear direction and delineation of functions.
Leadership and Policy Implementation	To ensure policies, procedures, and requirements are implemented and enforced by management.	Barrier failed because management selectively implemented requirements of Western's aviation program.
Training	To ensure pilots are competent to perform their jobs safely.	Barrier failed because management did not implement some requirements of Western's aviation training program.
Oversight	To ensure aircraft operations are accomplished in accordance with applicable procedures and requirements.	Barrier failed because internal oversight was not consistent throughout the program.
Lessons Learned	To provide information from previous aircraft accidents to ensure hazardous situations are identified and avoided.	Barrier failed because key lessons from previous accidents were not implemented.
Experience	To utilize expertise to perform tasks safely and efficiently.	Barrier failed because the Pilot lacked sufficient experience with the conditions at the time of the accident.
Accountability	To establish and maintain program credibility and ensure completion of mission tasks.	Barrier failed because integral elements of the aviation program were not implemented and personnel were not held accountable.

2.4 CAUSAL FACTORS

The root cause of the accident was the Pilot's lack of experience and training for the conditions he encountered.

There were also contributing causes (causes that increased the likelihood of the accident without individually causing the accident, but that are important enough to be recognized as needing corrective action). The causal factors are identified in Table 2.2, with a discussion of each cause.

Table 2.2 Causal Factors Analysis

Root Cause	Discussion
Pilot Inexperience	The Pilot's experience and training did not prepare him for the combination of terrain and weather conditions he encountered. The Pilot had limited experience flying in mountainous terrain, primarily in the Desert Southwest. Moreover, weather conditions normally experienced in the Desert Southwest differ significantly from conditions in the Colorado mountains. The Pilot's role in Western's aviation program was defined loosely as a "backup pilot" who would be brought along slowly. The Board believes this was an artificial distinction which contributed to the accident. Western must be more vigilant about assigning pilots to tasks commensurate with their qualifications, experience, and training.
Contributing Causes	**Discussion**
Lessons Learned Were Not Implemented	Western's aviation accidents have involved unqualified, inexperienced, and/or inadequately trained pilots. Prior accident investigation reports have recommended that hiring and training be carried out in ways that ensure aviation activities are accomplished safely and according to established policy. The Aviation Safety Officer was assigned pilot responsibilities after being hired by Western, although he was not qualified for these duties. Western must enforce its own rigorous qualification requirements. Additionally, there must be commitment to a strong, ongoing training program that includes initial and recurrent formal classroom training in Western's manuals and other program documents.

Contributing Causes	Discussion
Inadequate Oversight	Oversight of the aviation program was not consistently applied. The Board believes aviation officials were ambivalent about complying with their oversight responsibilities. Certain statements to the Board emphasized the importance of oversight and compliance; other statements suggested oversight was not very important and that oversight responsibilities were not clearly defined or designated. The Board believes the Aviation Manager must implement a thorough oversight function that is clearly understood. This function must include in-depth assessments and reviews by internal and external entities.
Roles, Responsibilities, and Authorities Were Not Clear	The Aviation Implementation Plan, Flight Operations Standards Manual, pilot position descriptions, and pilots' statements to the Board did not consistently delineate aviation program roles and responsibilities. There was uncertainty about the role of the Chief Pilot, including his responsibilities for training. The role the Aviation Safety Officer played in oversight of the aviation program was unclear. The Board learned that the Aviation Safety Officer was unaware of certain program requirements. He could not perform an oversight function without a thorough understanding of all policies, procedures, and requirements of the aviation program. The Aviation Manager must ensure that roles and responsibilities are clearly defined and accomplished.
Lack of Accountability	Western aviation personnel have not been held sufficiently accountable for performing roles and responsibilities as defined in program policies and procedures. The Board believes there must be accountability in all aspects of the aviation program. It is essential that appropriate action be taken when policies are not followed. Otherwise, program requirements and procedures seem hollow and will not receive serious attention. If responsible officials adhered to Western's policies, pilots who lack necessary qualifications, experience, or currency would not fly for Western.

3.0 CONCLUSIONS AND JUDGMENTS OF NEED

Conclusions are a synopsis of facts and analytical results that the Board considers especially significant. Judgments of need are managerial controls and safety measures believed necessary to prevent or mitigate the probability of recurrence. They flow from the conclusions and causal factors and are directed at guiding managers in developing follow-up actions.

Table 3.1 summarizes the conclusions of the Board and judgments of need regarding managerial controls and safety measures necessary to prevent or mitigate the probability of a recurrence.

Table 3.1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
Upon activating the flight plan from Las Vegas, New Mexico, to Pueblo, Colorado, the Pilot did not obtain an updated weather briefing when queried by a weather briefer.	Pilots need to update available information when weather conditions are potentially adverse.
The Pilot felt pressured to deliver the aircraft to a maintenance facility in Fort Collins on the day of the accident, which may have affected his decision making.	Western needs to reemphasize safety over the importance of accomplishing a mission.
The Pilot's response to unexpected weather conditions resulted in loss of tail rotor effectiveness and control of the helicopter, from which the Pilot was unable to recover.	Western needs to ensure that appropriate, formal, documented initial and recurrent training is provided. This would be in addition to aircraft procedures training.
The Pilot did not meet Western's qualifications or currency requirements to act as unsupervised pilot-in-command.	Management needs to ensure that pilots meet Western's rigorous qualification and currency requirements.
Western's aviation program manuals have not been revised to reflect changes in the aviation program.	Western needs to revise aviation program manuals to reflect changes as they occur.
Aviation management responsibilities were not clearly and consistently delineated.	The Aviation Manager needs to review and clarify for consistency all documents that specify duties and responsibilities, and ensure that all aviation personnel clearly understand their roles.
Internal oversight of the aviation program was inadequate.	The Aviation Safety Officer needs to exercise effective oversight of Western's entire aviation program.

4.0 BOARD SIGNATURES

Date: 5-24-97

David Bennion
Accident Investigation Board Chairperson
Western Area Power Administration
Salt Lake City, Utah

Date: 5/24/97

James R. Belleau
Accident Investigation Board Member
Western Area Power Administration
Loveland, Colorado

Date: 5-24-97

Len Dzamba
Accident Investigation Board Member
DOE Office of Field Support, EH-53
Germantown, Maryland

Date: May 24, 1997

Liova D. Juárez
Legal Advisor
Western Area Power Administration
Golden, Colorado

5.0 BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson	David Bennion, Western, CRSP
Member	James R. Belleau, Western, RMR
Member	Len Dzamba, DOE EH-53
Member/Legal Advisor	Liova D. Juárez, Western, CSO
Advisor	David Burch, Bell Helicopter, Inc.
Analytical Support	Jeffrey S. Oakley, Battelle Oak Ridge
Technical Writer	Gerry Himes, Source One Management, Inc., Western CSO
Technical Writer	Judy Farrell, Source One Management, Inc., Western CSO

APPENDIX A
Appointment of Type B Accident Investigation Board

WAPA F 1400.5?0
(7-91)

United States Government **Department of Energ**

memorandum

Western Area Power Administratio

DATE: APR 2 4 1997

REPLY TO ATTN OF: A3000

SUBJECT: Accident Review Board--Aviation Accident, April 23, 1997

TO: B. Barber, Office of Field Support, EH-53
J. Keselburg, J0000, Loveland, CO
D. Sabo, L0000, Salt Lake City, UT

This memorandum establishes an Accident Investigation Board to investigate the subject. The following Western employees will serve as Chairperson and members until the review is closed.

David Bennion - Administrative Officer
Salt Lake City, Utah; Chairman

Jim Belleau - Safety and Occupational Health Specialist
Loveland, Colorado; Trained Investigator

Len Dzamba - Safety Inspector
Office of Field Support, EH-53

Liova Juarez - Legal Advisor; Golden, Colorado

The scope of the board's investigation will include, but is not limited to identifying all relevant facts, analyzing those facts to determine the direct, contributing and root causes of the accident, developing conclusions, and determining the judgments of need that, when implemented, should prevent the recurrence of the accident. The investigation will specifically address the role of management systems as they may have contributed to the accident and the application of lessons learned from similar accidents within Western.

The team members may charge their time and expenses to work order number: N/F ACF AIRCA IM824.

The report shall be forwarded by memorandum which states the Board's recommendations, to me within 30 calendar days of this correspondence.

Please keep the Office of Safety and Security advised of your progress and solicit their assistance or the technical assistance of any others that you may need.

Michael S. Cowan
Chief Program Officer

cc:
J. M. Shafer, A0000
M. Hacskaylo, A0200
L. Juarez, A0201
J. Bladow, A0500
T. Dembrowski, A3700
J. Biggs, A3800
J. Belleau, J0710, Loveland, CO
D. Bennion, L0100, Salt Lake City, UT
L. Dzamba, Office of Field Support, EH-53

APPENDIX B
Loss of Tail Rotor Effectiveness

APPENDIX B

Loss of Tail Rotor Effectiveness

Helicopter Directional Control

Understanding loss of tail rotor effectiveness (LTE) requires some discussion of helicopter directional control. In single-main-rotor helicopters, torque from the aircraft's main rotor/transmission system attempts to turn the airframe in the opposite direction of main-rotor rotation. The main rotor of the Bell 206L-1 rotates in a counter-clockwise direction. Therefore, torque attempts to rotate the airframe in a clockwise direction. The Bell 206L-1 employs a tail rotor to produce thrust to counteract the rotation of the airframe and provide directional control of the helicopter at low airspeeds.

In addition to torque, helicopters are affected by wind. The natural tendency is for the aircraft to turn into the wind (weathervane). As airspeed increases, air passing around the aircraft fuselage and the vertical stabilizers assists the tail rotor in providing aircraft directional control. This continues until, at airspeeds above approximately 30 knots, the airflow around the aircraft provides the majority of the aircraft's directional control, thereby reducing the need for thrust produced by the tail rotor.

The amount of thrust required from the tail rotor is a function of several factors, including torque (related to power output), airspeed, and wind direction. Tail-rotor thrust is controlled by the pilot through foot pedals commonly referred to as anti-torque pedals. As the pilot pushes the left pedal, the aircraft nose will yaw to the left. Right-pedal input will yaw the nose to the right.

Rotor RPM Droop

Helicopter main rotor revolutions per minute (RPM) is expressed as a percentage of allowable RPM. Normal operating RPM for the Bell 206L-1 is 97-100 percent. The "collective" control in the cockpit controls main rotor blade pitch. As main rotor blade pitch changes, the power required to maintain main rotor RPM changes, and is controlled through a governor. If the pilot pulls up on the collective, main rotor blade pitch increases, drag on the rotor system increases, and therefore the power required to maintain main rotor RPM increases. If a pilot increases collective rapidly, the governor may not be able to keep up with the power required to maintain rotor RPM. This may result in a momentary decrease in rotor RPM, commonly referred to as "RPM droop."

LTE Testing

U.S. Army flight and wind tunnel testing concluded that " 'unanticipated right yaw' is the occurrence of an uncommanded right yaw rate, which does not subside of its own accord and which, if not corrected, can result in the loss of aircraft control." The Army noted that the term "loss of tail rotor effectiveness" was somewhat misleading, as the tail rotors of two aircraft tested exhibited the capability to produce some thrust during all flight regimes.

The test identified four characteristics during low-speed flight as contributing factors to unanticipated (uncommanded) right yaw:

- Weathercock stability (relative wind 120 to 240 degrees)
- Tail rotor vortex ring state (relative wind 210 to 333 degrees)
- Main rotor disc vortex interference (relative wind 285 to 315 degrees)
- Loss of translational lift (all azimuths)

Winds within the weathercock stability region (Figure B-1) will attempt to weathervane the nose of the aircraft into the relative wind. The aircraft will make an uncommanded turn either right or left, depending on the exact wind direction, until an appropriate yaw-control pedal input is made. If the relative winds are in the 120 to 240 degree area, the yaw rate will accelerate.

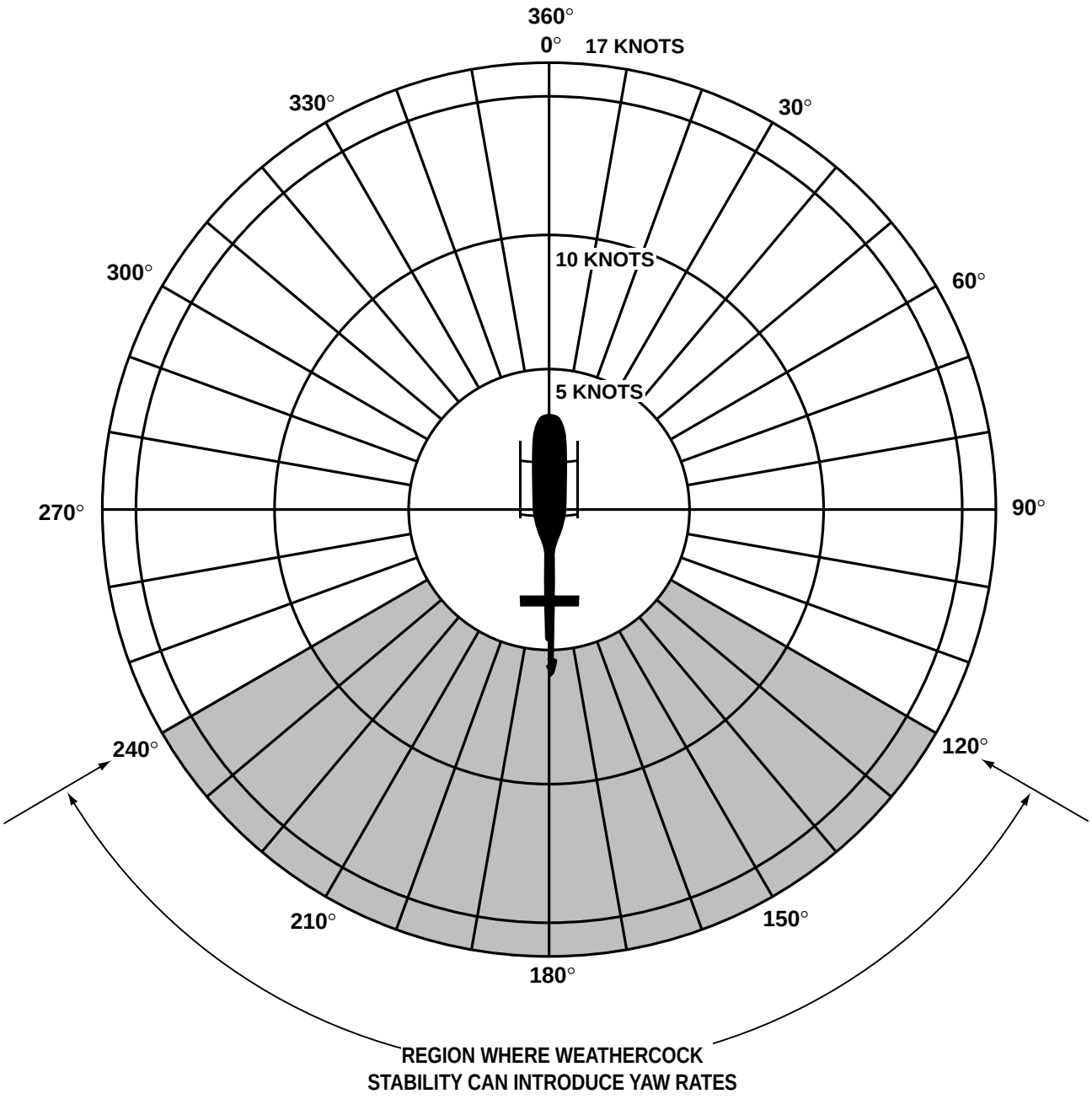
An aircraft encountering winds within the tail rotor vortex ring state (Figure B-2) will encounter tail rotor thrust variations, which result in yaw rates. The pilot must make corrective pedal inputs as the changes in yaw acceleration are recognized. If a right yaw rate is allowed to build, the aircraft can rotate into the wind azimuth region where weathercock stability will then accelerate the right turn.

Winds within the main rotor disc vortex region (Figure B-3) can cause the main rotor vortex to be directed onto the tail rotor. This can change the tail rotor angle of attack, increasing it initially as it comes into the area of the main rotor disc vortex and decreasing it as the main rotor vortex passes the tail rotor. The reduction in angle of attack causes a reduction in thrust and a right yaw acceleration. The aircraft will exhibit a tendency to make a sudden, uncommanded right yaw. If this goes uncorrected, it will develop into a high right-turn rate.

With loss of translational lift, power and anti-torque requirements increase. If the aircraft is in a right turn when translational lift occurs, the right turn will be accelerated as power is increased, unless corrective action is taken by the pilot. When operating at or near maximum power, this increased power demand could result in the loss of rotor RPM. This characteristic is most significant when operating at or near maximum power and is associated with unanticipated right yaw.

The Army's report states that, if a helicopter begins a right yaw in one of the above mentioned characteristics, the yaw rate may increase until appropriate corrective action is taken.

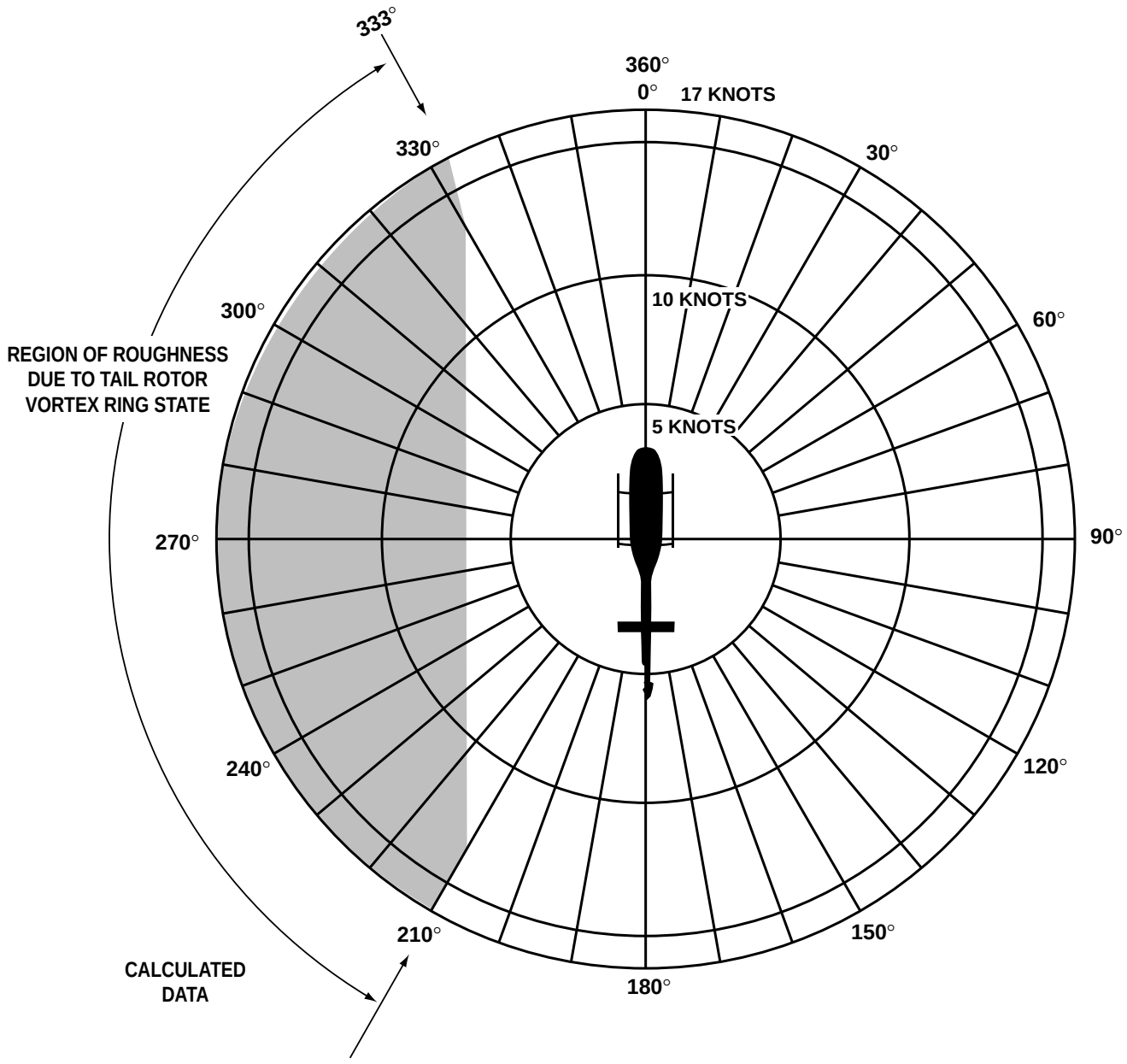
Based on the Army's findings and its report on unanticipated right yaw, Bell Helicopter, TEXTRON, of Fort Worth, Texas, issued Information Letter 206-84-41, entitled, "Low Speed Flight Characteristics Which can Result in Unanticipated Right Yaw." The Information Letter, dated July 6, 1984, is applicable to the Bell model 206L-1, operated by Western and involved in the accident. The Information Letter summarized the Army's findings and



From *Rotorbreeze,* July-August 1994

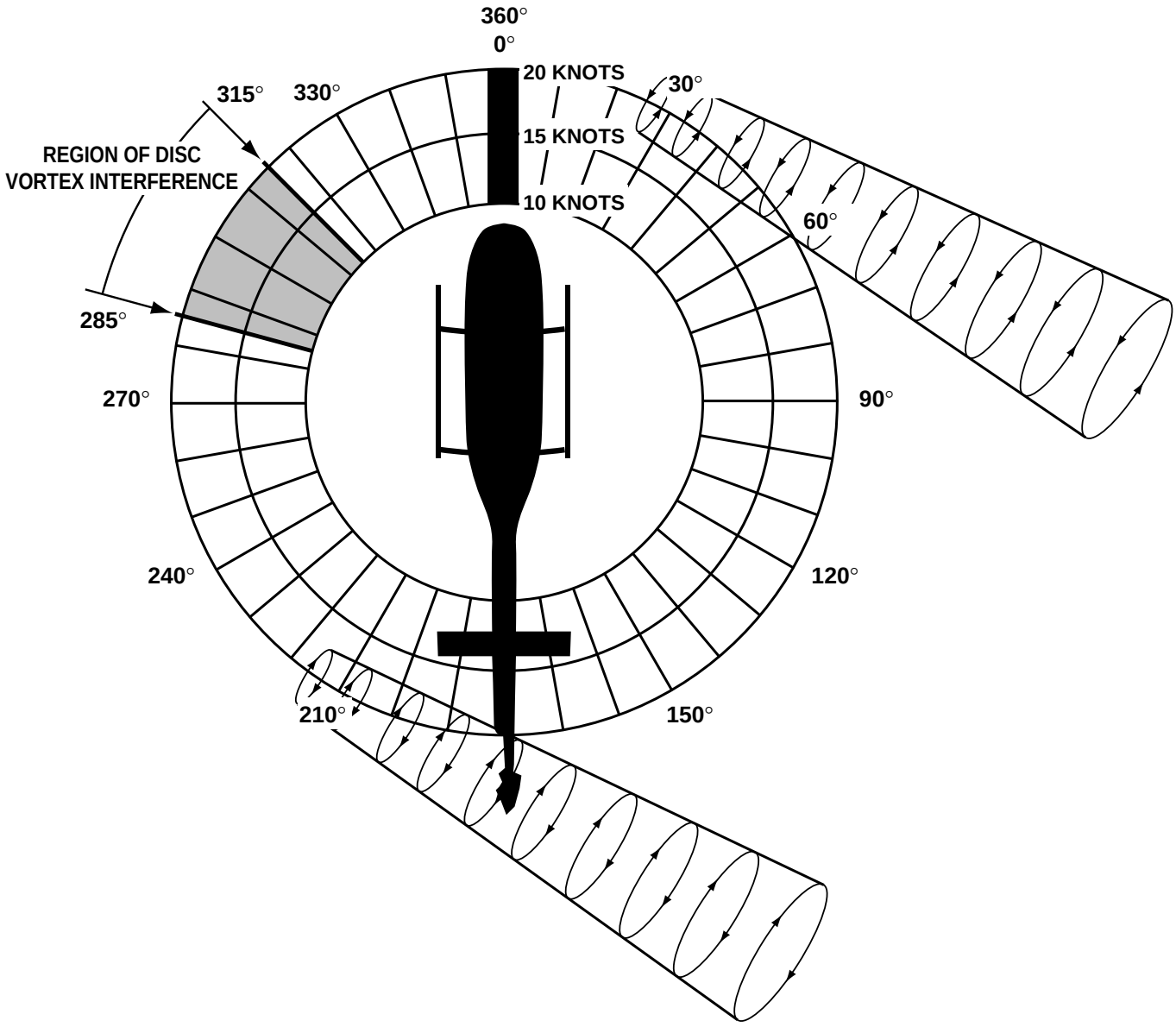
Figure B-1

Weathercock Stability



From *Rotorbreeze*, July-August 1994

Figure B-2
Tail Rotor Vortex Ring State



From *Rotorbreeze,* July-August 1994

Figure B-3

Main Rotor Disc Vortex Interference

proposed recovery techniques, which include a reduction of power and forward cyclic input.

Previous to issuance of the July 6, 1984, Information Letter, Bell Helicopter on October 31, 1983, issued an Operations Safety Notice for 206L series helicopter operations. The Safety Notice stated that recent flight testing revealed a remote possibility of unanticipated right yaw under certain conditions not related to a mechanical malfunction. The purpose of the Safety Notice was to:

- Emphasize the importance of staying aware of power and wind conditions.

- Provide a wind azimuth chart to show regimes where relative wind may affect the helicopter.

- Recommend a technique for recovery from an unanticipated right yaw.

The Federal Aviation Administration, U.S. Department of Transportation, issued an advisory circular, AC 90-95 on December 26, 1995, that examines unanticipated right-yaw phenomenon. The FAA stated that unanticipated right yaw, or loss of tail rotor effectiveness, has been determined to be a contributory factor in a number of accidents of various models of U.S. military helicopters. In addition, the National Transportation Safety Board has identified LTE as a contributing factor in several civil helicopter accidents wherein the pilot lost control.

The agency stated that, in most cases, inappropriate or late corrective action may have resulted in the development of uncontrollable yaw.

Mishaps related to uncontrollable right yaw have occurred in low-altitude, low-airspeed military missions and in civilian flight regimes involving power line patrol, traffic observation, medical rescue, and other similar operations.

FAA testing found that LTE is not a maintenance malfunction and may occur in varying degrees in all single-main-rotor helicopters at airspeeds of less than 30 knots. It can occur during any maneuver that requires the pilot to operate in a high power, low-airspeed environment with a left crosswind or tail wind. The agency also found that there is greater susceptibility to LTE in right turns, which is especially true during flight at low speeds since the pilot may not be able to stop rotation. The yaw is usually correctable if additional left pedal is applied immediately. If the response is incorrect or slow, the yaw rate may rapidly increase to a point where recovery may not be possible, depending on altitude above the ground.

In addition to the wind direction and low airspeed, other factors that contribute to LTE, according to the FAA, are gross weight, density altitude, and RPM droop. An increase in either gross weight or density altitude will decrease the power margin between maximum power available and the power required. At airspeeds below 30 knots, tail rotor thrust is progressively required to produce nearly 100 percent of the directional control. If the

required amount of tail rotor thrust is not available for any reason, the aircraft will yaw to the right.

Rapid application of power may cause a transient rotor RPM droop to occur. Any decrease in main rotor RPM will cause a corresponding decrease in tail rotor thrust. The pilot must anticipate this and apply additional left pedal to counter the main rotor torque. All power demands should be made as smoothly as possible to minimize the effect of power droop.

The advisory recommended the following recovery techniques:

- Application of full left pedal, while simultaneously moving the cyclic forward to increase speed. If altitude permits, power should be reduced. As recovery is achieved, flight controls should be adjusted for normal forward flight.

- Reduction of collective pitch aids in arresting the yaw rate, but may cause an increase in the rate of descent. A rapid increase in collective may further increase the yaw rate and decrease rotor RPM.

- If rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. The pilot should maintain full left pedal until rotation stops, then adjust to maintain heading.

- Varying wind directions can cause significantly differing rates of turn for a given pedal position. The pilot should remember that the tail rotor is not stalled. The corrective action is to apply pedal opposite to the direction of the turn.

- Avoiding LTE may best be accomplished by pilots being knowledgeable and avoiding conditions which are conducive to LTE. Appropriate and timely response is essential and critical.

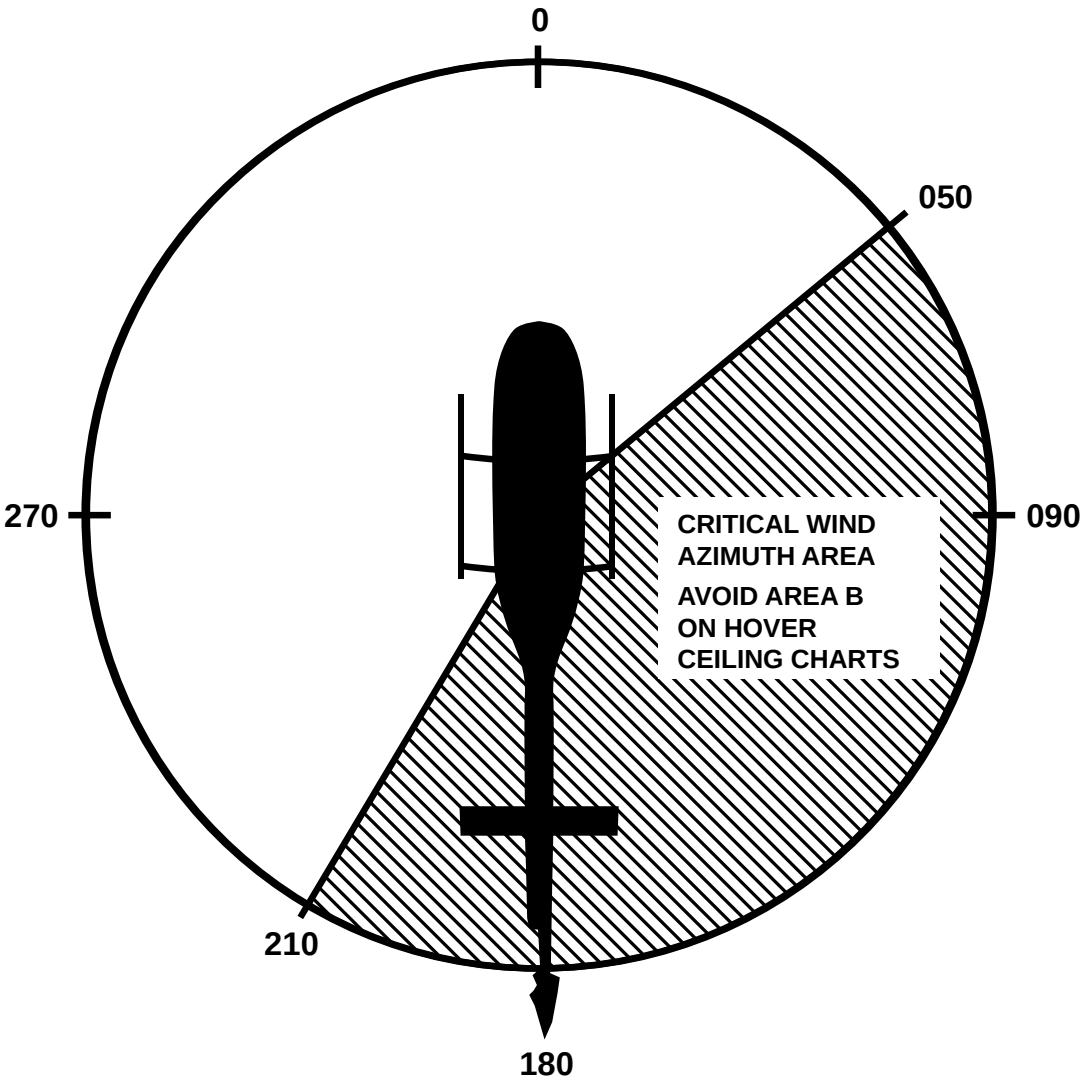
- Pilots can significantly reduce LTE exposure by maintaining an acute awareness of wind and its effects on the aircraft.

The flight manual for the Bell 206L-1 under Section 5, Performance Data, contains a Critical Relative Wind Azimuth Area chart (Figure B-4). This chart depicts relative wind positions that the manufacturer has identified as being critical to LTE.

Factors that significantly increased the likelihood of the accident without directly causing it.

Charting depicts the logical sequence of events and conditions (causal factors) that allowed the events to occur.

Barrier analysis reviews hazards, the targets (people or objects) of the hazards, and the controls or barriers that management control systems put in place. Barriers may be administrative, physical, or supervisory/managerial.



Critical relative wind azimuths

From the appropriate IGE chart obtain:

A maximum of 3550 pounds (1610 kilograms) for all allowable wind conditions, and a maximum of 4150 pounds (1882 kilograms) when wind conditions are calm or outside the critical wind azimuth area.

From the appropriate OGE chart obtain:

A maximum of 3450 pounds (1565 kilograms) for all allowable wind conditions, and a maximum of 3550 pounds (1610 kilograms) when wind conditions are calm or outside the critical wind azimuth area.

Figure B-4
Critical Relative Wind Azimuth Area