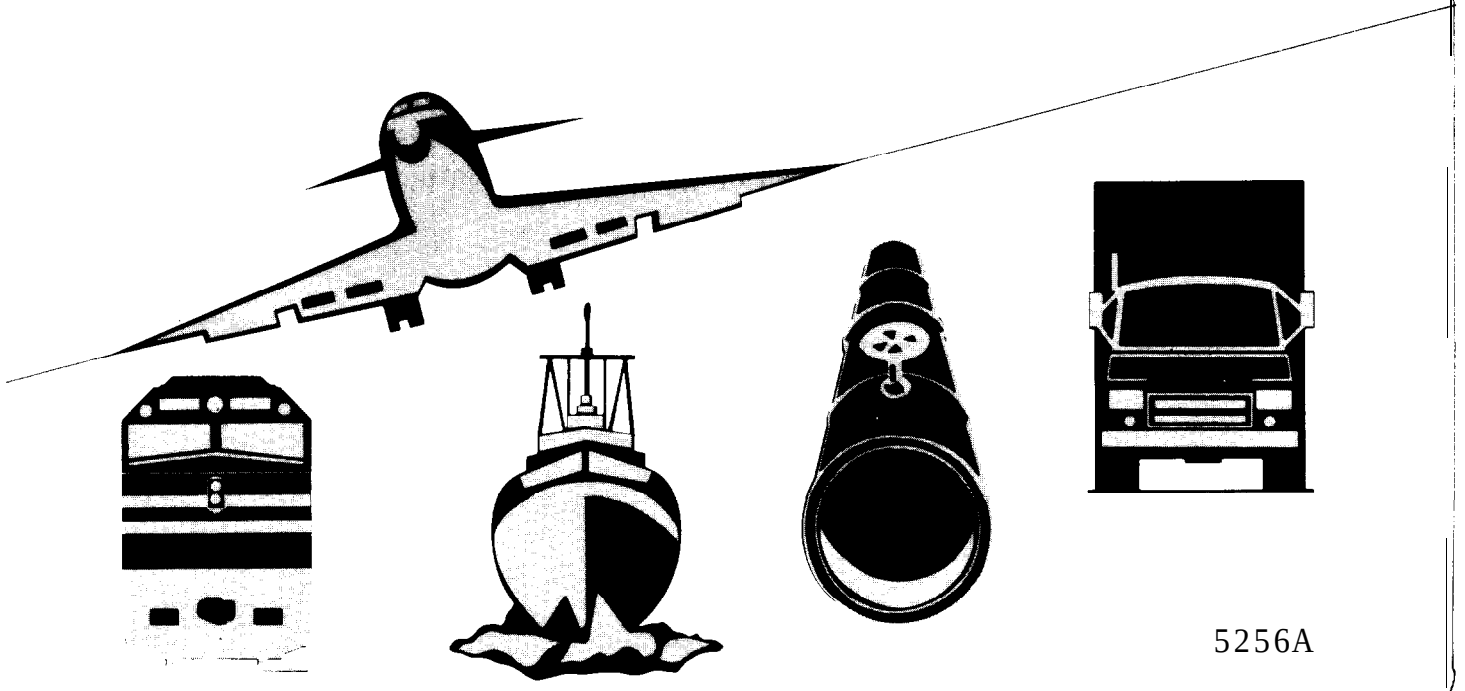
PB91-910401
NTSB/AAR-91/01

NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT REPORT

GRAND CANYON AIRLINES
FLIGHT CANYON 5
DE HAVILLAND TWIN OTTER,
DHC-6-300, **N75GC**
GRAND CANYON NATIONAL PARK AIRPORT
TUSAYAN, ARIZONA
SEPTEMBER 27, 1989



5256A

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable cause of accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation.

The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews. Copies of these documents may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. Details on available publications may be obtained by contacting:

National Transportation Safety Board
Public Inquiries Section, RE-51
800 Independence Avenue, S.W.
Washington, D.C. 20594
(202)382-6735

TECHNICAL REPORT DOCUMENTATION PAG

1. Report No. NTSB/AAR-91/01	2. Government Accession No. PB91-910401	3. Recipient's Catalog No.
4. Title and Subtitle Aircraft Accident Report-- Grand Canyon Airlines Flight Canyon 5, De Havilland Twin Otter, DHC-6-300, N75GC, Grand Canyon National Park Airport, Tusayan, Arizona, September 27, 1989		5. Report Date January 8, 199 1 6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Office of Aviation Safety Washington, D.C. 20594		10. Work Unit No. 5256A 11. Contract or Grant No. 13. Type of Report and Period Covered Aircraft Accident Report September 27, 1989
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D.C. 20594		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report explains the crash of a Grand Canyon Airlines de Havilland DHC-6-300 Twin Otte sightseeing flight at the Grand Canyon National Park Airport on September 27, 1989. The safet issues discussed in the report are airline procedures for go-around maneuvers; crew training airport certification; oversight of airport safety inspectors; emergency response; and passenger sea inspections. Safety recommendations addressing these issues were made to the Federal Aviatior Administration and the Arizona Department of Transportation.

17. Key Words	18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161		
19. Security Classification (of this report) UNCLASSIFIED	20. Security Classification (of this page) UNCLASSIFIED	21. No. of Pages 34	22. Price

NTSB Form 1765.2 (Rev. 5/88)

CONTENTS

EXECUTIVE SUMMARY

On September 27, 1989, Grand Canyon Airlines Flight "Canyon 5," a de Havilland DHC-6-300, Twin Otter, N75GC, was operating as a sightseeing flight under 14 CFR 135 from Grand Canyon National Park Airport, Tusayan, Arizona. The flight was to last about 50 minutes. The airplane crashed during its initial landing attempt and was destroyed. The two pilots and eight passengers received fatal injuries, nine passengers received serious injuries, and two passengers received minor injuries.

Canyon 5's first sightseeing flight on the morning of the accident was uneventful, and it departed on the second tour about 0900. A video tape taken by one of the passengers on the accident flight indicated that the takeoff, tour, and approach to the airport were normal.

Witnesses described the airplane's approach as normal; however, the airplane travelled about 1,000 feet down the runway, which was 8,999 feet long, at an altitude of about 5 feet prior to touchdown. The airplane reportedly dropped to the runway, bounced back into the air, continued another 1,000 feet and dropped back onto the runway near the intersection of taxiway "C." Witnesses then saw the airplane veer off to the right of the runway. When it neared the runway edge, observers saw it begin to climb in a nose-high attitude. The airplane continued to climb as it passed the control tower and reached an altitude of 150 to 200 feet above the runway. At this point, the aircraft rolled toward the left and crashed into trees on a hill about 1,200 feet to the left of the runway. The controllers reported that all communications with Canyon 5 had been normal. There were no reports of winds or gusts at the time of the accident.

The National Transportation Safety Board determines that the probable cause of the accident was improper pilot techniques and crew coordination during the landing attempt, bounce, and attempted go-around.

As a result of the investigation of this accident, seven recommendations were issued to the FAA concerning the POI's inspection of operator procedures, the adequacy of the certification inspection of the Grand Canyon National Park Airport, and the inspection of passenger seats. Four recommendations were issued to the Arizona Department of Transportation to improve electrical and communications equipment and aircraft rescue and fire fighting capability at the airport.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

GRAND CANYON AIRLINES, FLIGHT CANYON 5
A DE HAVILLAND TWIN OTTER, DHC-6-300, **N75GC**
GRAND CANYON NATIONAL PARK AIRPORT, TUSAYAN, ARIZONA
SEPTEMBER 27, 1989

1. *FACTUAL* INFORMATION

1.1 *History of Flight*

On September 27, 1989, *Grand Canyon Airlines flight "Canyon 5," a de Havilland DHC-6-300 Twin Otter,* **N75GC,** *was operating as a scheduled sightseeing flight under 14 CFR 135 from Grand Canyon National Park Airport, Tusayan, Arizona. The flight was to last about 50 minutes. The airplane carried* 19 *passengers and 2 flight crewmembers.*

The first officer and captain of flight Canyon 5 reported for duty at 0640 and 0715 mountain standard time, respectively. Canyon 5 was to be the first of three airplanes to depart for the 0800 tour flight; however, it was changed to the number two tour position because air had to be added to the airplane's tires. Canyon 3 assumed the number one position. The airplanes also remained in that sequence for the 0900 tour flight. The first tour was uneventful, and Canyon 5 departed on the second tour about 0900. A video tape taken by one of the passengers on the accident flight showed that the takeoff, tour, and approach to the airport were normal.

After the tour, Canyon 5 reported 5 statute miles northwest of the airport at **0948:30,** *and the local controller cleared the flight to land on runway 21. At* **0948:34,** *the flight acknowledged the clearance. This transmission was the last one known from the flight. The two air traffic controllers who were on duty in the tower described the airplane's approach as normal, and each controller diverted his attention from observing Canyon 5, which was on short final, to locating traffic that was entering the traffic pattern. When they looked back at the runway, Canyon 5 was off to the right of the runway, with a cloud of dust at its tail, and angling back toward the centerline of the runway in an unusually nose-high attitude. They said that the airplane continued to climb as it passed the tower and reached an altitude of 150 to 200 feet above the runway. At this point, the aircraft rolled toward the left and crashed into trees on a hill on the east side of the runway. Another controller, who was reporting for duty, stated that he saw the airplane in "a left turn descent approximately midfield... 300 feet above the ground, heading toward the tree line on the east side of the airport." During the impact sequence, the airplane severed an electrical cable that rendered the airport electrical system and telephone system inoperative. Shortly before impact, the controllers activated the crash*

alarm, and telephoned 911. The controllers reported that all communications with Canyon 5 had been normal.

A Scenic Airlines captain who had landed ahead of Canyon 5 reported no problems on landing due to winds or gusts. He observed Canyon 5 over the runway with a normal climbout angle but with a cloud of dust appearing initially at the tail of the airplane. He stated that the airplane then seemed to "stop climbing" and that the nose rose with a "jerk" until the airplane appeared to be "standing on its tail, hanging from its propellers." The airplane then rolled on its left wing and crashed into the trees. He said that the maneuver seemed to be in slow motion until the nose approached a horizontal position, at which time the airplane fell rapidly.

The flightcrew of America West Airlines flight 1080 in a DHC-8 was holding short of runway 21 waiting for its departure clearance when Canyon 5 made its approach. The crew observed Canyon 5 in a normal attitude, about 5 feet above the runway, as the aircraft "floated" about 1,000 feet down the runway. The first officer observed Canyon 5 touch down and bounce 5 feet into the air. He stated that it "looked as if the pilot was struggling with a cross wind but there was not much wind." He commented that if there was any more than about 10 to 15 knots of wind, they would have felt the effects of it in their aircraft. He expected Canyon 5 to land again and glanced into the cockpit of his airplane. Approximately 5 seconds later, he saw a large cloud of red dust in his peripheral vision, refocused his attention to Canyon 5, and called the captain's attention to Canyon 5. The first officer observed Canyon 5 emerging from the dust cloud in an "unusually" nose-high attitude and climbing to 150 to 200 feet. The left wing began to drop as the airplane drifted to the left and appeared to be "tail walking" (oscillating about the vertical axis). Canyon 5 slowly lost altitude as it continued to attain a steeper angle of bank, and the nose fell below the horizon in a near vertical left bank.

The crew of flight 1080 commented that there did not seem to be any immediate reaction to the crash from the tower or the airport's aircraft rescue and fire fighting (ARFF) unit. About 1.5 minutes later, the crew asked the tower, "are you aware of the problem?" The tower advised that it was, but that it was having difficulty contacting "Crash 1."The crew then notified its operations agents on the company frequency to see if they could do anything to help. At about 1000, a yellow crash truck passed their airplane on its way to the crash site.

Survivors of Canyon 5 reported that the takeoff, tour, and landing approach appeared to be normal as the airplane made a right turn and lined up with the runway. They stated that the pilot in the right seat was flying the airplane and that the pilot in the left seat had been narrating the tour. During the landing, two passengers noted that the airplane traveled along the runway at a low altitude for what seemed to be a long time, a situation they thought unusual because the airplane should have been landing. Several passengers stated that initially the airplane touched down, then bounced back into the air followed by a hard landing on the right wheel. Two passengers believed that the right wing tip also contacted the ground. One survivor, a private pilot, stated that there was a drop and a hard hit which bounced the

airplane about 15 feet. He then felt a "floating" sensation as if there was no response to controls and then "hitting" a second time. He stated that upon hitting the second time, the captain took over the controls applying full throttle power. Several passengers recalled that at this point there was yelling in the cockpit. The passenger who was a private pilot heard one of the crewmembers shouting "come up, come up," which he believed was addressed to the airplane. Several passengers reported that the airplane then went into a steep nose-up attitude and a left bank. Most of survivors reported hearing the buzzing sound or stall warning horn after the airplane left the ground the second time, and a few recalled seeing a red light in the cockpit. Several passengers reported that after the airplane touched down the second time both the captain and first officer had their hands on the controls on the ceiling between the pilot seats. However, they were unable to identify the controls that each pilot was manipulating.

Company practice was for the captain to fly the first tour so that the first officer could record engine data. The captain and first officer would then alternate duties as flying pilot and nonflying pilot on subsequent legs. It was also company practice for the flying pilot to make position reports in the Grand Canyon and for the nonflying pilot to narrate the tour. Additionally, the first officer was required to handle the air-to-ground communication in the traffic pattern. The first officer of Canyon 5 was heard making position reports during the 0900 tour, as well as in the traffic pattern.

The accident occurred in a wooded area approximately 1200 feet to the left of the runway centerline and approximately half way down the runway. The accident occurred at 0952, during the hours of daylight, at 35° 57.1' north latitude and 112° 08.8' west longitude.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	2	8	0	10
Serious		9	0	9
Minor	8	2	0	2
None	0	0	0	0
Total	2	19	0	21

1.3 Damage to Aircraft

The airplane was destroyed by impact. The value of the airplane prior to the accident was estimated at $750,000.

1.4 Other Damage

The airplane fuselage contacted and separated a 0.5 inch electrical cable that comprised one phase of a pole-suspended three-phase electrical power line that supplied electrical power to the airport.

Numerous trees and bushes were damaged along the wreckage path, which was about 145 feet long.

1.5 Personnel Information

The flightcrew consisted of a captain and first officer, both of whom were qualified in accordance with existing Federal Aviation Regulations (FARs) and Grand Canyon Airlines' requirements.

The captain, age 47, was hired by Grand Canyon Airlines on April 23, 1986. He held an airline transport pilot certificate, with ratings for airplane multiengine land and commercial privileges for airplane single-engine land, issued on August 23, 1987. He also held a flight instructor certificate issued on September 11, 1988. His FAA first class medical certificate was issued on April 28, 1989, without any limitations.

At the time of the accident, the captain had accumulated approximately 4,120 flying hours, of which 2,610 hours were in the DHC-6. His last proficiency check was completed on August 27, 1989. He was upgraded to captain on October 7, 1987, and designated check airman of initial operating experience (IOE) and Grand Canyon route checks on June 3, 1988. On May 9, 1989, he was authorized to conduct initial and recurrent testing and competency checks, instrument proficiency checks, line checks, IOE, and route checks.

The chief pilot of Grand Canyon Airlines told investigators that during the spring and early summer of 1989 the captain of Canyon 5 was responsible for checking out all new first officers. He stated further that because of this experience the captain was highly qualified to take over the controls when a trainee made a poor landing.

On the day of the accident, the captain had accumulated approximately 1.5 hours of flight time and had been on duty approximately 2.7 hours. He was off duty from September 21 through September 23, 1989, and had averaged slightly more than 11 hours of duty each day from September 24 through September 26, 1989, accumulating approximately 4 hours flight time during each of his duty days.

Grand Canyon Airlines' records showed that the captain passed a company-required drug test on May 25, 1988. This was the only company-required drug test taken during his employment with Grand Canyon Airlines.

The captain was involved in an incident in N75GC on February 27, 1989. He was flying in the right seat as an instructor for a captain-trainee who was in the left seat. The chief pilot for the airline related that after the captain-trainee completing several landings in varying flap configurations (0, 10, 20, 30, and 40 degrees), the captain opted to control the airplane during a 30-degree flap landing. The reference speed for the final approach was 65 knots. The chief pilot reported that the airplane was flared at about 60 knots over the runway "numbers," at an altitude of about 2 feet, and touched down on the centerline at about 55 knots. Touchdown was initially on the right main landing gear and then on the left main gear just

before the fixed distance marker, which was 1,000 feet from the approach. While still in a nose-high attitude, the airplane veered (ground looped) so sharply to the right that the left wing tip scraped along the runway. The captain reported to the chief pilot that hard left rudder was applied to regain directional control, and right yoke deflection was used to keep the left wing up. The nose wheel steering tiller was not used on the runway and the brakes were not used because of the sharpness of the turn. The engine condition levers were moved forward after touchdown, but reverse was not used. The airplane experienced only minor damage, and the incident was not investigated by the Safety Board or the FAA. Although inspection of the airplane following the incident discovered a worn nose wheel centering lug that was subsequently replaced, the reason for the incident was not determined. Neither the company nor the FAA took any action against the captain as a result of the incident.

The first officer, age 42, was hired by Grand Canyon Airlines on June 12, 1989. He held a commercial pilot certificate with ratings for airplane single and multiengine land and instrument airplane, issued on February 21, 1986. He also held a flight instructor certificate issued November 8, 1987. His FAA second class medical certificate was issued on April 6, 1989, with the limitation, "Holder shall wear lenses that correct for distant vision and possess glasses that correct for near vision while exercising the privileges of this airmen certificate." The first officer's glasses were found in the wreckage following the accident and pictures taken by a passenger showed him wearing glasses during the flight.

At the time of the accident, the first officer had accumulated approximately 1,309 flying hours, of which about 339 hours were in the DHC-6. His last proficiency check in the DHC-6 was completed on June 12, 1989.

On the day of the accident, the first officer had accumulated 1.5 hours of flight time and had been on duty approximately 3.1 hours. He was on duty approximately 11 hours each day from September 21 through September 23, 1989, averaging about 5 hours of flight time each day. He was off duty from September 24 through September 26, 1989, and had spent the time camping.

Because of a reduction in tourism during the fall and winter months, the first officer knew that he was to be furloughed in October and was seeking employment with DHC-6 tour operators in Hawaii. Other captains reported that the first officer's landings were, with rare exceptions, extremely smooth. The chief pilot stated that the first officer's landings were better than those of the other first officers, as well as many of the captains with the airline.

Company records showed that the first officer had passed a company-required drug test on January 30, 1989 prior to being hired. This was the only company-required drug test taken during his employement with Grand Canyon Airlines.

1.6 Aircraft Information

The airplane, serial No. 439, a de Havilland DHC-6-300, was manufactured in 1975. The airplane was acquired by Grand Canyon Airlines on May 30, 1987. It was equipped with two Pratt and Whitney PT6A-27 engines.

The airplane had been modified by supplemental type certificate (STC) SA1841NM to a sightseeing configuration. This modification substantially increased the size of the passenger windows and lowered the passenger seats. At the time of the modification, the original three-bladed propellers were replaced with four-bladed Hartzell HC-D4N-3C propellers. The airplane had two crew seats and 19 passenger seats.

The maximum allowable takeoff gross weight for the airplane was 12,500 pounds, and the maximum landing weight was 12,300 pounds. Grand Canyon Airlines operates with an FAA-approved "short form" center of gravity computation program. Compliance with this program ensures that the company's airplanes will be below 12,500 pounds and that the center of gravity limitations will be met for takeoff, cruise, and landing.

On the morning of September 27, 1989, Canyon 5 had a total fuel load of 1,600 pounds. The takeoff weight for the second tour was estimated at 12,137 pounds; the taxi and run-up fuel burn was estimated at 25 pounds. Assuming a nominal fuel burn of 325 pounds for the tour, Canyon 5 would have weighed approximately 11,787 pounds. Canyon 5 was within the center of gravity requirements for takeoff and landing.

1.7 Meteorological Information

Surface weather observations at Grand Canyon Airport are made by Federal Aviation Administration (FAA) personnel certificated to make such observations by the National Weather Service. Surface weather observations for the airport at 0945 were: 20,000 feet thin broken, visibility 50 miles, temperature 73° F, dewpoint 41° F, winds 160° at 07 knots, and altimeter setting at 30.38 inches of mercury.

The observation at 1045 was: 8,000 feet scattered, 20,000 feet thin broken, visibility 50 miles, winds 200° at 12 knots, and altimeter setting at 30.36 inches of mercury. The density altitude was calculated to be 8,500 feet msl.

Additionally, a surface weather observation was made by a person employed by America West Airlines who was certificated by the National Weather Service to make surface weather observations. The observation was made from the ramp in front of the America West office using the wind sensor located on top of the main terminal building. The 1000 observation was 25,000 thin scattered, visibility 20 miles, temperature 72° F, dewpoint 310 F, winds 210° at 05 knots, and altimeter setting at 30.36 inches of mercury.

Witnesses reported that the dust cloud observed when Canyon 5

departed the right side of the runway continued to drift off to the right and slowly dissipated after Canyon 5 angled back over the runway. They also stated that the dust cloud did not exhibit any rotation or change in intensity. It was also reported that no "dust devils," (small narrow whirlwinds produced by localized heating) were observed prior to or just after the accident.

1.8 Aids to Navigation

There were no known difficulties with navigational aids.

1.9 Communications

There were no known communications difficulties with the airplane or with the airport control tower before the accident.

1.10 Aerodrome Information

Grand Canyon National Park Airport is located at Tusayan, Arizona, approximately 6 miles south of the National Park Service Grand Canyon Village. Runway 3-21, the only runway, is 8,999 feet long and 150 feet wide and has a bituminous asphalt surface. Runway 3 is the instrument runway and has an instrument landing system and a medium intensity approach light system with runway alignment indicator lights (MALSR). Runway 21 has runway end identifier lights (REIL) and a visual approach slope indicator (VASI). The airport elevation and runway 21 touchdown zone elevation is 6,606 feet. The touchdown zone elevation for runway 3 is 6,553 feet, giving a 0.8 percent downslope to the southwest.

Grand Canyon National Park Airport was certificated by the FAA on February 1, 1985, with the State of Arizona as the owner and AVCO, Inc., as the operator. On August 1, 1988, a new certificate named the State of Arizona as the owner and operator. The airport was certificated by the FAA under 14 CFR Part 139 as an Index A airport for Aircraft Rescue and Fire Fighting (ARFF) service. Operations at the airport exceed 150,000 movements annually.

The three most recent annual airport certification/safety inspections conducted by the FAA prior to the accident took place on April 21 and 23, 1987; April 14, 1988; and, February 9 and 10, 1989. The FAA teams reported only minor exceptions during the inspections.

1.11 Flight Recorders

Because it is not currently required by FARs, Canyon 5 was not equipped with either a cockpit voice recorder (CVR) or a flight data recorder (FDR). In October 1991, CVRs will be required on turbine-powered airplanes having six or more passenger seats. Grand Canyon Airlines is currently developing an STC for cockpit CVR's for the DHC-6 in order to have the units installed prior to the start of the 1991 tourist season.

1.12 Wreckage and Impact Information

The airplane initially struck and severed one wire of a pole-suspended three-phase electrical power line that was approximately 30 feet above the ground. The main impact was approximately 100 feet beyond the severed electrical line. The measurements of the main impact area were 145 feet long by 8.5 feet wide, with the wreckage aligned on a heading of 068° magnetic (See figure 1).

Moving from the location of where the airplane struck the electrical wire toward the fuselage, the left wing and left engine were the first large items located on the wreckage path. A ground scar approximately 50 feet long by 10 feet wide was located just before the left wing. The fuselage came to rest mostly intact on its left side and was located about 40 feet from the left wing. The right wing, with the engine attached, was lying inverted just forward of the fuselage nose.

The right wing tip was damaged and scraped. The outboard flap hinge arm had been displaced upward into the wing. The outboard flap hinge arms on the wing and fore flap had been abraded half way through the hinge bolt. The scrape or score marks on the hinge were on a 12° angle from forward outboard to aft inboard. In addition, the hinge had been displaced rearward and upward, distorting and tearing the tip rib. The displacement of the hinge had bent and twisted the outboard bays of the outer fore flap and the aileron, buckling the surfaces and tearing and buckling the joint plates at the inboard end of these bays. The distortion limited the free and full travel of the aileron. However, the amount of travel that would have been available to the pilots could not be determined due to the postcrash damage to the wing and control system. No abrasion contact was evident on the aileron trailing edge. It was also noted that three rivet heads on the underside of the right wing tip showed signs of scraping on a hard surface. The flaps were found at 20° as was the flap handle. The elevator trim tabs were in the neutral position and the interconnect to the flap screwjack was at 0.1° nose down.

The fuselage was found mostly intact and resting on its left side. The cockpit had extensive impact damage from the windshield bottom framing to the top of the cockpit, crushing the top upward and rearward. Pieces of trees were imbedded in the cockpit roof. The left main landing gear had separated from the fuselage. The right main landing gear was found attached to the fuselage with evidence of rubbing or scraping on the outboard sidewall of its tire. Continuity was established for the nose wheel steering mechanism and all components were in a serviceable condition.

The left engine had separated from the wing and was found lying immediately behind the left wing. The propeller assembly was attached to the engine and the blades were twisted and bent forward of the engine. The right engine was attached to the wing. The right engine propeller assembly had separated from the engine at the engine reduction gear box and was located to the left of the main fuselage. Both engines and propellers had evidence of rotation and power at impact.

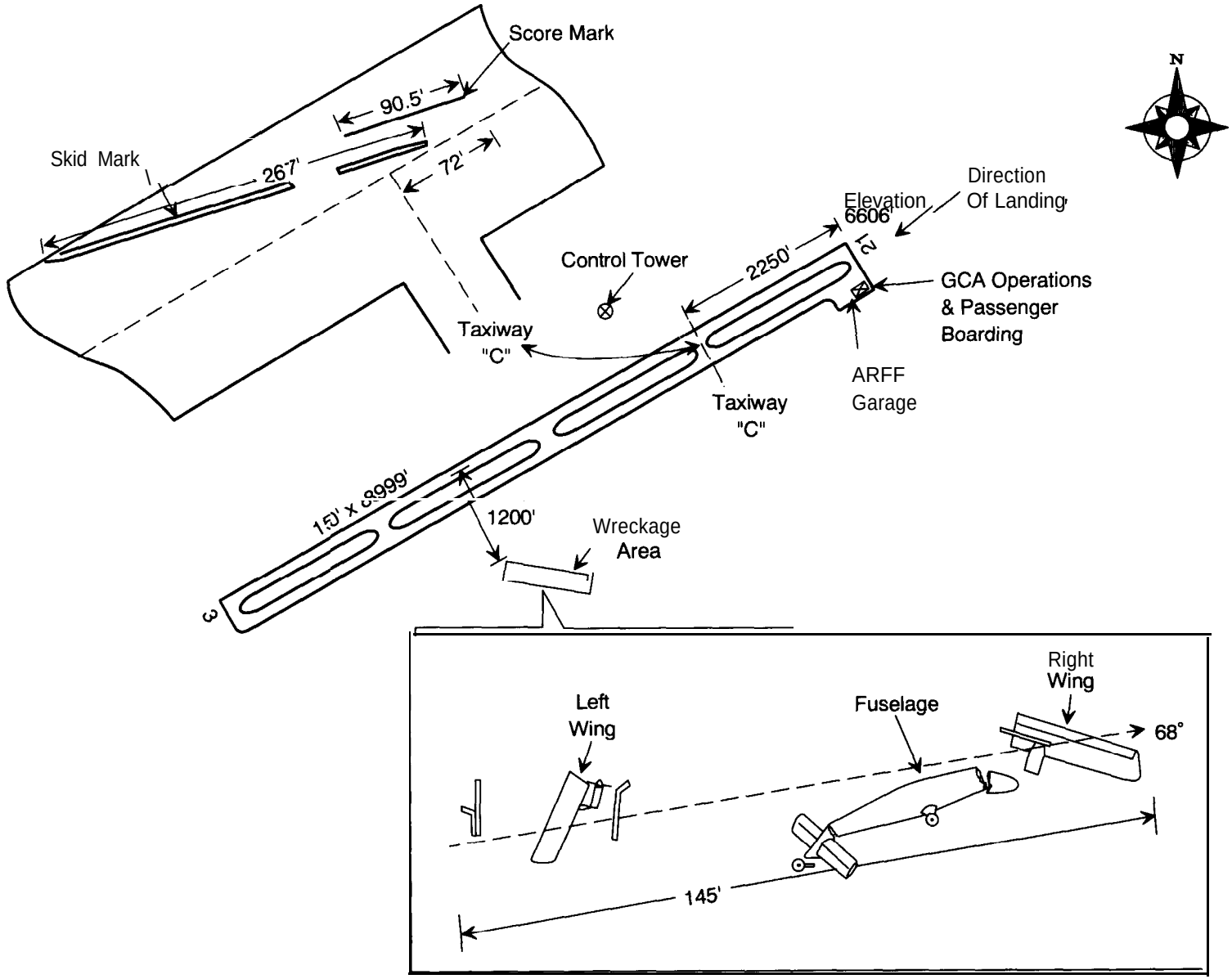


Figure 1. --Wreckage orientation and skid/score marks on runway.

A thin scoring mark with metal transfer was found on runway 21. The mark began 72 feet north of the extended centerline of taxiway "C" and 27.75 feet right of the centerline of runway 21. The mark was continuous for 91.4 feet and was 36.7 feet to the right of the runway 21 centerline at its termination point. About 2.25 inches to the right of this score mark were three parallel marks spaced .75 inch apart. These parallel marks began 70.5 feet beyond the start of the score marks and were 8 feet 1 inch long. These three marks were parallel to the score mark.

A tire skid mark was present on the runway beginning 9.5 feet right of the centerline of runway 21 and 52 feet down the runway from the beginning of the score mark and curving slightly to the right. The skid mark ran continuously for about 82 feet, was interrupted, and then began again 127.8 feet from the beginning. From this point, the skid continued down the runway toward the runway edge, a distance of 139 feet, with a slight left curve but did not appear to continue off the runway. The total length of the skid mark was 267 feet. Figure 1 shows the runway, the position of the metal transfer score mark, the tire skid marks on the runway, and the wreckage diagram.

1.13 Medical and Pathological Information

Autopsies were performed and toxicological samples were obtained from the pilot and copilot. The analysis of these samples indicated no evidence of drugs or alcohol. The autopsies found no evidence of preexisting adverse medical conditions.

1.14 Fire

There was a small grass fire near the point where the airplane contacted the electrical wires. The fire was quickly extinguished by rescue personnel.

1.15 Survival Aspects

The upper portions of the cockpit were disrupted by impact with trees and the terrain, compromising the survivable volume. Although the cabin maintained a survivable volume, passenger seats 2C and 2D through 6C and 6D separated from their floor and sidewall track attachments, due to impact loads exceeding the floor, wall track, and seat design limitations.

Two survivors stated that they had to crawl out the window on the main cabin entrance door, which was against the ground. They then had to crawl between the fuselage and the ground to egress the airplane. Other passengers stated that they were unable to egress the wreckage, due to injuries, or that they were pinned in by the bodies of other passengers. These survivors were removed from the wreckage by ARFF personnel. Survivors stated that there was a strong smell of fuel around the wreckage but that there was no fire. All of the fatalities were due to blunt impact trauma.

1.16 Tests and Research

The engines were taken to Pratt and Whitney of Canada for further inspection. During the **teardown** *examination, it was found that on the left engine fuel control unit (FCU), the compressor delivery pressure (P3) elbow had been interchanged with the metering bellows pressure* **(P_y)** *elbow. Externally, the two elbows appear identical. However, internally, they have different orifice diameters. A test engine was configured in this manner and run in a test cell. It was found that the switching of the two elbows resulted in the engine accelerating* **.3** *second faster from idle to peak RPM than normal but there was no adverse performance penalty on the engine. Additionally, tests were run using a similar propeller and propeller control settings to the accident airplane. Additional tests determined that neither the propeller model used nor the fuel control settings would have had any adverse effect on the performance of the airplane or on the ability of the engines to develop full power. Records indicate that P3 and* P_y *nozzles were most likely installed when the engine and FCU were overhauled by the manufacturer.*

1.17 Additional Information

1.17.1 Grand Canyon Airlines' Operations

Grand Canyon Airlines' procedure for landing was to leave the engine condition **levers**[1] *in the cruise position until touchdown. At touchdown, the nonflying pilot was to move the condition levers forward to the takeoff/reverse or the high idle thrust position. A Grand Canyon Airlines' pilot reported that this procedure was adopted to reduce the ground noise signature of the airplane on final approach. Company management reported that the practice was adopted to preclude the possibility of entering into reverse thrust (Beta mode) while in flight since Beta mode is locked out in the low idle position. The airlines' procedure was for the flying pilot to control the power levers and the nonflying pilot to control the condition levers during final approach. In the DHC-6, the power levers are located at the front of the overhead panel near the captain's seat, and the condition levers are located to the right of the power levers. When the first officer is flying the airplane, he must reach across the condition levers to grasp the power levers. The captain must then reach behind and around the first officer's arm in order to grasp the condition levers. Figure 2 is a photograph taken by a passenger aboard Canyon 5 that shows the location of the power and the condition levers and positions of the pilots' hands during the approach prior to the accident.*

An instructor pilot with Grand Canyon Airlines stated that when landing on runway 21, full flaps **(37.5°** *but normally* **refered** *to as flaps* **40°)** *were usually selected about 2 miles out at approximately 7,500 mean sea level (MSL) or about 900 feet above ground level. The latest point to deploy full flaps would be at the* **localizer** *antenna which is* 1,000 *feet from*

---

[1] *The engine condition lever controls the propeller governor,* **whereas** *the engine power Lever controls the engine fuel control unit.*

Figure 2.--Canyon 5 flightcrew hand positions during approach to landing.

the threshold. He said that engine power is usually set to 10 psi of torque and maintained until the airplane enters ground effect. He stated that touchdown ideally occurs at idle power with the first sound of the stall warning horn and the squeak or chirp of the tires occurring simultaneously. He believed that bounces occur in training because of inexperience and that it takes from 10 to 15 knots excess airspeed above the stall airspeed for bounces to occur with full flap landings at idle power settings. He stated that the reference approach speed for a landing weight of 11,787 pounds is about 70 knots with full flaps. The stall speed is about 56 knots.

Company management reported that full flap landings were performed on runway 21 in order to reduce the ground roll so that the airplane could make the first turnoff and reduce the taxi time to Grand Canyon's ramp. Approaches to runway 3 were accomplished with the flaps set at 20°. A photograph taken by a passenger on the accident flight showed that Canyon 5's first landing on runway 21 on the morning of the accident was with the flaps in the full flap position.

Grand Canyon Airlines' pilot operating manual for the DHC-6 advises that in a go-around situation the power levers should be advanced smoothly to takeoff power settings; the flaps should be retracted to cruise (0°) position when clear of obstacles. The manual contains a caution statement that "In a go-around with flaps extended, the nose will point below the actual flight path." Pilots reported that applying power at low airspeeds when the flaps were fully deployed would result in the airplane pitching up. The pilots further reported that positive pressure against the control yoke was needed to stop or prevent this pitching tendency. While some pilots reported that occasionally it was necessary to use both hands on the control yoke to prevent the airplane from pitching up, no one reported that the control forces exceeded the FAA maximum limitation of 50 pounds.

During the Safety Board's investigation, Grand Canyon Airlines' pilots and a de Havilland representative reported that the installation of the four-bladed propellers on the DHC-6 results in the airplane making much firmer landings than with the three-bladed propellers. Boeing Canada de Havilland reported that tests with the four-blade modification indicated that propeller drag was somewhat higher at low-power settings. It was reported that the increased drag would cause the airplane to settle more quickly after power was reduced during the landing flare. However, Grand Canyon Airlines' pilots reported that the airplane was still relatively easy to fly and to land. The four-bladed propellers had been installed to reduce the ground noise signature of the airplane.

It was reported that the airline did not have a formal cockpit resource management (CRM) program as part of its crew training syllabus. Such a training program is not required by current FARs. On October 2, 1990, the FAA established the Advanced Qualification Program which allows 14 CFR Part 121 or Part 135 operators to develop, on a voluntary basis, innovative training programs that incorporate the most recent advances in training methods and techniques.

Since the accident, Grand Canyon Airlines has contracted with Scenic Airlines' Training Department for initial ground and cockpit simulator training, as well as initial flight qualification, for all flight crew candidates. All candidates are required to pass a 5-hour flight training program upon completion of ground and simulator training. Upon successful completion of this training, candidates undergo company-specific training prior to being employed. The airline has reemphasized a captain's flight duties and responsibilities in all crew training and has placed specific emphasis on the crew decisionmaking process and the timing of decisions. This training includes some elements of a CRM program. Additionally, the airline has discontinued the use of full flap landings other than in special circumstances and during training. The airline has maintained the procedure of placing the condition lever in the high idle thrust position at touchdown.

1.17.2 Aircraft Rescue and Fire Fighting

Control tower personnel stated that as Canyon 5 passed the tower they realized by the attitude of the airplane that the flight was in trouble and that an accident was likely to occur. Just before the final impact, control tower personnel activated the crash alarm/siren and telephoned 911, but the alarm and the call, near the end of the conversation, were interrupted by the loss of electrical power and telephone service.

The investigation revealed that when Canyon 5 severed one of the pole-suspended cables of a three-phase electrical supply, electrical power and telephone service to the airport were cut off. Four airport maintenance personnel, who were also assigned ARFF duties, were to respond to the accident with two ARFF vehicles, but they remained unaware of the crash until about 0957 when the emergency electrical generator was manually started and electrical power and telephone service were restored. The control tower was equipped with a battery-powered VHF radio. However, neither the acting airport manager nor the airport's maintenance personnel had personal radios and therefore they could not be notified of the accident by the control tower until electrical power was restored.

When electrical power was lost, the acting airport manager, who was aware of the power loss but was unaware of the accident, unlocked two outer doors and one inner padlocked door to manually start the emergency generator. When the generator was started, he contacted the tower by telephone and was informed of the accident; he departed for the scene of the accident in his airport vehicle, preceded by Crash 1, about 0959. Maintenance personnel, who heard the siren/alarm after electrical power was restored, contacted the tower from the ARFF trucks and were advised of the accident and its location. They obtained clearance to enter the taxiway and encountered no difficulties en route to the accident scene.

On scene, one of the responders extinguished a small brush fire caused by the downed power line, and the other went immediately to the airplane on foot. He assisted survivors until units from the Forest Service, the National Park Service and the National Park Lodges arrived about 1001. The National Park Service took charge of the rescue operations. Although two of the four maintenance workers were emergency medical technicians (EMT's),

they could render only limited assistance to the survivors because their trucks carried only the FAA-required minimum emergency medical equipment. After arriving on scene, one of the responders had to return to the airport's ARFF garage to retrieve backboards that had been inadvertently left behind. The autopsies of the pilots and passengers found that the injuries were so extensive that the delay in the notification of AAFF personnel and the lack of additional medical equipment would not have prevented any of the fatalities.

The airport maintenance workers did not disconnect the airplane's battery when they arrived at the scene because they had not received the aircraft familiarization training required by 14 CFR 139.319 and did not know where the battery was located. Only two of the four workers had received any fire fighting training. In addition, the investigation found no records showing that any of the maintenance workers had received the minimum required ARFF training.

The airport emergency plan, coordinated with the local agencies in July 1985, contained no written agreements with the agencies that would provide medical, fire fighting, and law enforcement assistance during airport emergencies. No records were found to show that a full-scale emergency plan exercise had been held in the 3 years preceding the accident or that annual reviews of the plan and a table-top exercise of the plan had been conducted as required by 14 CFR 139.325. The last FAA inspection of the airport was conducted on February 9 and 10, 1989, and only minor discrepancies were found.

The airport manager stated that although no mutual aid agreements were in effect with the local participating agencies at the time of the accident, the airport was covered under the Coconino County Emergency Operations Plan.

The airport manager stated further that the airport staff had experienced a transition of personnel during the previous year. Only the airport manager and one of the ARFF responders had been on the airport staff for a period of 1 year or more. The other responders had been employed for 10 months or less. The former ARFF/EMT training coordinator had resigned his position 3 weeks prior to the accident. However, two of the four responding ARFF personnel had received the 20-hour Recruit I fire fighting training, which included live structural fire training, at the Arizona State Fire Academy. The same personnel were state-certificated EMTs and had completed a 120-hour approved course of instruction and had passed the state certification examinations.

The other two responders had been employed by the airport for less than 6 weeks and had reportedly received basic training, consisting of airport familiarization, ARFF equipment operation, communications, protective equipment use, and ARFF response procedures. However, a search of Grand Canyon's AAFF training records did not find records to support all of the reported training required by 14 CFR Part 139.

In the early stages of the investigation, the Safety Board concluded that if the standby electrical generator had been equipped with an automatic start feature, electrical power would have been available almost immediately after disruption of the main power source, and the alarm siren would have been heard much sooner. Also, the investigation found that numerous improvements to airport communications were needed. For example, battery-operated, hand-held radios or cellular telephones would have permitted voice communications between the control tower and key airport employees. Additionally, a one-call telephone notification system could also have improved airport communications. Such a system would enable control tower personnel or the airport manager to notify, with one call, each other, as well as the 911 emergency dispatcher, and the senior airport ARFF representative.

The FAA requirements for initial and recurrent training of ARFF personnel are diverse and extensive, thereby necessitating an adequate recordkeeping system to ensure that such personnel complete the training. To better comply with ARFF training requirements, an ARFF training officer should have been designated responsible for ensuring that all training was conducted within the required period of time. Also, this officer should ensure that cross training is provided between ARFF personnel and mutual aid agencies.

Finally, the airport emergency plan should have specified who was to be the on-scene commander during the response to an aircraft accident. Following the crash of Canyon 5, National Park Service personnel arrived on scene, relieved the airport ARFF personnel, and took command. Although this arrangement was adequate for this accident, it may not be appropriate in other situations, such as an accident and fire involving a de Havilland Dash 8 airplane that currently operates from the Grand Canyon Airport and carries up to 43 people or the proposed operation of a Boeing 737, which would carry more than 120 passengers.

The Safety Board's investigation could not determine why the most recent FAA airport inspections did not disclose the probems with the airport ARFF program that were discovered after the accident.

As a result of its investigation the Safety Board issued Safety Recommendations A-90-1 and A-90-2 to the FAA and A-90-3 through A-90-6 to the Arizona Department of Transportation on January 17, 1990. These recommendations and the most recent replies are as follows:

To the FAA--

A-90-1

Conduct an airport certification inspection with a special team of inspectors at the Grand Canyon National Park Airport for compliance with 14 CFR 139 and order corrective actions where noncompliance is found.

A-90-2

Develop and promulgate measures to improve management oversight and supervision of airport safety inspectors to ensure that airport certification inspections are performed in a manner that will achieve full compliance by airport operators with the requirements of 14 CFR 139.

In its letter of August 6, 1990, the FAA stated that it had performed an airport certification inspection of Grand Canyon National Park Airport on May 2 through 4, 1990. At that time, the FAA inspection team found the airport to be in compliance with 14 CFR 139. Safety Recommendation A-90-1 has been classified as "Closed--Acceptable Action."

The FAA letter of August 6, 1990, cited four actions which have been taken to address FAA improvements to "management oversight and supervision of airport safety inspectors in response to safety recommendation A-90-2." The actions are (1) revisions to the Airport Certification Handbook (2) a l-year round of airport inspections by headquarters staff, (3) a l-year trend-monitoring system, and (4) an instruction to the Assistant Administrator for Aviation Safety to conduct periodic independent appraisals. Although the Safety Board found some benefit in the FAA actions, the response did not provide a permanent improvement to problems in the supervision and guidance of airport inspectors. Therefore, Safety Recommendation A-90-2 was classified as "Open--Unacceptable Response," pending further action by the FAA.

Additionally the Safety Board made the following recommendations to the Arizona Department of Transportation (ADOT) on January 17, 1990:

A-90-3

Install an auto-transfer start system on the emergency electrical generator for automatic start-up of the generator if commercial electrical power is lost.

A-90-4

Provide an alternate form of voice communication independent of commercial electrical power, and alternate telephone systems for the control tower and key airport employees.

A-90-5

Develop mutual aid agreements with off-airport fire fighting, law enforcement, and medical agencies and conduct airport familiarization tours for these agencies.

A-90-6

Qualify at least one airport aircraft rescue and fire fighting employee as training officer or trainer to be responsible for training other employees, maintaining appropriate records, and providing familiarization tours for mutual aid agencies.

In its letter of August 28, 1990, ADOT reported that an auto-transfer start system for the emergency electrical generator had been purchased and installed. Based upon this response Safety Recommendation A-90-3 was classified as "Closed-Acceptable Response." In its letter of March 26, 1990, ADOT stated that electrical power for communication between the airport base operations and the air traffic control tower had been converted to a 12-volt system with a trickle charger. Additionally, new communications equipment had been purchased that greatly enhances the airport staff's capability to contact each other and the tower even in the event of a complete commercial power outage. Safety Recommendation A-90-4 was classified as "Closed--Acceptable Action."

Regarding the airport's ARFF capability, the letter of August 28, 1990, stated that an the FAA-approved airport emergency plan would be amended to require immediate notification of the National Park Service Dispatch Telephone number (911) and that semi-annual table top exercises will take place. In its reply the Safety Board stated that this action, though positive, did not completely meet the intent of the recommendation in that the action taken by the ADOT did not develop a formal written mutual aid agreement or address conducting airport familiarization tours for agencies that might respond to an accident on the airport. The Safety Board's letter classified Safety Recommendation A-90-5 as "Open--Acceptable Response" pending further response.

Finally, the ADOT informed the Safety Board that an airport training officer had been designated who had completed a ARFF instructor's training course. Based upon this information, Safety Recommendation A-90-6 was classified as "Closed--Acceptable Action."

1.17.3 Seat Frame Modifications

The seats, windows, and cabin structure on Canyon 5 had been modified under STC SA1841NM, approved by the FAA on March 11, 1983. In accordance with the STC, the airplane's cabin windows were enlarged, the cabin structure was modified to accommodate the larger windows, and the passenger seat legs were shortened by about 4 inches. Also, the seat frames had been chromium (chrome) plated to enhance their appearance and reduce maintenance. The STC did not specify a finish for the seat frames. The plating was not performed by an FAA-approved repair station and the process was not supervised by an FAA-licensed repairman. The floor and sidewall seat tracks were as originally supplied by the manufacturer of the aircraft.

Inspection of the passenger seats in the accident airplane found instances of corrosion in the hollow-tube seat legs, multiple seat frame separations at welds, and cracks at repair welds located at the lower

seatback support frames. The sidewall track was broken on each seat that had separated from the airframe. Examination of the seat leg mounting brackets and floor tracks indicated that the seats separated from their mounting tracks because the lateral impact loads exeeded the design specifications and FAA requirements. Corrosion of the seat legs or seat frames on the accident airplane had not progressed to a point to have significantly reduced their strength. The finding of corrosion caused the investigators to examine the seats of other Grand Canyon Airlines and Scenic Airlines airplanes that had been similarly modified.

The Safety Board's inspection of other modified seats found cases of moderate to severe corrosion in the seat legs of several airplanes, which could have become a serious passenger safety hazard in the event of a hard landing or accident. Several cases were found where the hollow-tube seat frames were so corroded that some frame tubes and seat legs had virtually no remaining wall thickness beneath the chrome plating. Seat frames that were not chrome plated had no corrosion. Metallurgical examination of some of the corroded seat frames and legs indicated that the internal corrosion was apparently related to the chrome plating process. The examination did not find conclusive evidence as to the cause of the accelerated corrosion. However, it is believed that the chemicals used to prepare the frames for plating were not flushed from inside the tubing. These chemicals had removed the mill-applied corrosion protective layer in the tubes and had accelerated the corrosion process.

In response to these findings both Grand Canyon Airlines and Scenic Airlines replaced all the chrome-plated seats in their fleets with new seats as quickly as they could be produced. The new seats are not chrome plated.

However, the Safety Board was concerned that the cracked seat frames, cracked welds, and serious corrosion were not detected until this accident occurred. The Safety Board believed that the airworthiness of passenger seats may not be the subject of adequate surveillance by FAA inspectors and that passenger seats may not be properly inspected. Therefore, to ensure that FAA air carrier principal maintenance inspectors were made aware of this problem and that greater emphasis would be placed on the inspection of passenger seats and seat mounting systems, the Safety Board issued Safety Recommendations A-90-37 through -39 to the FAA on March 19, 1990:

A-90-37

Instruct principal maintenance inspectors to direct air carrier, air taxi, and commercial operators to inspect passenger seats manufactured by Field Engineering West, Ltd., for cracked welds and to repair the seats as necessary.

A-90-38

Instruct principal maintenance inspectors to direct air carrier, air taxi, and commercial operators to inspect passenger seats that have been chromium plated subsequent to

manufacture for corrosion and to repair or replace, as necessary, seats that are corroded.

A-90-39

Instruct principal maintenance inspectors to review the adequacy of passenger seat inspections conducted by air carrier, air taxi, and commercial operators to ensure that the inspections address cracks, corrosion and the adequacy of any repairs.

In its letter of August 5, 1990, the FAA stated that it had issued Action Notice 8300.67, "Passenger Seat Inspection for Cracks, Corrosion, and Inproper Repair." This action notice complied with the Safety Board's intent, therefore, Safety Recommendations A-90-037 through -039 have been classified as "Closed--Acceptable Action."

2. ANALYSIS

2.1 General

The investigation determined that the airplane had been maintained in accordance with applicable FAR and company operations specifications. There was no evidence of any preexisting airworthiness discrepancies or of any preimpact structural, flight control, electrical system, or engine failures that were causal to the accident.

The flightcrew was properly certificated and qualified in accordance with applicable FARs and company requirements. There was no evidence of adverse medical conditions that affected the flightcrew. Toxicological specimens indicated that neither the captain nor the first officer were under the influence of, or impaired by, drugs or alcohol at the time of the accident.

2.2 Weather

Statements by other Grand Canyon Airlines' pilots and pilots of other airlines indicated that there was no significant surface wind, gusts, or windshear at the time of the accident. The pilot of Canyon 3, which landed shortly before Canyon 5, stated that he experienced no turbulence during his approach. The captain of a flight that landed shortly after the accident stated that he had no difficulty with turbulence during the approach and landing to runway 21. Additionally, the crew of an airplane that was holding short of runway 21 reported that they felt no effects of any wind buffeting their airplane. The Safety Board concludes that these reports were consistent with the meteorological data pertinent at the time and location of the accident.

The Safety Board also concludes that there was no. evidence of any nearby "dust devils" at the time of the accident. Witnesses on the ground did not report strong or swirling winds or the observation of a dust devil.

A dust cloud was observed at the location near Canyon 5 when it was at or near the edge of the runway. However, according to witnesses, the dust cloud was produced by the thrust of the propellers against the ground. In addition, the dust cloud did not exhibit any rotation and drifted to the right of runway 21 and quickly dissipated. Therefore, the Safety Board concludes that weather was not a factor in the accident.

2.3 Airplane Operations and Flightcrew Actions

The Safety Board examined various landing and recovery scenarios that could have resulted in the airplane floating during the approach, a bounced landing, loss of lateral control, and a 150 to 200 foot climb while the airplane was in a nose-high, left wing down attitude. The Safety Board believes that poor pilot technique, inadequate company approved procedures, and lack of crew coordination resulted in the sequence of events.

The pilots and controllers who witnessed the approach stated that the airplane appeared to be under control and stabilized during its approach and flare for landing. However, the airplane floated down the runway-at an altitude of about 5 feet for about 1,000 feet. The airline's chief pilot stated that with full flaps, such a long float is usually caused by excess airspeed during the approach or engine power above flight idle. The excess power prevents a normal deceleration of the airplane while in ground effect. The Safety Board believes that either scenario is consistent with the details of this accident. When the airplane was leveled at 5 feet above the runway, it necessitated a secondary flare or other recovery techniques to obtain a successful landing at the end of the float.

With respect to the airplane bouncing in a wings-level attitude about 1,000 feet down the runway, the Safety Board could not determine with certainty if the airplane was fully stalled or if there was excess airspeed during the bounce. Certain facts, however, support the latter scenario. Passengers did not report hearing a stall-warning horn in the floating phase of the flight. After the bounce, the airplane flew another 1,000 feet before the wing tip touched the runway. If the airplane had been fully stalled at the bounce, an additional 1,000 feet of flight would be unusual. The airborne distance between the bounce and wing tip contact is more consistent with excessive airspeed at the bounce, followed by a decaying airspeed during the second landing attempt.

A bounce with excessive airspeed could develop if the power is reduced and the trim of the airplane is changed, resulting in a quick drop to the runway before pilot action is taken to prevent ground contact. If this were the case, the aircraft may have skipped off the main gear or, due to the full flap configuration and resulting-low pitch attitude with excess airspeed, it may have bounced off the nose gear.

Regardless of why the bounce developed, the airplane was airborne after the bounce and most likely transitioned to a near-stall condition. The events following the bounce are consistent with an attempted recovery to a landing. Although the Safety Board could not determine the cause of the loss of control when the right wing tip hit the ground, the data are consistent

with a developing stall condition. Near-stall conditions could have developed by the time of the wing drop, limiting flight control effectiveness. The observations of the flightcrew from America West Flight 1080 that the airplane appeared "struggling with a crosswind" are consistent with a near-stall condition between the bounce and wing contact. A near-stall rather than a stall condition is more consistent with passengers not hearing the stall warning horn during this phase of flight. In addition, passenger statements indicated that the crew applied power after the wing drop. Thus, it is unlikely that the control problems associated with the wing drop were caused by an asymmetric power condition because this would have required the power to have been applied prior to the wing drop. The Safety Board concludes that, in the absence of adverse wind conditions, the roll excursions observed by the witness flightcrew were caused by the near-stall condition of Canyon 5. It is likely that the right wing tip struck the runway while aileron control effectiveness was reduced due to the near stall.

The wing touched down at about 10 seconds and 1,000 feet past the bounce, about 2,180 feet down the runway, and came off the runway about 90 feet later. At the stall speed of the airplane, the wing was in contact with the ground for less than 1 second. The period from the first wing contact to the airplane becoming airborne required the airplane to be in contact with the ground for about 300 feet or 3 seconds.

The investigation found that the tire skid track made by the airplane initially curved slightly to the right, consistent with the right wing down attitude. Further, the right main wheel showed extensive scuffing on the outboard face of the tire. It is therefore believed that the skid mark was caused by the airplane being yawed nose left relative to its direction of travel consistent with the scrape marks on the wing tip.

The position of the skid track, the wing tip scrape marks, and the geometry of the airplane were used to determine the roll and yaw angle while the airplane was on the ground. The marks on the runway indicate that the right wing tip aileron/flap hinge contacted the runway before the right wheel. Contact of the wheel and the hinge with the runway surface would have required a bank angle in excess of 19.7°. The scrape marks on the runway indicated that during the time the right wheel and hinge were simultaneously on the surface, the airplane's yaw angle was very small, consistent with the scrape marks on the flap/aileron hinge, which were 12° airplane nose left. Additionally, the marks indicate that the airplane maintained a direction of travel about 15° to the right of the runway heading, After 90 feet of wing contact, the wing was raised and the tire marks curved slightly to the left, lessening the excursion angle toward the edge of the runway.

The investigation sought to determine the factors that might have caused the pilots to lose control of the airplane during the go-around. During the dynamic situation while the airplane was right wing down and heading for the side of the runway, the pilot's reaction might have been to raise the nose and add power for an anticipated go-around, At airspeeds near stall, the downwash on the horizontal stabilizer tends to raise the nose of the airplane, requiring the control yoke to be pushed forward to maintain a normal pitch attitude for the same trim setting. If the pilot pulled back on

the control yoke while adding power, this could have resulted in the airplane lifting off in a nose-high, power-on stall or near-stall condition. In addition, the visual reference may have been misleading. According to the operations manual for the DHC-6, with 40° of flaps, the airplane's deck angle is below the flight path angle during a go-around. Therefore, an increase in pitch to a "typical" nose-up reference attitude while the flaps were at 40° would increase the possibility of aerodynamic stall and subsequent loss of lift.

The three scoring/paint transfer marks on the runway and the scraping marks on the rivets on the right wing tip indicate that the aileron/flap hinge had been crushed up into the wing during the wing tip strike. The investigation found that the displacement of the aileron/flap arm up into the wing tip affected the full and free movement of the aileron. When the right wing's outboard aileron/flap hinge arm was crushed into the wing tip and while the wing was in contact with the runway, down aileron travel would have been improbable. Because the control linkages were still intact, right wing up, aileron travel may have been possible after the wing was clear of the runway. The range of up or down aileron travel, relative to normal travel, could not be determined because of the postaccident condition of the aileron and aileron control system. The extent of aileron control loss and interference with control wheel movement could not be determined. The Safety Board considers it likely that the flightcrew experienced at least some degree of difficulty with aileron control during the attempted go-around. The Safety Board could find no evidence that rudder or elevator control were in any way hampered.

The Safety Board believes that during the period after the wing tip strike and the last liftoff in which the tower controllers and the pilots on the ground saw the airplane "tail walking" and moving to the left with the left wing down, the airplane was climbing primarily on the power of the engines, and the airplane wing was in a partially stalled condition. A fully stalled condition probably developed during the final seconds prior to and during the descent to impact. Despite the possibility that only limited or even no aileron roll control authority may have been available, the Safety Board could not determine why the flightcrew could not control the roll excursion with rudder input. In addition, the Safety Board could not determine why the flightcrew did not reduce the pitch of the airplane unless the left wing down roll angle was of primary concern in the final moments of flight as the airplane moved to the left toward the crash site.

The fact that the airplane was able to climb about 150 to 200 feet in a near-stalled condition indicates that full power was applied to the engines in an attempted go-around. Additionally, finding the flaps at 20° at the accident site indicates that the pilots either landed with the flaps at 20° or had reduced the flap setting from 40 to 20 at some time between the bounce on the runway and the final impact. Retracting the flaps to 20° during a go-around attempt is the standard procedure. Given that it was standard company practice to land on runway 21 with full flaps, most likely 40° flaps were used for the approach and the flaps were raised to 20° during the go-around attempt. Additionally, while it could not be determined when the flap handle was selected to 20°, the Safety Board believes that there was

sufficient time between the airplane leaving the runway and impact for the flaps to have been retracted from 40° to 20°.

Without the benefit of a CVR, the investigation could not examine the flightcrew's actions before the bounce or while attempting to recover from the bounced landing. Statements by survivors indicate that the captain took control of the airplane about the time of the second touchdown, that power was added after the wing tip struck, and that yelling took place in the cockpit during the accident sequence. However, it could not be determined exactly when the captain took control of the airplane, or the nature of the communication between the pilots.

It is known that although the captain took control of the airplane, he did not prevent the airplane from landing on the right wing tip and the outside of the right tire. His corrective actions were either too late or improper because control of the airplane was lost at ground contact.

In one possible sequence of flightcrew actions, the first officer may have began to lose lateral control after the bounced landing while he attempted to recover from the bounce and reland the airplane. The crew communications overheard by the survivors may have been the captain urging the first officer to recover the airplane, or may have been comments addressed by either pilot to the airplane.

In another possible sequence, poor crew coordination may have contributed to the captain's unsuccessful intervention and recovery. The statements by survivors about crewmembers' yelling may indicate that the pilots were confused about whether they should initiate a go-around or stay on the ground and attempt to regain control of the airplane on the runway. This confusion could have been present after the first bounce when the first officer was having difficulty relanding the airplane, or after the second touchdown and wing tip strike.

Under this scenario, it is possible that one crewmember may have initiated a go-around, while the other's initial reaction could have been to stay on the ground. Such confusion, if it was present, could have prompted the crew to react improperly after initial touchdown when immediate and coordinated action might have resulted in a successful go-around or landing. The Safety Board notes that this type of confusion can only be minimized by close teamwork and adherence to detailed operational procedures.

The Safety Board is concerned that Grand Canyon Airlines' procedure of not moving the condition levers to the maximum RPM position until touchdown may have added to the crew's workload and confusion during the bounced landing. For the captain to take command of the airplane, he would have had to push up the condition levers and then grasp the power levers. This additional action could have delayed the captain's acquisition of control from the first officer. Additionally, because the first officer was grasping the power levers during the approach, both crewmembers could have had their hands on the power levers simultaneously or the captain could have put his hand over the top of the first officer's hand. In the latter situation, the first officer's hand could have been trapped momentarily by

the captain. Such a situation could have delayed the first officer's ability to reach the flap lever and reset the flaps.

In summary, the Safety Board concludes that the flightcrew used poor piloting techniques while trying to land the airplane. The captain's supervision of the first officer was inadequate, and his intervention during the attempted landing was untimely or improper. To an unknown extent, confusion and resulting poor crew coordination may have complicated the captain's attempt to intervene and recover the airplane.

The Safety Board has previously cited poor crew coordination as a factor in airline accidents and has recommended that CRM training be given to pilots to develop the necessary teamwork and procedures to prevent breakdowns in pilot actions similar to those that caused this accident. Most recently, as a result of the investigation of Aloha Islandair flight **1712,**[2] *the Safety Board recommended to the FAA that scheduled 14 CFR 135 operators develop and use CRM programs in their training by a specified date. The accident involving Canyon 5 further supports the need for CRM training. In addition, it demonstrates the need for specific training for captains in the supervision of first officers, in decisionmaking regarding intervention when first officers are flying, and in the proper timing and execution of intervention.*

Additionally the Safety Board concludes that the procedures used by Grand Canyon Airlines of landing with full flaps and not setting the condition levers to maximum RPM position until touchdown may have complicated the pilots' workload. The Safety Board believes that the FAA should determine whether the procedures used are compatible with the crew coordination training for emergency or unusual situations and whether the go-around maneuver from stall or near stall airspeeds can be easily initiated and implemented under the existing conditions, such as at high density altitudes and high gross weights while at maximum flap settings.

3. CONCLUSIONS

3.1 Findings

1. *The airplane was certificated, equipped, and maintained in accordance with Federal regulations and approved procedures.*

2. *There was no preexisting damage to the airplane, its systems, or powerplants before the landing attempt that contributed to the accident.*

3. *The flightcrew was properly certificated and qualified for their duties.*

---

[2] *Aloha* **IslandAir,** *Inc., flight 1712, de Havilland DHC-6-300, near* **Halawa** *Point, Molokai, Hawaii, October 28, 1989. NTSB* **IAAR-90/05.**

4. *Weather was not a factor in the accident.*

5. *Company procedures were to use full flaps (40°) when landing on runway 21. The flaps were found set to 20° at the accident site, probably because the pilots retracted the flaps during the go- around attempt, which is the standard procedure.*

6. *The airplane traveled down the runway about 5 feet in the air for about 1,000 feet before it bounced on landing.*

7. *Following the bounced landing the airplane traveled about 1,000 feet in the air, then touched down on the right wing tip and the outside portion of the right main tire and skidded towards the right side of the runway.*

8. *The impact of the right wing tip with the runway crushed the aileron/flap hinge up into the wing, which may have limited the amount of aileron movement available for recovery.*

9. *The damage to the aileron may have reduced the lateral control effectiveness during the attempted go-around. However, the elevator and rudder controls were not affected. Therefore, the use of available flight controls and good pilot techniques could have prevented the accident.*

10. *Following the bounced landing, full power was applied to the engines and an attempted go-around initiated.*

11. *Grand Canyon Airlines practice of not placing the condition levers to the takeoff position until touchdown and permitting flightcrews to cross arms to reach the power levers and the condition levers when the first officer is flying the airplane may have caused some confusion and loss of reaction time during a critical phase of flight.*

12. *Using 40° flaps settings for landing increased the crew workload during an attempted go-around.*

13. *The flight crew lost control of the airplane during the bounced landing and was not able to regain control of the airplane during the attempted go-around maneuver.*

14. *The lateral loads placed on the passenger seats during the impact sequence were in excess of the FAA design requirements.*

15. *Corrosion of the internal walls of the hollow tube seat frames was caused by residue of the chrome plating process. The corrosion of the seat frames did not contribute to the severity of the passenger injuries.*

16. The emergency response was delayed because of the loss of electrical power and telephone service and because the emergency generator needed to be manually started. The delay in the emergency response did not contribute to the number of fatalities.

17. The airport did not comply with FAA requirements for ARFF training, recency of a full-scale emergency drill, and mutual aid agreements.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was improper pilot techniques and crew coordination during the landing attempt, bounce, and attempted go-around.

4. RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following recommendations to the FAA:

Determine whether airline procedures 1) requiring the pilots to coordinate and set the condition levers to maximum RPM position after touchdown and/or 2) allowing the airplane to operate with full flaps while at high gross weights and high density altitudes, are consistent with a safely initiated and implemented go-around maneuver in a DHC-6-300 from a stall or near-stall condition. (Class II, Priority Action) (A-91-11)

Require that captain upgrade and recurrent training programs include training on techniques for proper supervision of first officers and intervention to correct flying errors during critical phases of flight. (Class II, Priority Action) (A-91-12)

On January 17, 1990 the following Safety Recommendations were issued to the Federal Aviation Administration and the Arizona Department of Transportation.

--to the Federal Aviation Administration:

A-90-1

Conduct an airport certification inspection with a special team of inspectors at the Grand Canyon National Park Airport for compliance with 14 CFR 139 and order corrective actions where noncompliance is found.

A-90-2

Develop and promulgate measures to improve management oversight and supervision of airport safety inspectors to ensure that airport certification inspections are performed in a manner that will achieve full compliance by airport operators with the requirements of 14 CFR 139.

--to the Arizona Department of Transportation:

A-90-3

Install an auto-transfer start system on the emergency electrical generator for automatic start-up of the generator if commercial electrical power is lost.

A-90-4

Provide an alternate form of voice communication independent of commercial electrical power, and alternate telephone systems for the control tower and key airport employees.

A-90-5

Develop mutual aid agreements with off-airport fire fighting, law enforcement, and medical agencies and conduct airport familiarization tours for these agencies.

A-90-6

Qualify at least one airport aircraft rescue and fire fighting employee as training officer or trainer to be responsible for training other employees, maintaining appropriate records, and providing familiarization tours for mutual aid agencies.

Additionally, the Safety Board issued Safety Recommendations A-90-37 through -39 to the FAA on March 19, 1990:

A-90-37

Instruct principal maintenance inspectors to direct air carrier, air taxi, and commercial operators to inspect passenger seats manufactured by Field Engineering West, Ltd., for cracked welds and to repair the seats as necessary.

A-90-38

Instruct principal maintenance inspectors to direct air carrier, air taxi, and commercial operators to inspect passenger seats that have been chromium plated subsequent to manufacture for corrosion and to repair or replace, as necessary, seats that are corroded.

A-90-39

Instruct principal maintenance inspectors to review the adequacy of passenger seat inspections conducted by air carrier, air taxi, and commercial operators to ensure that the inspections address cracks, corrosion and the adequacy of any repairs.

BY THE NATIONAL *TRANSPORTATION SAFETY BOARD*

/s/ *James L. Kolstad*
Chairman

/s/ *Susan Coughlin*
Vice Chairman

/s/ Jim *Burnett*
Member

/s/ John *K. Lauber*
Member

/s/ *Christopher A. Hart*
Member

January 8, 1991

5. APPENDIXES

APPENDIX A

PERSONNEL INFORMATION

Captain William H. Welch

Captain Welch was born on February 21, 1942. He was hired by Grand Canyon Airlines on April 23, 1986. The captain held an airline transport pilot certificate, with ratings for airplane multiengine land and commercial privileges for airplane single engine land, issued on August 23, 1987. He also held a flight instructor certificate issued on September 11, 1988. His FAA first class medical certificate was issued on April 28, 1989 without any limitations.

At the time of the accident, he had accumulated approximately 4,120 total flying hours, of which 2,610 hours were in the DHC-6. His last proficiency check was completed on August 27, 1989. He was upgraded to captain on October 7, 1987, and designated a check airman of initial operating experience (IOE) and Grand Canyon route checks on June 3, 1988. On May 9, 1989, he was authorized to conduct initial and recurrent testing and competency checks, instrument proficiency checks, line checks, IOE, and route checks.

On the day of the accident, the captain had accumulated approximately 1.5 hours of flight time, and he had been on duty approximately 2.7 hours. He was off duty from September 21 through September 23, 1989, and averaged slightly over 11 hours of duty each day from September 24 through September 26, 1989, with approximately 4 hours flight time on his duty days.

First Officer Keith K. **Crosson**

First Officer **Crosson** was born on March 13, 1946. He was hired by Grand Canyon Airlines on June 12, 1989. The first officer held a commercial pilot certificate, with ratings for airplane single and multiengine land and instrument airplane, issued on February 21, 1986. He also held a flight instructor certificate issued November 8, 1987. His FAA second class medical certificate was issued on April 6, 1989, with the limitation, "Holder shall wear lenses that correct for distant vision and possess glasses that correct for near vision while exercising the privileges of this airmen certificate." He had previously obtained a waiver of demonstrated ability by special examination on August 28, 1973. His physical problem was, "defective vision **20/200** corrected to **20/20** bilaterally." The limitation was, "must wear glasses for distant vision while flying." The waiver, S/N **40D97325,** was for a second class medical certificate.

At the time of the accident, the first officer had accumulated approximately 1,309 total flying hours, of which about 339 hours were in the DHC-6. His last proficiency check was completed on June 12, 1989.

The first officer had accumulated 1.5 hours of flight time and had been on duty approximately 3.1 hours on the day of the accident. He was on duty approximately 11 *hours each day from September 21 through September 23,* 1989, *and averaged about 5 hours of flight time. He was off duty from September 24 through September 26,* 1989. *The first officer initially failed to pass the following subjects at the completion of ground school: Meteorology, PT-6, Emergency Procedures, Air Taxi, Systems, and Operations Manual. He received some additional instruction and subsequently passed all of the ground school tests.*

*U.S.G.P.O:1991-281-626:20033