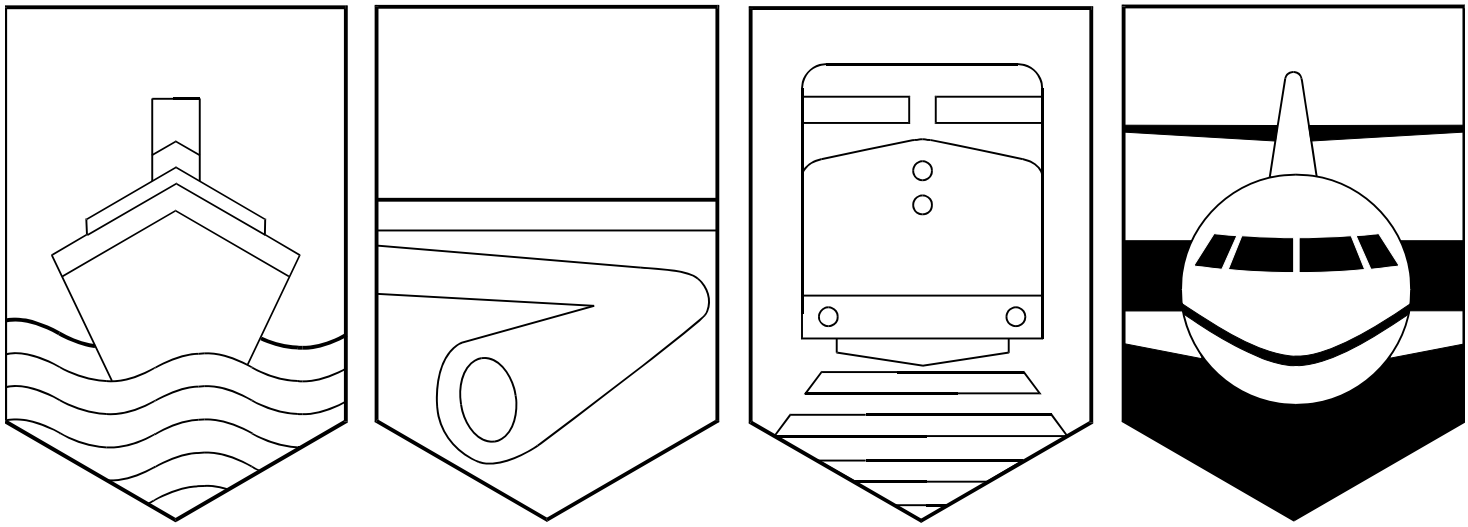
Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada



AVIATION OCCURRENCE REPORT

FUEL EXHAUSTION

BUFFALO AIRWAYS (1986) LTD.
DOUGLAS DC-3C C-FROD
FORT SIMPSON AIRPORT, NORTHWEST TERRITORIES .5 nm SW
26 JUNE 1994

REPORT NUMBER A94W0106

Canada

MANDATE OF THE TSB

The Canadian Transportation Accident Investigation and Safety Board Act provides the legal framework governing the TSB's activities. Basically, the TSB has a mandate to advance safety in the marine, pipeline, rail, and aviation modes of transportation by:

- conducting independent investigations and, if necessary, public inquiries into transportation occurrences in order to make findings as to their causes and contributing factors;
- reporting publicly on its investigations and public inquiries and on the related findings;
- identifying safety deficiencies as evidenced by transportation occurrences;
- making recommendations designed to eliminate or reduce any such safety deficiencies; and
- conducting special studies and special investigations on transportation safety matters.

It is not the function of the Board to assign fault or determine civil or criminal liability. However, the Board must not refrain from fully reporting on the causes and contributing factors merely because fault or liability might be inferred from the Board's findings.

INDEPENDENCE

To enable the public to have confidence in the transportation accident investigation process, it is essential that the investigating agency be, and be seen to be, independent and free from any conflicts of interest when it investigates accidents, identifies safety deficiencies, and makes safety recommendations. Independence is a key feature of the TSB. The Board reports to Parliament through the President of the Queen's Privy Council for Canada and is separate from other government agencies and departments. Its independence enables it to be fully objective in arriving at its conclusions and recommendations.

Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

Aviation Occurrence Report

Fuel Exhaustion

Buffalo Airways (1986) Ltd.
Douglas DC-3C C-FROD
Fort Simpson Airport,
Northwest Territories .5 nm SW
26 June 1994

Report Number A94W0106

Synopsis

The Douglas DC-3C freighter was on a charter flight from Trout Lake to Fort Simpson, Northwest Territories. While turning final for runway 31 at Fort Simpson, the flight crew advised the Flight Service Station that they were attempting a forced landing on a road. The aircraft crashed into trees about one-half nautical mile short of the runway and was substantially damaged. The first officer was seriously injured and the captain received minor injuries.

The Board determined that the flight was commenced with a fuel quantity below the minimum requirements, resulting in loss of engine power because of fuel exhaustion. Contributing to the occurrence was the lack of flight crew coordination.

Ce rapport est également disponible en français.

Table of Contents

List of Figures

1.0 Factual Information

1.1 History of the Flight

Buffalo Air Flight 526, a Douglas DC-3C freighter based in Yellowknife, was hauling jet fuel to Trout Lake from Fort Simpson, Northwest Territories, in support of forest fire suppression operations.

Before the departure from Yellowknife to Trout Lake, the flight crew checked the en route weather and filed a company flight itinerary. Dispatch issued the flight crew an aircraft-fuel-load receipt which indicated that the aircraft had been fuelled the night before with a total fuel quantity of about 436 imperial gallons (imp. gal.): full main tanks (336 imp. gal.), and 50 gallons in each auxiliary tank (100 imp. gal.). The first officer confirmed this quantity with a fuel dip-stick borrowed from the refueller.

At 0740 mountain daylight saving time (MDT)[1], the flight crew departed Yellowknife in accordance with visual flight rules (VFR)[2]. On board the aircraft were 17 full 45-imperial-gallon drums of Turbo-B jet fuel.

1 All times are MDT (Coordinated Universal Time [UTC] minus six hours) unless otherwise stated.

2 See Glossary for all abbreviations and acronyms.

At 0925 the aircraft landed at Trout Lake, and the 17 drums of jet fuel were off-loaded; the aircraft then departed for Fort Simpson at 0945. The 82-nautical-mile (nm) flight to Fort Simpson was flown at an altitude of about 2,500 feet above sea level (asl); the flight crew reported encountering light headwinds.

At 1020 the aircraft landed at Fort Simpson. Once again 17 drums of jet fuel were loaded on board, then the aircraft departed at 1049. The captain climbed the aircraft to an altitude of 3,500 feet asl. After he levelled off the aircraft, the captain adjusted the engines to 575 brake horsepower (bhp) settings.

At 1120, the aircraft landed at Trout Lake and the drums were off-loaded, and at 1135 the aircraft was once again airborne on the second round-trip shuttle flight.

Thirty-five minutes later the aircraft landed at Fort Simpson. While the cargo was being loaded on the aircraft, the flight crew discussed their different calculations regarding the aircraft's fuel quantity. The first officer indicated that the aircraft required fuel. The captain calculated that the aircraft had sufficient fuel remaining. The captain decided that they would refuel at Fort Simpson on the next shuttle flight; nonetheless, since the flight crew considered the cockpit fuel gauges unreliable, the captain requested that the first officer confirm the fuel quantity using a dip-stick.

At 1228, the aircraft departed Fort Simpson and climbed to 5,000 feet asl. About eight minutes later, the flight crew

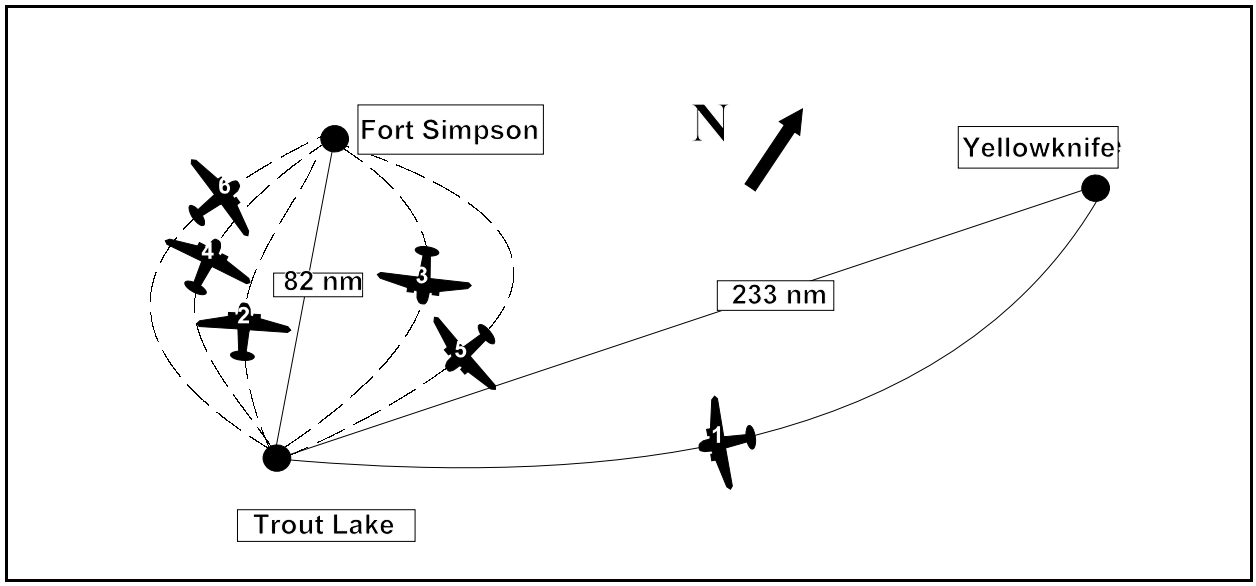


Figure 1 - Flight Segments

noticed that the fuel pressure was fluctuating, indicating that the auxiliary tanks were empty. The captain repositioned the fuel tank selectors to their respective main tanks and enquired about the dip-stick measurements. The first officer responded that he had not checked the fuel quantity because the fuel dip-stick was missing. The crew discussed the fuel quantity remaining and the captain calculated that the aircraft had approximately 45 minutes of fuel remaining.

Following the 1300 touchdown at Trout Lake, the cargo was unloaded and 31 empty fuel drums were loaded on board the aircraft for Fort Simpson.

At 1325 the aircraft departed Trout Lake. The first officer was the pilot flying (PF) the aircraft, and was in the right seat. The captain performed the duties of the pilot not flying (PNF). Twenty miles southwest of Fort Simpson, the PNF reported their position to Fort Simpson Flight Service Station (FSS). He also requested that the aircraft refueller be advised that they would require fuel on arrival. The flight crew then completed the descent checks and, at 10 miles southwest of the airport, the PNF updated FSS of their position and received the airport advisory.

Approximately six miles from the airport, at an altitude of about 400 to 500 feet above ground level (agl), the PF advised the PNF that the left engine was losing fuel pressure. Shortly thereafter, the left engine lost power. Immediately, the PNF switched the left fuel boost pump to the ON position, and the left fuel selector from LEFT MAIN to LEFT AUXILIARY tank position. The engine resumed power momentarily, but lost power again. The PNF then switched the left fuel selector to the RIGHT AUXILIARY tank position and the engine regained power; however, it promptly lost power again.

Realizing that the fuel had been depleted in three of the four tanks, the captain took control of the aircraft and headed straight for runway 31. As the captain called for the engine failure check for the left engine, the first officer advised the captain that the right engine was losing power. With a loss of power in both engines, and without sufficient altitude to glide to the airport, the first officer called the Fort Simpson FSS to advise that the flight crew would attempt a landing on the road (Mackenzie Highway) north of the Liard River. However, the approach to the road was

unsuccessful and the aircraft crash-landed into a treed area. (See Appendix A.)

At about 1403, several witnesses at the Liard River ferry crossing observed the aircraft flying low in a northwesterly direction. The aircraft was estimated to be at about 40 feet agl when it crossed overhead the ferry terminal and was descending. The witnesses reported that they heard the sound of the engines cutting in and out before the aircraft passed overhead their vantage points. They also reported seeing the landing gear being extended. The aircraft then disappeared from view behind the trees.

Immediately thereafter, the aircraft struck trees near the road, and crashed about 1/2 nm short of runway 31. The aircraft had been flown for approximately 4 hours and 37 minutes since its last refuelling.

The aircraft struck terrain at latitude 61°45'N and longitude 121°14'W, at an elevation of 450 feet asl[3], at approximately 1404 during the hours of daylight.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	1	-	-	1
Minor/None	1	-	-	1
Total	2	-	-	2

Both pilots received injuries to the head and upper body.

1.3 Damage to Aircraft

The aircraft sustained substantial damage.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

	Captain	First Officer
Age	38	28
Pilot Licence	ATPL	CPL
Medical Expiry Date	01 Sept 94	01 Mar 95
Total Flying Hours	14,000	1,300
Hours on Type	9,000	850
Hours Last 90 Days	315	200
Hours on Type Last 90 Days	315	170
Hours on Duty Prior to Occurrence	7.5	7.5
Hours off Duty Prior to Work Period	8.5	8

The flight crew was certified, trained, and qualified for the flight in accordance with existing regulations. Information regarding the crew members' flying experience was obtained from their personal records and company files.

The captain was described by the chief pilot, colleagues, and himself as a highly experienced pilot who would always attempt to get the job done as quickly and efficiently as possible.

The first officer commenced his flying career with this company and his licence was endorsed for DC-3 and DC-4 aircraft. He was described by colleagues as a professional pilot and a hard worker with a good attitude. He was also described as a pilot who would generally assert himself when necessary.

3 Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

1.6 Aircraft Information

Manufacturer	Douglas Aircraft Corporation
Type and Model	DC-3C
Year of Manufacture	1942
Serial Number	12307
Certificate of Airworthiness (Flight Permit)	Valid
Total Airframe Time	18,456 hr
Engine Type (number of)	Pratt & Whitney R-1830-92 (2)
Propeller/Rotor Type (number of)	Hamilton Standard 23E50-437 (2)
Maximum Allowable Take-off Weight	26,899 lb
Recommended Fuel Type(s)	100/130, 100 LL
Fuel Type Used	100 LL

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

The aircraft's weight and centre of gravity (C of G) for the occurrence flight were within the prescribed limits. The weight and balance, manifest forms, and a flight plan form were all located in the cockpit of the aircraft. These documents were completed in advance of the flight, in accordance with company procedures.

The company maintenance department reported that the aircraft was functioning normally on previous flights; no discrepancies regarding abnormal fuel consumption were noted in the maintenance records.

1.7 Meteorological Information

The Fort Simpson and vicinity sky conditions forecast by Environment Canada Atmospheric Environment Service (AES) were broken to overcast, with cloud bases at 1,500 feet agl. The visibility was forecast to be six miles and better, with a few light rain showers.

A pilot report (PIREP) issued four minutes prior to the accident reported the bases of cloud at 2,800 feet agl.

The 1400 Surface Weather Record issued by AES indicated the visibility was 15 miles, the wind was from 320 degrees at 10 knots, and the temperature was 13 degrees Celsius.

The 1800 850-millibar (mb) chart indicates that the winds over the upper Mackenzie valley at 5,000 feet asl were from 310 to 320 degrees at about 10 knots.

1.8 Aids to Navigation

At the time of the accident, the Fort Simpson Airport was served by the following navigational aids: one non-directional beacon (NDB), a very high frequency omni-directional range (VOR), and distance measuring equipment (DME). Both the NDB and the VOR/DME were serviceable, and were being used by the crew for navigation to and from Fort Simpson.

The crew was also using a Global Positioning System (GPS) for en route navigation.

1.9 Communications

Very high frequency (VHF) radio communications between Flight 526, the FSS specialist, and other aircraft on the mandatory frequency (MF), 122.2 megahertz (MHz), had been established and were functioning normally at the time of the accident. A record of the communications was transcribed from the FSS tape recordings.

1.10 Aerodrome Information

The Fort Simpson Airport is certified and is operated by Transport Canada. It is located about 6 nm southeast of the town site, with a field reference elevation of 555 feet asl. Runway 31/13 is a 6,000-by-150-foot, asphalt runway.

The terrain immediately southeast of the airport slopes downward toward the Liard River. The vegetation succession levels range from shrubs near the river edge, to willows, and finally to about 125-foot-tall coniferous and deciduous trees. The aircraft's initial point of impact was approximately 100 feet below the runway elevation.

Airport emergency response services (ERS) are available for on-aerodrome occurrences.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

1.12 Wreckage and Impact Information

1.12.1 Accident Site

The aircraft struck the trees and rising river valley terrain approximately 2,900 feet from the threshold of runway 31. The accident site is immediately adjacent to the Mackenzie Highway near the Liard River ferry crossing.

1.12.2 Aircraft Wreckage

During its final flight path, the aircraft struck trees on a heading of about 300 degrees magnetic (°M), in a shallow descent of approximately 5 degrees, and with a 28-degree right-wing-low attitude. The aircraft continued through the trees in this direction and attitude for about 97 feet; it then swung to the right and the nose struck the ground in a flat cartwheel motion. The aircraft came to rest, right side up, 164 feet from the point of initial impact, on a heading of 100°M. The tail was propped up in 12-inch diameter poplar trees.

1.12.3 Ground Scars

The ground and tree scars left by the aircraft indicated deceleration and were consistent with the direction of travel of the aircraft. There was no evidence found of propeller rotational signatures.

1.12.4 Airframe Systems

A post-accident examination of the airframe revealed no evidence of pre-impact structural failure or loss of control continuity. The impact airspeed could not be determined from the examination of the aircraft instruments.

1.12.5 Propeller Examination

The right propeller was located on the right side of the wreckage trail 141 feet past the point of initial impact. One blade on each of the three-bladed propellers was bent back in an asymmetrical position. Neither propeller was in a high-blade angle or feathered position, and neither revealed evidence of rotational, torsional, or leading edge damage.

The absence of propeller blade rotational damage and leading edge damage is consistent with the absence of engine power at the time of impact.

1.12.6 Engine Examination

The engines were examined to the degree possible, and no evidence of a malfunction was found.

1.12.7 Fuel System Examination

A visual field inspection of the aircraft's fuel tanks revealed that there was no usable fuel on board. The fuel that was remaining in the aircraft's tanks was removed, measured, and examined. The absolute quantity extracted from all four tanks totalled about three imp. gal., and was of the proper grade and quality.

The fuel system was examined and there was no evidence of a system defect or malfunction prior to or during the flight.

The aircraft departed Yellowknife with an approximately balanced wing fuel quantity, and the cross-feed system was not utilized during the flight segments until engine power was lost. On final approach, both engines lost power within about two minutes of each other. The almost simultaneous loss of power indicates that there was equal fuel consumption

between engines. It is, therefore, unlikely that fuel leakage, rich carburation, or an engine malfunction occurred.

During the wreckage examination, the fuel dip-stick was located under the auxiliary power unit platform at the rear of the aircraft. The dip-stick is normally stored in this area.

1.13 Medical Information

There was no evidence that incapacitation or physiological factors affected the crew's performance.

1.14 Fire

There was no evidence of fire either before or after the occurrence.

1.15 Survival Aspects

The accident final flight path deceleration forces were attenuated, and progressively absorbed, by a growth of thick willows, smaller trees, and finally larger trees. In addition, the 28-degree right-wing-low attitude caused the aircraft to pivot in a flat cartwheel type of manoeuvre during contact with the thick willow growth. During this manoeuvre, much of the forward energy was dissipated, and the aircraft slid backwards before coming to a stop.

The cabin area maintained its integrity throughout the accident; however, the cockpit immediately forward of the seats was severely damaged.

The aircraft was not equipped with shoulder harnesses, nor were they required by regulation.

The emergency locator transmitter survived the crash. It activated and functioned normally after the impact.

The easy access to the crash site, located about 150 feet north of the Mackenzie Highway, allowed rescue personnel to quickly evacuate the flight crew.

1.16 Fuel Services Available

Fuel service is available at the Fort Simpson Airport. The fuel facility is located approximately 2,500 feet south of the forestry base where the DC-3C was loading and unloading its cargo. The hours of operation of the fuel service follow regular working hours from Monday to Friday. A callout charge is levied for after-hours and weekend fuel services. The occurrence flight was conducted on a Sunday.

There is no fuel service available in Trout Lake.

1.17 Company Operations

Buffalo Airways employs a pilot self-dispatch system. Accordingly, the pilot-in-command of any flight has the sole authority to make decisions as to initiation, continuation, delay, diversion or re-routing, and refuelling of the flight when conditions are such that operational decisions are necessary. The pilot-in-command has the sole responsibility for ensuring that the flight is conducted safely.

During the investigation, it was determined that the company pilots were not subject to management pressure to operate aircraft below the company minimum fuel requirements. In addition, the flight crew was directed by the chief pilot to refuel on every leg, when possible, for the assurance of meeting the fuel requirements and the carriage of optimum cargo loads.

1.18 Fuel Requirements

1.18.1 Air Regulations

For flight planning purposes and for ensuring that adequate fuel is carried on board, Air Regulation 544 states the following:

> The amount of fuel and oil carried on board any aircraft ... at the

commencement of any VFR flight shall be sufficient, taking into account anticipated wind and other weather conditions, to fly to the place of intended landing and thereafter

a) in the case of an aircraft other than a helicopter, for 45 minutes at normal cruising speed.

Excerpts from sections 26, 27, and 29 of Air Navigation Order (ANO) Series VII, No. 2, state the following:

No person shall authorize a flight and no person shall commence a flight, unless, having regard to the meteorological conditions and delays that are expected in flight, the aeroplane carries

a) sufficient fuel and oil to ensure that the flight can be completed safely;

The fuel and oil carried ... in the case of a propeller-driven aeroplane, be at least sufficient to allow the aeroplane,

a) when an alternate airport is not required,

i) to fly to the airport to which the flight is planned and thereafter for a period of 45 minutes at normal cruising speed, and

ii) to have a reserve of fuel, based on consideration of ... contingency factors.

In computing the amount of fuel and oil, ... the following contingency factors shall be considered:

(a) meteorological conditions forecast;

(b) anticipated air traffic control routings and traffic delays;

(c) one instrument approach at the airport to which the flight is planned, including a missed approach;

(d) the procedures set out in an air carrier's operations manual for loss of pressurization, where applicable, or failure of one power unit while en route; and

(e) any other conditions that may delay the landing of the aeroplane.

1.18.2 Company Requirements

The company minimum fuel requirements as outlined in Section 1, page 33, of the *Company Operations Manual* are as follows:

Fuel Loading

The minimum quantity of fuel with which it is permissible to operate the aircraft on any flight, from any station, is to be 146 Imperial gallons plus taxi fuel which must be distributed in the following order:

a. Under all conditions each rear tank must carry a minimum of ten Imperial gallons.

b. The remainder (126 Imp. gal. plus ten Imperial gallons taxi fuel) is to be evenly distributed between the two front tanks.

Neither pilot was sufficiently conscious of the minimum fuel requirements outlined in the *Company Operations Manual.*

1.19 Fuel Calculations and Monitoring

1.19.1 Fuel Load

At the start of the day, the aircraft had a total fuel quantity, as indicated on the fuel receipt, of about 436 imp. gal.: full main tanks (336 imp. gal.), and 50 gallons in each auxiliary tank (100 imp. gal.). The first officer confirmed this quantity with a fuel dip-stick.

Section 1, page 33, of the *Company Operations Manual* refers to the aircraft's unusable fuel quantity. Subsection 10, paragraph (3), under the title "Fuel System" states:

> When it is necessary to conserve fuel, tanks can be drained to approximately two gallons by flying 3° to 5° wing low on the side opposite to the tank being drained and in a slight climb.

The captain reported banking the aircraft during the final descent, in an attempt to conserve fuel. The total unusable fuel would then be 8 imp. gal.; therefore, the aircraft had a total usable fuel quantity of 428 imp. gal.

1.19.2 Start, Taxi, Run-up, and Take-off Fuel

Section 6, page 1, of the *Company Operations Manual* states that "normally all flights will be planned using 550 bhp per engine." In addition, the manual states that an "additional 10 Imp. gal. will be allowed for every run-up, taxi, and take-off."

If a run-up is not required before departure, the company pilots use an amount less than 10 imp. gal. The captain stated he used a figure of 7 imp. gal. for taxi and take-off; this occurrence flight had six take-offs.

1.19.3 Climb and Cruise Fuel

A Climb Performance Chart located in Section 6, page 6, of the *Company Operations Manual* outlines the fuel requirements for the aircraft to climb to altitude with the climb power setting of 785 bhp.

This chart has many parameters, such as outside air temperature, the altitude at which the climb was started, the altitude at which the climb was completed, the time to climb, the distance to climb, the fuel required to climb, etc. For example, the fuel required to climb from sea level to 5,000 feet asl is 22 imp. gal. and the fuel required from sea level to 2,000 feet asl is 9 imp. gal. This aircraft had six climbs ranging from 1,000 feet to 5,000 feet.

The Power Chart as outlined in Section 3, page 3, of the *Company Operations Manual* states:

> The fuel consumption for both engines at 550 bhp engine settings, below 5,000 feet asl, and with the mixture control set to AUTO LEAN is about 71 Imperial gallons per hour. The fuel consumption for both engines at 575 and 600 bhp engine settings, with the above conditions, is about 75 and 77 Imperial gallons per hour respectively.

Neither the captain nor the first officer consulted the fuel consumption charts during their fuel calculations and related discussions. All the flight segments on the day of the occurrence were flown with the engine set to 575 bhp with the mixture in the AUTO RICH position; the fuel consumption would have been greater than the stated 75 imp. gal. per hour.

To expedite flight planning and fuel calculations, some flight crew add 10 to 15 imp. gal. per hour to the fuel consumption calculations instead of computing the climb fuel requirements. The flight crew of another DC-3, which was substituted to complete the fuel haul after the accident, reported that their estimated fuel consumption for the remaining flights was between 85 to 90 imp. gal. per hour.

1.19.4 Fuel Monitoring

To monitor the aircraft's fuel quantity, the pilots of the occurrence aircraft used the cockpit fuel quantity indicator, which they reported as unreliable, and a fuel tank dip-stick. No visual checks of the fuel quantity were conducted by the flight crew.

To visually check the fuel quantity, there are many rules of thumb used by DC-3 pilots. If, during the visual inspection, the fuel cannot be seen by looking straight down into

the tank through the eight-inch diameter filler cap, the fuel quantity is usually less than 35 imp. gal. The fuel tank seams are also used for visual fuel quantity checks. The first seam from the bottom of the tank equates to about 50 imp. gal., and the second seam from the bottom equates to about 100 imp. gal. This method, however, can only be utilized with the aircraft in a level, three-point attitude.

1.20 Crew Coordination

The captain had flown approximately 30 hours with the first officer in the previous year.

The flight crew had not received any formal training from the company in crew or cockpit resource management (CRM) or pilot decision making (PDM). The captain had previously received CRM and PDM training from a former employer. CRM is commonly described as the effective use of all resources available to flight crew, including equipment, technical/procedural skills, and the contributions of flight crew to others.

The objective of CRM training has been stated as follows:

> To use all available resources to ensure safe and efficient flight operations, while at the same time providing the technical and pilot skills training that is needed to maintain proficiency in the most effective way possible.

2.0 Analysis

2.1 Introduction

Because it was determined that the aircraft was airworthy prior to impact, and that the weather was suitable for visual flight at the time of the occurrence, it was necessary to concentrate on the human areas of flight planning in order to determine why the accident occurred. The following analysis, therefore, focuses primarily on fuel management and crew coordination.

2.2 Fuel Calculations

During a discussion with the first officer on the last flight into Trout Lake, about 15 minutes out of Fort Simpson, the captain stated that the aircraft had 45 minutes of fuel remaining. After landing in Trout Lake with approximately 30 minutes of fuel remaining, the aircraft departed for Fort Simpson with less fuel than the minimum required as outlined in the *Air Regulations* and company requirements. The previous two flights to Fort Simpson had taken 35 minutes; however, the captain still felt that there was enough fuel remaining to complete the flight to Fort Simpson. Neither pilot was sufficiently conscious of the minimum fuel requirements outlined in the *Company Operations Manual*.

There was no evidence that company management placed any pressure on company pilots to continue flights with less than the minimum fuel requirements. The self-dispatch policy used by the company placed full responsibility for all decisions, after the flight was assigned, with the pilot-in-command.

The fuel dip-stick, which is used to cross-check the accuracy of the fuel gauges, could not be located during the last station stop fuel check. Although the accuracy of the fuel gauges may have been jeopardized without the dip-stick reading, a visual check of the fuel tanks through the eight-inch diameter filler cap would have revealed the approximate fuel quantity. Thus, the dip-stick would merely have confirmed the low fuel status as indicated on the fuel gauges.

2.3 Pilot Decision Making

In the absence of any management pressure, mechanical malfunction, or any other identified source of external influence, it is apparent that the captain chose to attempt the flight with fuel below the minimum requirements. The company requirements and the aviation regulations require extra fuel for reserves and contingencies to provide for a margin of safety. It was the captain who decided the flight could be completed safely. His calculations must have been incorrect.

The final decision to fly with low fuel was also made in the context of risk assessment attitudes influenced by remote flying operations which, at times, may result in higher levels of risk. However, it is clear that, in deciding on this course of action, the captain misjudged the fuel requirements necessary to safely complete this flight.

2.4 Crew Coordination

In multi-crewed aircraft, team-work is essential for the detection of errors in various areas, such as fuel management. Effective cockpit communications are essential to good team-work. Neither the captain nor the first officer had received formal training from this company in CRM or PDM, although the captain had taken a CRM course with a previous employer.

Following a discussion regarding the aircraft's fuel status at the previous station stop, the captain's fuel calculations and decision to conduct the accident flight were consequently accepted by the first officer. Although the calculations differed, the first officer, who had much less flying experience than the captain, did not sufficiently assert himself regarding the aircraft's low fuel state.

2.5 Shoulder Harnesses

Both pilots received injuries to the head and upper body, likely because they were thrown forward against the instrument panel and controls on impact.

The aircraft was not equipped with shoulder harnesses. If shoulder harnesses had been available and worn by the flight crew, the injuries might have been less severe, or prevented.

3.0 Conclusions

3.1 Findings

1. The flight crew was certified, trained, and qualified for the flight in accordance with existing regulations.

2. The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

3. The aircraft was airborne for 4 hours and 37 minutes without refuelling.

4. The engines stopped on approach because of fuel exhaustion.

5. There was no evidence found of any airframe failure or system malfunction prior to or during the flight.

6. Damage to the propeller systems was consistent with a lack of power at the time of impact.

7. The flight crew operated the aircraft with less than the required company minimum quantity of fuel as outlined in Section 1, page 33, of the *Company Operations Manual*.

8. The flight crew operated the aircraft with less than the minimum required quantity of fuel as outlined in ANO, Series VII, No. 2, sections 26 and 27, and Air Regulation 544.

9. Neither of the flight crew members had received formal CRM or PDM training from the company.

10. Shoulder harnesses, although not required by regulation, were not installed in the aircraft, and both crew members received injuries to the head and upper body.

3.2 Causes

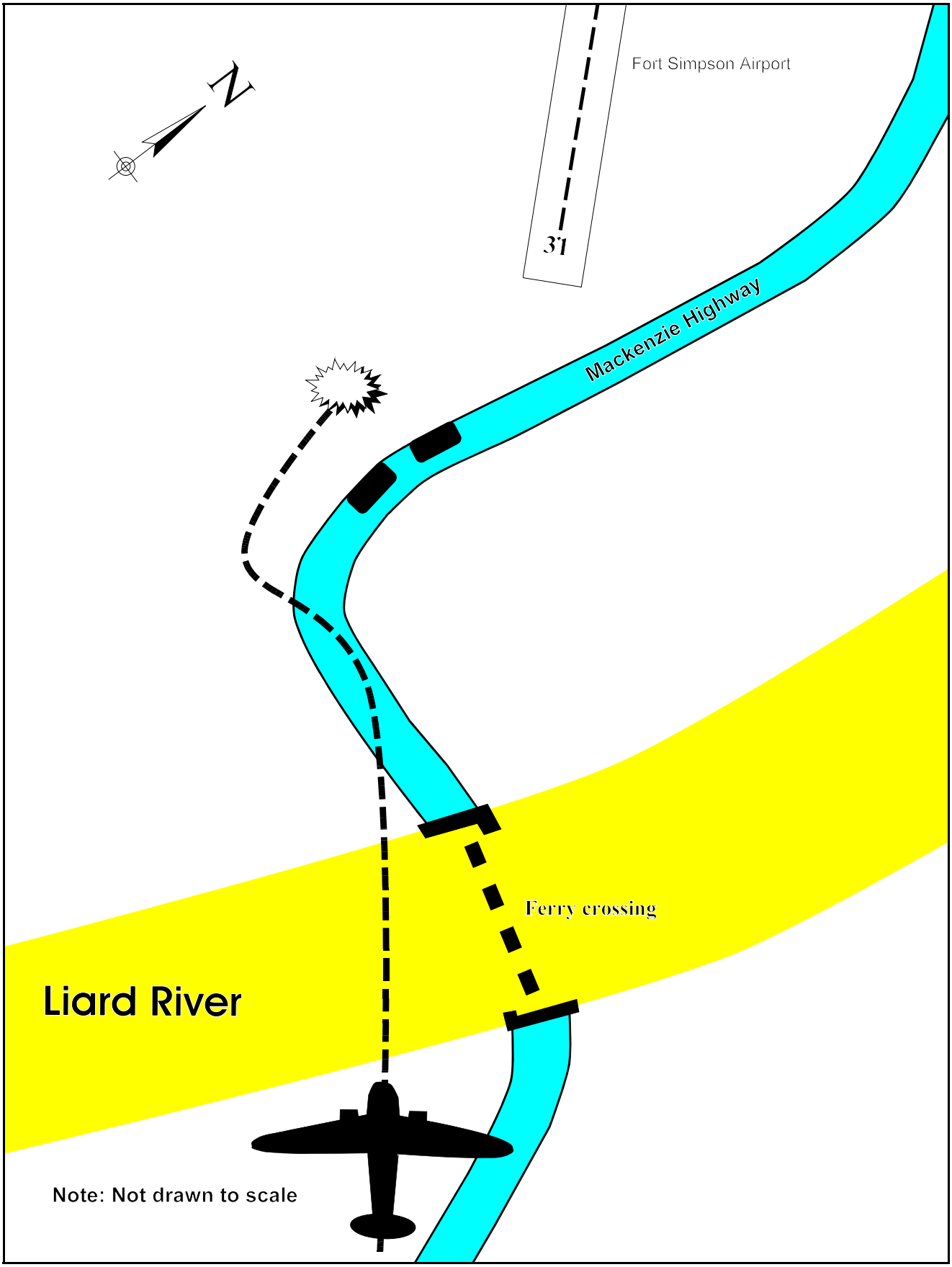
The flight was commenced with a fuel quantity below the minimum requirements, resulting in loss of engine power because of fuel exhaustion. Contributing to the occurrence was the lack of flight crew coordination.

4.0 Safety Action

The Board has no aviation safety recommendations to issue at this time.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson John W. Stants, and members Zita Brunet and Hugh MacNeil, authorized the release of this report on 07 June 1995.

Appendix A - Occurrence Flight Path


N
Fort Simpson Airport
31
Mackenzie Highway
Ferry crossing
Liard River
Note: Not drawn to scale

Appendix B - Glossary

AES	Atmospheric Environment Service
agl	above ground level
ANO	Air Navigation Order
asl	above sea level
ATPL	airline transport pilot licence
bhp	brake horsepower
C of G	centre of gravity
CPL	commercial pilot licence
CRM	crew resource management
DME	distance measuring equipment
ERS	emergency response services
FSS	Flight Service Station
gal	gallon(s)
GPS	Global Positioning System
hr	hour(s)
Imp	Imperial
lb	pound(s)
LL	low lead
mb	millibar
MDT	mountain daylight time
MF	mandatory frequency
MHz	megahertz
N	north
NDB	non-directional beacon
nm	nautical miles
PDM	pilot decision making
PF	pilot flying
PIREP	pilot report of weather conditions in flight
PNF	pilot not flying
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
VFR	visual flight rules
VHF	very high frequency
VOR	very high frequency omni-directional range
W	west
'	minute(s)
°	degree(s)
°M	degrees of the magnetic compass

TSB OFFICES

HEAD OFFICE

HULL, QUEBEC*
Place du Centre
4th Floor
200 Promenade du Portage
Hull, Quebec
K1A 1K8
Phone (819) 994-3741
Facsimile (819) 997-2239

ENGINEERING
Engineering Laboratory
1901 Research Road
Gloucester, Ontario
K1A 1K8
Phone (613) 998-8230
24 Hours (613) 998-3425
Facsimile (613) 998-5572

*Services available in both official languages

REGIONAL OFFICES

ST. JOHN'S, NEWFOUNDLAND
Marine
Centre Baine Johnston
10 Place Fort William
1st Floor
St. John's, Newfoundland
A1C 1K4
Phone (709) 772-4008
Facsimile (709) 772-5806

GREATER HALIFAX, NOVA SCOTIA*
Marine
Metropolitain Place
11th Floor
99 Wyse Road
Dartmouth, Nova Scotia
B3A 4S5
Phone (902) 426-2348
24 Hours (902) 426-8043
Facsimile (902) 426-5143

MONCTON, NEW BRUNSWICK
Pipeline, Rail and Air
310 Baig Boulevard
Moncton, New Brunswick
E1E 1C8
Phone (506) 851-7141
24 Hours (506) 851-7381
Facsimile (506) 851-7467

GREATER MONTREAL, QUEBEC*
Pipeline, Rail and Air
185 Dorval Avenue
Suite 403
Dorval, Quebec
H9S 5J9
Phone (514) 633-3246
24 Hours (514) 633-3246
Facsimile (514) 633-2944

GREATER QUÉBEC, QUEBEC*
Marine, Pipeline and Rail
1091 Chemin St. Louis
Room 100
Sillery, Quebec
G1S 1E2
Phone (418) 648-3576
24 Hours (418) 648-3576
Facsimile (418) 648-3656

GREATER TORONTO, ONTARIO
Marine, Pipeline, Rail and Air
23 East Wilmot Street
Richmond Hill, Ontario
L4B 1A3
Phone (905) 771-7676
24 Hours (905) 771-7676
Facsimile (905) 771-7709

PETROLIA, ONTARIO
Pipeline and Rail
4495 Petrolia Street
P.O. Box 1599
Petrolia, Ontario
N0N 1R0
Phone (519) 882-3703
Facsimile (519) 882-3705

WINNIPEG, MANITOBA
Pipeline, Rail and Air
335 - 550 Century Street
Winnipeg, Manitoba
R3H 0Y1
Phone (204) 983-5991
24 Hours (204) 983-5548
Facsimile (204) 983-8026

EDMONTON, ALBERTA
Pipeline, Rail and Air
17803 - 106 A Avenue
Edmonton, Alberta
T5S 1V8
Phone (403) 495-3865
24 Hours (403) 495-3999
Facsimile (403) 495-2079

CALGARY, ALBERTA
Pipeline and Rail
Sam Livingstone Building
510 - 12th Avenue SW
Room 210, P.O. Box 222
Calgary, Alberta
T2R 0X5
Phone (403) 299-3911
24 Hours (403) 299-3912
Facsimile (403) 299-3913

GREATER VANCOUVER, BRITISH COLUMBIA
Marine, Pipeline, Rail and Air
4 - 3071 Number Five Road
Richmond, British Columbia
V6X 2T4
Phone (604) 666-5826
24 Hours (604) 666-5826
Facsimile (604) 666-7230