AVIATION OCCURRENCE REPORT

UNSTABILIZED APPROACH/HARD LANDING

ALBERTA CITYLINK
BRITISH AEROSPACE JETSTREAM 31 C-FBIE
LLOYDMINSTER, ALBERTA
20 JANUARY 1998

REPORT NUMBER A98W0011

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British Aerospace Jetstream 31 C-FBIE
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Synopsis

At 1700 MST, Alberta Citylink flight 933, C-FBIE, a British Aerospace Jetstream 31, serial number 815, took off from Calgary, on a scheduled flight to Lloydminster, Alberta. The aircraft carried a two-pilot crew, 13 passengers, and 250 pounds of freight and baggage. A non-precision automatic direction finder (ADF) approach was conducted to runway 25. The first officer was flying the approach, and when the runway environment became visual, the captain took control, requested 35 degrees of flap, and commenced the final descent to the runway. On touchdown, the left main landing gear collapsed and both propellers struck the runway surface. The aircraft slid along the runway on the belly pod for about 1 800 feet, and when the left wing contacted snow on the edge of the runway, the aircraft turned about 160 degrees. The passengers and crew evacuated through the over-wing exit. There was no fire and no injuries.

The Board determined that an unstabilized approach resulted in a heavy landing because the captain changed the configuration of the aircraft, and the high rate of descent was not arrested before contact was made with the runway surface. Contributing to the high rate of descent were the reduction of engine power to flight idle, airframe ice, and the time available for the final descent. Contributing to the damage on landing was the left-to-right movement of the aircraft.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

At 1700 mountain standard time (MST)[1], Alberta Citylink flight 933, C-FBIE, a British Aerospace Jetstream 31, serial number 815, took off from Calgary, Alberta, on a scheduled flight to Lloydminster, Alberta. The aircraft carried a two-pilot crew, 13 passengers, and 250 pounds of freight and baggage.

The crew planned a non-precision automatic direction finder (ADF)[2] approach to runway 25 at Lloydminster with an overcast ceiling of 400 feet, visibility of 5 statute miles (sm) in blowing snow and mist, and the wind from 110 degrees true at 7 knots. When the aircraft was inbound, the flight service station (FSS) specialist reported that the visibility had decreased to 3 sm. The crew were aware of approximately ⅛ to ¼ inch build-up of ice on the aircraft during descent and so planned for a flap 20 landing. The first officer was flying the approach from the right-hand seat while the captain was monitoring the instruments and looking outside the aircraft for visual contact with the runway environment. When the captain saw the runway from the minimum descent altitude (MDA), he took control for the landing. The aircraft was north of the extended centre line of runway 25. FLAPS 35 was selected, the power was reduced to flight idle, a turn to regain the centre line was carried out, and a descent was commenced from MDA. The aircraft contacted the runway surface heavily, moving left to right. As a result, the left main landing gear collapsed. Both propellers struck the runway, and the left propeller separated from the engine. The aircraft slid along the runway on the belly pod for a distance of about 1 800 feet. The left wing contacted the snow on the edge of the runway, resulting in a turn of about 160 degrees. The evacuation took place immediately after the aircraft came to rest; all occupants escaped quickly through the right, over-wing exit.

The FSS specialist informed emergency response services (ERS) immediately after the aircraft crashed. The airport manager and others in the vicinity responded immediately. ERS, dispatched from Lloydminster, arrived about 17 minutes later. The aircraft occupants walked to the nearby terminal building without assistance.

The aircraft struck the runway at latitude 53° 18′ N and longitude 110° 4′ W, at approximately 1810, during the hours of darkness, and at an altitude of 2 194 feet above sea level (asl)[3].

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1 All times are MST (Coordinated Universal Time minus seven hours) unless otherwise noted.

2 See Glossary at Appendix B for all abbreviations and acronyms.

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

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	2	13	-	15
Total	2	13	-	15

1.3 Damage to Aircraft

The aircraft was substantially damaged in the occurrence.

1.4 Other Damage

There was minor runway damage from propeller blade tip contact on impact, and several runway edge marker lights were broken off.

1.5 Personnel Information

1.5.1 General

	Captain	First Officer
Age	33	22
Pilot Licence	ATP	CML
Medical Expiry Date	98/11/01	99/01/01
Total Flying Hours	4 786	1 450
Hours on Type	635	151
Hours Last 90 Days	136	201
Hours on Type Last 90 Days	136	151
Hours on Duty Prior to Occurrence	12	12
Hours off Duty Prior to Work Period	72	72

1.5.2 Captain's History

The captain began employment with the company in February 1997 and started flying as first officer on the Jetstream 31 in March 1997. He was upgraded to captain in October 1997. Prior to joining Alberta Citylink, he flew as captain on Piper Navajo and other light twins. He was licensed and qualified for the flight and held a valid class 1 medical with no restrictions. A review of his previous check rides indicates that he met the requirements with only minor debriefing points noted.

The captain had not flown since 16 January 1998. He started work on 20 January 1998 at 0600 and had flown a total of 6.2 hours during that day.

1.5.3 First Officer's History

The first officer started employment with the company in March 1997 as first officer on the King Air 100. He qualified on the King Air 200 in July 1997 and on the Jetstream 31 in October 1997. He was licensed and qualified for the flight as first officer and held a valid class 1 medical with no restrictions. Prior to joining Alberta Citylink, the first officer flew for a charter and air ambulance operator in northern Alberta.

The first officer had not flown since 16 January 1998. He reported for duty at 0600 on the morning of 20 January 1998 and had flown 6.2 hours prior to the accident.

1.5.4 Crew Assignment

The captain and first officer had flown together previously as a crew, but crew assignments varied as many of the first officers maintained dual currency, flying also as first officers on company King Air aircraft.

1.6 Aircraft Information

1.6.1 General

Manufacturer	British Aerospace
Type and Model	Jetstream 3112-01
Year of Manufacture	1988
Serial Number	815
Certificate of Airworthiness (Flight Permit)	Valid
Total Airframe Time	16,180.1
Engine Type (number of)	Garrett TPE 331-10UGR-516H (2)
Propeller/Rotor Type (number of)	McCauley 4HFR34C652J/B-L106LA-0 (2)
Maximum Allowable Take-off Weight	15 322 lbs
Recommended Fuel Type(s)	Jet A, JetA-1, Jet B
Fuel Type Used	Jet A-1

1.6.2 Aircraft

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The maintenance logbooks contained no evidence of uncorrected deficiencies relevant to the circumstances of the occurrence. The aircraft's weight was within limits, and the centre of gravity was within the normal range.

1.6.3 Flap Lift Dump

The flap system incorporates a lift dump capability to decrease the stopping distance by increasing drag and the weight on the wheels. Lift dump lowers the flaps to 70 degrees from the maximum selected flap position of 35 degrees. The lift dump occurs when:

- a FLAPS 35 selection has been made;
- either or both engine power levers have been selected to below their flight idle setting to activate power lever micro-switches; and
- the nose landing gear oleo micro-switch has operated at aircraft touchdown.

1.7 Meteorological Information

The amended terminal forecast for Lloydminster faxed by Springbank FSS to the company base at Calgary and available to the crew prior to departure was: winds from 110 degrees true at 6 knots, visibility 2 sm in light snow and mist, with the ceiling overcast at 400 feet. Temporarily between 1700 and 2000 UTC, the visibility was forecast to be greater than 6 sm in light snow with a scattered cloud layer at 400 feet and an overcast ceiling at 1 500 feet. From 2000 UTC, the winds were to be from 110 degrees true at 6 knots, visibility 6 sm in light snow, with a scattered layer of cloud at 800 feet and an overcast layer at 2 000 feet. Temporarily between 2000 and 0500 UTC, visibility was to decrease to 2 sm in light snow and mist, with an overcast ceiling at 800 feet.

The weather passed to the crew by Lloydminster FSS prior to commencing the approach was: winds 110 degrees true at 7 knots, visibility 5 sm in light snow and fog, temperature minus 13 degrees Celsius, dew point minus 12 degrees Celsius, and the altimeter setting was 30.00.
Earlier in the day, the ceiling was as low as 100 feet above ground level (agl), with visibility of ¼ mile in fog. During the day, the ceiling and visibility increased to a high overcast ceiling and visibility greater than 15 sm. The lower layers started moving into the area about one hour prior to the arrival of this flight.

1.8 Aids to Navigation

The Lloydminster Airport is equipped with a non-directional beacon (NDB) operating on a frequency of 241 kHz and distance measuring equipment (DME) operating on a frequency of 110.75 mHz. All ground-based navigation aids were reported to be operating within normal parameters. There were no reported unserviceabilities on the aircraft navigation receiving equipment.

1.9 Communications

All communications between the aircraft and ground facilities had been established and were normal, and all communications equipment functioned properly. A review of the FSS tapes did not reveal any abnormalities.

1.10 Aerodrome Information

The Lloydminster Airport is a municipally operated, certified facility with a 150-foot-wide, 5 577-foot-long paved main runway, oriented 070 degrees/250 degrees magnetic, at an altitude of 2 194 feet asl.

1.11 Flight Recorders

1.11.1 General

The flight data recorder (FDR) and the cockpit voice recorder (CVR) were sent to the TSB Engineering Branch for analysis.

The CVR was a Loral CVR, model A 100, serial number 15586 that recorded the crew and area microphone channels on a 30-minute continuous loop. The occurrence data from the crew and the radio communications to the aircraft were of good quality.

The FDR was an Allied Signal UFDR, model 980-4100-GWXS, serial number 4514 that recorded indicated airspeed, pressure altitude, heading, vertical G, time, and a very high frequency (VHF) key indication. The data retrieved from the FDR were of good quality.

1.11.2 Recorded Information

The following information has been extracted primarily from the TSB Engineering Branch analysis of the FDR.

Following the crew's procedure turn inbound call, the FSS reported the latest wind conditions and surface visibility. The landing gear was lowered and the flaps were extended to 20 degrees as the aircraft levelled at the MDA of 2 640 feet asl, or 457 feet agl.

During the gear and flap extension, the speed decreased by 24 knots, from 138 knots indicated airspeed (KIAS) to the V_{ref} speed of 114 KIAS (Appendix A). The crew corrected for the decrease in speed, accelerating to 144 KIAS. During the acceleration, the aircraft briefly climbed approximately 70 feet, then descended back to the MDA.

Approximately three miles back from the runway threshold, and before visual contact was established, the aircraft was left of the inbound track. A track correction to the right followed, as evidenced by a 15-degree increase in heading. When the final descent to the runway commenced, the aircraft began to decelerate from 140 KIAS at an initial rate of 1.5 knots per second. The captain requested flaps 35; a high sink rate subsequently developed, reaching a peak of approximately 1 700 feet per minute (fpm) as the heading briefly reached about 230 degrees magnetic; the runway track is 253 degrees. Meanwhile, the rate of deceleration increased, eventually reaching 5 knots per second at the time of the hard landing. The first officer reported the flight on final when the recorded altitude, speed, and heading were approximately 200 feet agl, 129 KIAS, and 228 degrees, respectively. Following the FINAL call, the heading began to increase, suggesting a track correction to the right, and the descent rate reduced to approximately 1 200 fpm. Approximately 1½ seconds prior to the landing, the pitch of the engine/propeller sounds increased, indicating an increase in power. The descent rate was not arrested prior to touchdown, resulting in a hard landing with a high vertical deceleration of approximately 2.25 g, at 99 KIAS, and on the approximate runway heading of 252 degrees. The FDR stopped recording approximately four seconds after initial runway contact. The CVR continued to record until the power was shut off.

1.12 Wreckage and Impact Information

The wing structure and the engine support beams in the wing were damaged in the hard landing, allowing the right engine to droop. The propeller blades were abraded and curled rearwards, and the left propeller separated from the reduction gearbox. The flaps were damaged and displaced and the belly-mounted baggage pod was crushed. The left main gear attachment spigots had sheared off and the right main gear radius rod support had fractured. The left main gear collapsed, and the aircraft was supported by the belly pod and damaged right main gear. The left main gear sliding tube was bent, and the left tire was cut and deflated from rim contact at impact. The main gear damage pattern was consistent with the aircraft drifting to the right at impact. The sheared left main gear spigots and the fractured right main gear radius rod were examined at the TSB Engineering Branch and were found to have failed due to overstress. The damaged components met all material and dimensional design specifications.

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

1.13 Medical Information

Not applicable.

1.14 Fire

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

1.15 Survival Aspects

1.15.1 Aircraft Evacuation

When the aircraft came to rest in a snowbank alongside the runway, the right emergency exit was opened immediately and the passengers began evacuating through this exit. There was an attempt to open the main passenger door, but it could not be opened. Impact damage resulted in sheet metal distortion on the wing walk area, causing the occupants difficulty in leaving the aircraft. The main passenger door, which is hinged at the bottom, was held closed by the snowbank.

The fuel cells, some of which were ruptured during the impact sequence, leaked fuel onto the right wing walk causing it to be extremely slippery for exiting occupants. The leaking fuel soaked into the surrounding snowbank creating a potential fire hazard.

After clearing some snow, the main passenger door was opened from the outside, but no tests were conducted to see if it was possible to open the door from the inside. The later model Jetstream 32 has an emergency exit on both the right and left side of the fuselage.

1.15.2 Emergency Response

The airport operator is the city of Lloydminster and, when required, emergency response is done by the city. In this case, the services were called immediately after the accident. Response time was 17 minutes.

1.16 Tests and Research

Flights in a Jetstream 31 simulator at Flight Safety in Seattle, Washington, USA, were carried out using the data from the FDR to duplicate as closely as possible the accident flight at Lloydminster. The airport at Lloydminster, or another airport at the same altitude with the same runway heading and the beacon on the field, could not be located in the simulator data base. Runway 25 at Calgary was used for the flights, but this proved difficult to accurately calculate where the final descent was to begin; therefore, no significant conclusions could be drawn from these flights.

1.17 Organizational and Management Information

Alberta Citylink is the company contracted by Air BC to conduct flights as a connector from Calgary to Medicine Hat, Lethbridge, Lloydminster, and Cold Lake. Bar XH, based in Medicine Hat, is the parent company that supplies the aircraft and the operating personnel.

The company president oversees the operation through an operations manager, a chief pilot, and a chief of maintenance. At the time of the accident the chief pilot was responsible for the recurrent training of aircrew.

1.17.1 Company Training

The company conducts flight crew and maintenance training at the base in Medicine Hat for the Jetstream aircraft operated by Alberta Citylink. Flight simulator training, both initial and recurrent, is conducted at Flight Safety in Seattle. The company conducts bi-annual recurrent training followed by a PPC. The training includes recurrent ground school, precision and non-precision approaches, emergency procedures; including engine failures on take-off, and crew coordination and line monitoring.

1.17.2 Manual Information

Operational information for pilots is contained in the *BA 31 Pilot's Handbook*, the *Flight Safety Jetstream 3100 Training Manual,* and the *Operating Requirements Manual* of 650584 Alberta Inc. (company name prior to Alberta Citylink). The illustration of a non-precision approach is contained in the *BA 31 Pilot's Handbook* and shows the speeds to be flown, checklists to be carried out, rates of descent, etc. There is no guidance to pilots in any of the manuals to make the appropriate calls when an approach becomes unstabilized, nor is it a requirement.

1.17.3 Duty Period

This was the first work day following three days off. Both pilots reported for duty at 0600 the morning of the accident. Their flying was to consist of three return flights to Lloydminster arriving back in Calgary at about 1940. There is a four-hour layover in Calgary between the morning and afternoon flights. This would have been a 12-hour-40-minute duty period. The first flight in the morning was delayed due to poor weather at Lloydminster. The weather did improve, and the two return flights to Lloydminster were uneventful. The flights are scheduled in accordance with *Canadian Aviation Regulations, Part VII Commercial Air Services, Division II - Flight Time Limitations* and *Flight Duty Time Limitations and Rest Periods.*

The performance and judgement of an individual suffering from fatigue becomes degraded, and one common effect is an increase in that individual's willingness to take risks to finish tasks more quickly. Research indicates that the effects of fatigue are strongest at the beginning and at the end of an extended work day.

1.17.4 Staff Turnover

Like many companies of similar size, Alberta Citylink periodically loses pilots to larger companies due to the potential for higher pay. Retention of personnel is important, and Alberta Citylink management is constantly dealing with this issue.

1.18 Additional Information

1.18.1 Pilot's Handbook Information

The wind at the time of the approach was varying between 070 degrees to 110 degrees from 5 to 7 knots, which is below the maximum tailwind component of 10 knots in the limitations section of the *Pilot's Handbook*.

The following information regarding landing in icing conditions is contained in the *Standard Operating Procedures (SOPs)* for 650584 Alberta Inc. (Alberta Citylink):

> The following limitations apply for the purpose of planning operations into known or forecast icing conditions:
>
> a) Factored field lengths should be used as calculated.
> b) The approach/target threshold speed previously calculated for the Flap 35 degrees landing should be increased as necessary to remain clear of buffet. This does not affect the previously calculated landing distances. The approach/target threshold speed must not be allowed to exceed 15 knots above the applicable threshold speed for normal Flap 35 degrees landings as the risk of exceeding the scheduled field length then becomes unacceptably high. If it appears certain that the speed at threshold will exceed this figure and the runway is known to be critical, then the attempt to land should be abandoned.
> c) The airframe de-ice boots must be cycled prior to selecting flaps.
> e) The wing/tail AUTO system must not be selected for approach and landing.
> f) The igniters should be selected to continuous.
> g) For landing with noticeable amount of ice accretion on any part of the aircraft increase the landing speed by 10 KIAS.

In the normal procedures section of the aircraft "Flight Manual" the following caution is written:

> After entry into icing conditions:
>
> CAUTION: If the airframe icing system is operated before a significant ice build up, the ice may only flex and bridge over the inflated boots.
>
> 1 Operate the airframe de-icing only when a significant build-up of ice has occurred. The optimum thickness for ice shedding will vary depending on the nature of the ice, but 0.5 in (13 mm) of ice should be allowed to accumulate on the wing boots before operating the airframe de-icing system.

In the performance section of the *Flight Manual* under Landing Speed, reference is made to the landing approach speed charts that calculate the V_{ref} speeds. This part indicates, for landing with noticeable ice accretion on any part of the airplane, to increase the landing speed by 10 KIAS.

Under the title "Approach Climb Speed" for flight with noticeable ice accretion, the recommendation is to increase the approach climb speed by 10 KIAS.

1.18.2 Stabilized Approach

A stabilized approach is a prerequisite to a successful landing. A stabilized approach is assured when an aircraft has a constant rate of descent along the approach path, the appropriate airspeed, a stable power setting, and is configured for landing. In the Company SOPs, some of the components listed as "Stabilized Approach Factors" are: stabilized airspeed, stabilized sink rate, a constant profile, and a normal sink rate of 500 to 800 fpm.

A Flight Safety Foundation Task Force studied a number of approach and landing accidents and found that "omission of action/inappropriate action" was the primary causal factor in 24 of the 76 business jet approach and landing accidents (ALAs) followed by "lack of positional awareness in the air," which was involved in 15 accidents. The study included both jet and turboprop fatal ALAs worldwide with a take-off weight greater than 12 500 pounds, and some of the conclusions and recommendations are applicable to the approach and landing at Lloydminster. The following are considered pertinent:

3. Unstabilized and rushed approaches contribute to ALAs. Operators should define in their flight operations manuals the parameters of a stabilized approach and include at least the following:

    1. Intended flight path;
    2. Speed;
    3. Power setting;
    4. Attitude;
    5. Sink rate;
    6. Configuration; and
    7. Crew readiness

    A suggested definition or policy that might be considered by operators:

    All flights shall be stabilized by 1 000 feet (305 meters) height above touchdown (HAT). An approach is considered stabilized when the following criteria are met:

    - The aircraft is on the correct flight path;
    - Only small changes in heading and pitch are required to maintain that path;
    - The aircraft speed is not more than V_{ref}+20 knots indicated airspeed (KIAS) and not less than V_{ref}-5 KIAS;
    - The aircraft is in the approach and landing configuration. *Note that many light twins have limited single-engine go-around capability and that they should not be configured for landing until the landing is assured;*
    - Sink rate is a maximum 1 500 feet (457.5 meters) per minute;
    - Power setting is minimum specified for the type of aircraft; and
    - All briefings and checklists have been performed.

    Specific types of approaches are considered stabilized if they also fulfill the following:

    - Instrument landing system (ILS) approaches - must be flown within one dot of the glide path or localizer, and a Category II approach or a Category III approach must be flown within the expanded localizer band;

- Visual approaches - wings must be level on final when the aircraft reaches 500 feet (152 meters) HAT;
- Circling approaches - wings must be level on final when the aircraft reaches 300 feet (91.5 meters) HAT.

✓ Corporate policy should state that a go-around is required if the aircraft becomes unstabilized during the approach. Training should reinforce this policy;
✓ Before descent, a checklist-triggered risk assessment by the crew for the upcoming approach should be company SOP. Prior to commencement of the approach, the crew should confirm the risk assessment;
✓ The implementation of constant-angle and rate-of-descent procedures for non-precision approaches should be expedited globally; and
✓ Training should be made available to flight crews for learning proper use of constant-angle descent procedure, as well as approach design-criteria and obstacle-clearance requirements.

4. Failure to recognize the need for and to execute a missed approach when appropriate, is a major cause of approach and landing accidents.

- Company policy should specify go-around gates for approach and landing operations. Parameters should include:

  - Visibility minimums required prior to proceeding past the final approach fix (FAF) or the outer marker (OM);
  - Assessment at FAF or OM of crew and aircraft readiness for the approach;
  - Minimum altitude at which the aircraft must be stabilized; and
  - Companies should declare and support no-fault go-around and missed-approach policies.

5. The risk of ALAs is higher in operations conducted during conditions involving:

   1. Low light;
   2. Poor visibility;
   3. The likelihood of optical illusions; and
   4. Wet or otherwise contaminated runways.

2.0 Analysis

2.1 Introduction

The analysis discusses the decisions made by the captain and the actions of the crew during the final seconds of the approach. The duty period, the emergency response, and the airframe ice will also be discussed.

2.2 The Approach

2.2.1 General

The first officer, who had flown the en route portion of the flight, continued to fly the approach. The crew briefed for a 20-degree flap landing with a threshold speed of 114 KIAS prior to commencing the approach. The briefings and checklist items covered were in accordance with procedures given in the *BA 31 Pilot's Handbook*. Altitudes and airspeeds were monitored by the captain, the pilot-not-flying (PNF), throughout the approach. After the gear was selected down and flaps selected to 20 degrees, the airspeed decreased to 114 KIAS. This was corrected and the speed increased to 144 KIAS achieving a ground speed of 150 knots. The approach speed shown in the *SOPs* for a non-precision approach is 130 KIAS, so the speed of 144 KIAS was not a concern to the PNF as he was adding the additional 10 knots recommended for landing in icing conditions. The Alberta Citylink *SOPs* state that in icing conditions, the additional 10 knots is added to the landing speed, not to the approach speed. Although in itself the additional 10 knots added to the approach speed may be insignificant, when combined with other factors, the additional speed became a factor. The time available for the final descent from MDA was affected by the increased closure rate that resulted from the high ground speed.

2.2.2 Captain's Decision to Land

Crew coordination, checklists, and approach monitoring were normal prior to reaching the minimum descent altitude of 2 640 feet as evidenced by the PNF calling low airspeed, altitude, and a reminder at 2½ and 2 miles for the pilot flying (PF) to remain on the instruments as the airport environment was not visual.

When the PNF obtained visual contact, he indicated that he had control of the aircraft which may have surprised the first officer. After seven seconds of information exchange, it was decided that the captain would land the aircraft. The ground speed put the aircraft closer to the runway, and a number of actions took place that de-stabilized the approach; power was reduced to flight idle, flaps were selected to 35 degrees despite the fact that 20 degrees of flap was briefed, and two turns were made to line up with the runway. This set up a high rate of descent as the aircraft descended from 457 feet agl in 16 seconds. An aircraft on a stabilized approach at an airspeed between 121 and 140 knots will take about 16 seconds to descend from 200 agl. In the conditions that existed; visibility reduced in snow showers, darkness, and a concentration on the landing area, the captain did not arrest the rate of descent prior to contact with the runway. The forces generated by the sudden deceleration combined with a left-to-right movement collapsed the undercarriage, and the aircraft skidded down the runway on the belly pod and the damaged right main gear. The power was reduced and the flap selected to 35 degrees because, at the high ground speed, the runway was approaching fast, and the captain believed that this action was required to make the descent to the touchdown point. The selection of 35 degrees of flap made the lift dump capability available to increase the drag after touchdown and decrease the landing distance. The airspeed decay and variations in descent rate on short final are considered characteristic of an unstabilized approach.

Selecting the power to flight idle prior to touchdown in the Jetstream 31 is not recommended due, in part, to the increased drag created by the propellers. Normally, on approach, between 18 to 20 per cent power is used and is gradually reduced to flight idle during landing flare. Just prior to the impact, power was increased, but there was insufficient time to overcome the inertia of the descending aircraft.

2.2.3 Actions of the First Officer

After the captain took control of the aircraft for the landing, the first officer performed the duties of the PNF and, in accordance with the captain's requests, he lowered the flap, turned the landing lights on, and reported to the FSS that the flight was landing. Although the time was short, the first officer did not make any calls to indicate that the aircraft was descending at a high rate of descent. The company manuals do not indicate action required should an approach become unstabilized.

2.2.4 Duty Period

Following three days off, both pilots reported for duty at 0600 the morning of the accident. Their flying was to consist of three return flights to Lloydminster arriving back in Calgary about 1940. This is a planned duty period of 12 hours and 40 minutes. Between the morning and the afternoon flight, there is a four-hour layover in Calgary. The same crew normally does this flight three days in a row before days off are taken. On the day of the accident the first flight in the morning was delayed due to poor weather at Lloydminster. The weather did improve, and the two return flights to Lloydminster were uneventful. Although the duty periods are scheduled in accordance with Canadian Aviation Regulations (CARs), the working days are of long duration, and, on a day when flights are delayed and when weather impacts on the decision making process, fatigue can be a factor.

2.3 Emergency Response

The emergency response services were requested by the FSS specialist at the time of the accident, and they responded from the city. It took about 17 minutes for the vehicles to arrive. In this case, there was no fire or injuries. Those responsible for the operation of airports, in consultation with Transport Canada (TC) and the airlines, have done a risk assessment and determined that emergency response from the local community meets the requirements.

2.4 Airframe Ice

During the descent, the flight encountered icing conditions that were described by the crew as moderate, however, the accumulation was under ½ inch, the minimum amount stated in the *Flight Manual* to operate the de-icing boots. In the company *SOPs,* it is stated that the boots must be cycled prior to selecting flaps. These two instructions appear to be in conflict. The aircraft had under ¼ inch of ice on the leading edges of the wings, horizontal stabilizer, and vertical stabilizer. The aerodynamic effects associated with ice accretion and their influence on this aircraft's recovery from a high rate of descent were not determined.

3.0 Conclusions

3.1 Findings

1. The flight crew were licensed 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. There was no evidence found of any airframe failure or system malfunction prior to or during the flight.

4. Weather conditions were adverse, but within limits for a night instrument landing.

5. When the captain saw the airport environment, he assumed control of the aircraft for the landing.

6. There was a delay of seven seconds before the final descent was commenced.

7. The final segment of the approach to landing was unstable due to the reduction of power to flight idle, the manoeuvring turns, and the time available for the final descent.

8. The high rate of descent that developed was not arrested prior to touchdown.

9. The aircraft landed hard, while drifting to the right, collapsing the left main gear and damaging the right main gear.

10. Examination by the TSB Engineering Branch of all broken landing gear components indicated that the failures were overload in nature.

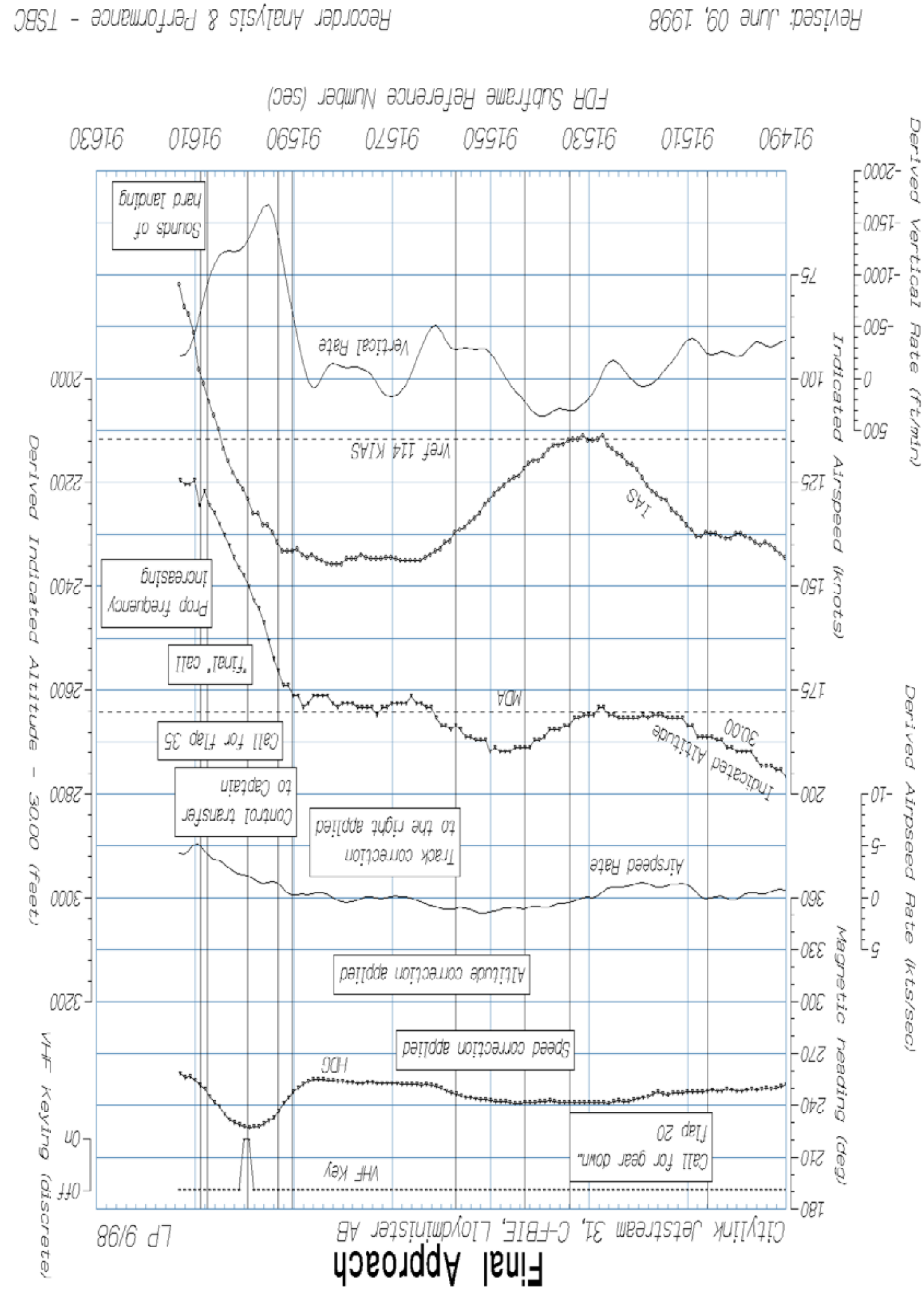
11. The *Flight Manual* and Alberta Citylink SOPs differ in the recommended procedure for operating the de-ice system prior to selection of flaps.

3.2 Causes

An unstabilized approach resulted in a heavy landing because the captain changed the configuration of the aircraft, and the high rate of descent that resulted was not arrested before contact was made with the runway surface. Contributing to the high rate of descent were the reduction of engine power to flight idle, airframe ice, and the time available for the final descent. Contributing to the damage on landing was the left to right movement of the aircraft.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 06 May 1999.

Appendix A - Plot of Approach and Landing



Appendix B - List of Supporting Reports

The following TSB Engineering Branch Reports were completed:

LP 08/98 - Landing Gear Trunnions

LP 09/98 - FDR/CVR Analysis

Appendix C - Glossary

ADF	automatic direction finder
agl	above ground level
ALA	approach and landing accident
asl	above sea level
ATP	Airline Transport License
CARs	Canadian Aviation Regulations
CML	commercial pilot license
CVR	cockpit voice recorder
DME	distance measuring equipment
ERS	emergency response service
FAF	final approach fix
FDR	flight data recorder
fpm	feet per minute
FSS	Flight Service Station
g	G load factor
HAT	height above touchdown
in	inches
lb	pound(s)
ILS	instrument landing system
KIAS	knots indicated airspeed
kHz	kilohertz
MDA	minimum descent altitude
mHz	megahertz
mm	millimetres
MST	mountain standard time
N	north latitude
NDB	non-directional beacon
nm	nautical miles
OM	outer marker
PF	pilot flying
PNF	pilot not flying
sm	statute mile(s)
SOPs	Standard Operating Procedures
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UFDR	universal flight data recorder
VHF	very high frequency
V_{REF}	the airspeed equal to the landing 50-foot point speed (1.3 V_{SO}) with full flaps and landing gear extended. V_{REF} is adjusted for wind gusts by adding ½ the gust to a maximum of 10 knots.
V_{SO}	stalling speed or the minimum steady flight speed in the landing configuration
W	west longitude
°	degree(s)
′	minute(s)