9 December 1977

Aircraft Accident Report # H70003

Hawker-Siddeley HS-125, Registration CF-CFL
Churchill Falls, Newfoundland 9 December 1977.

Transport Canada, Aviation Safety Bureau

"This accident was investigated to provide guidance toward the prev of a recurrence. The content of this report is confined to cause-r circumstances and is published for accident prevention purposes only.

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The corporate jet aircraft with two pilots and six passengers on board crashed during a night landing approach.

The investigation determined that due to inadequate cockpit discipline and poor crew co-ordination during the landing approach the aircraft was allowed to deviate below the proper flight path until it struck the ground.

This accident was investigated and this report was prepared by the Aviation Safety Investigation Division, Aviation Safety Bureau, Transport Canada.

INDEX

1. FACTUAL INFORMATION

1.1 History of the Flight

The corporate jet HS-125 aircraft departed Montreal at 2123Z (GMT),[1] 9 December 1977 with Churchill Falls as destination. The estimated time enroute was 1 hour 45 minutes. The flight proceeded normally and was in contact with Air Traffic Services enroute. When in range of Churchill Falls the flight received a clearance for the approach from Moncton ATC. At 2228Z the pilot acknowledged the clearance to the Churchill Falls airport (see figure 1) and received the latest weather. The aircraft left cruising altitude shortly thereafter; the descent was normal to the minimum initial altitude for the instrument approach. The flight reported outbound to Churchill Falls advisory at approximately 2252Z. The final transmission from the crew was that they were two miles back on final with a confirmation that they could see the strobe lights and the VASIS.[2]

Moncton centre was alerted shortly after 2300Z when it was evident that the aircraft had not landed. A local search was initiated with two helicopters from the airport but because of deteriorating weather, the search had to be discontinued and the aircraft was not found that night. Search and Rescue were alerted at 2314Z. Near blizzard conditions occurred that night and the next day December 10. It wasn't until the 11th December that the air search was resumed and the aircraft was located two miles short of the threshold of runway 14. There was no sign of life.

1 *All times in this report are in GMT.*

2 *For more complete details of events during the approach see Appendix "A".*

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	6	
Serious			
Minor/None			

1.3 Damage to Aircraft

The aircraft was destroyed on ground impact; wreckage was scattered along a trail of about 300 feet. See figure 2.

1.4 Other Damage

Nil

1.5 Personnel Information

a) Pilot-in-Command (Captain)[1]

The Captain was 53 years old and held a valid Airline Transport Pilot Licence. He started to fly in 1945 and acquired some 11,000 hours including 3100 hours on the HS-125. In the past twelve months he had accumulated 520 hours on the HS-125. He was employed by the company in July 1970. His last medical was on November 21, 1977 and his profile was "S-1GA-1-1" (see 1.13-1). He had been on duty 9 hours before the accident, and had 16 hours off duty prior to the commencement of the flight.

1 *Both pilots were fully qualified; the pilot in the left seat has been designated as Pilot-in-Command for report purposes.*

b) Co-Pilot (First Officer)

The First Officer was 52 years old and held a valid Airline Transport Licence. He started to fly in 1959 and his total flying time was in excess of 15,000 hours. He had flown some 2600 hours on the HS-125 including 450 hours flown in the past 12 months. His last medical was in October 1977 and his profile was "1-1GA-1-1". He had been on duty 9 hours before the accident and had several days off prior to commencement of the flight.

(c) Check pilots who had administered their routine flight checks reported that during such checks the pilots performed well as a team and carried out all required altitude and other call-outs.

1.6 Company/Aircraft Information

The aircraft was owned and operated by a large private corporation, to provide transport for their executive personnel and high priority cargo. The corporation employed 3 pilots who rotated as a two man crew on the one aircraft. The company aviation operations were well managed. The record keeping, training and flight operations activity was done in a professional manner. Maintenance, performed on a contract basis, was of a high standard.

The aircraft was a Hawker Siddeley HS-125 (403A(C)) manufactured in 1970 and powered by two Rolls Royce Viper Model 522 engines. The airworthiness and maintenance status of the aircraft was satisfactory and there were no known deficiencies prior to or during the flight.[1] Maximum authorized take-off weight was 23,600 lbs. The weight and centre of gravity were within specified limits.

1 *Pilots reported that on this HS-125, as on others of the type, ADF indications became unreliable in conditions conducive to precipitation static. Such conditions existed in the Churchill Falls area at the time of the accident. According to the CVR record the crew experienced some unreliable indications during the latter part of the flight.*

1.7 Meteorological Information

An extensive area of light to moderate snow ahead of a low pressure system spread gradually into the Labrador area in the afternoon and evening of December 9 with light snow commencing at Churchill Falls at 2200Z. Between 2200Z December 9 and 0430Z December 10, light snow was reported in each observation from Churchill Falls with ice crystals starting at 0100Z. Visibilities during this period ranged from 3 to 10 nautical miles in snow or ice crystals and the lowest reported ceilings were 3500 feet.

The actual weather at Churchill Falls for the period of the accident was: ceilings 3500 feet or higher, visibilities from 3 to 10 miles in light snow or ice crystals, surface winds light, less than 13 knots from an easterly to northeasterly direction. The 2300Z observation (after the accident) reported a partially obscured condition in light snow with a measured overcast ceiling of 3800 feet, stratocumulus 4/10, stratus 6/10, visibility 3 miles, surface winds 090° at 7 knots, temperature -21°C, dew point -23°C, and the altimeter setting 29.85 inches.

Upper air soundings taken at Goose Bay are believed to be most representative of conditions over Churchill Falls on the evening of December 9. This ascent shows a stable temperature profile with temperatures at -16° throughout the layer, surface to 500 millibars; the ascent indicates the air was saturated between 4000 and 16000 feet, suggesting the presence of clouds throughout that layer. A combination of very cold air temperatures, a stable lapse rate and precipitation in the form of ice crystals and snow suggested that light rime might be expected in the cloud layer. The same conditions would contribute to the ice crystal condition at Churchill Falls which started to show up at 0100Z on the 10th.

Pilot reports in the vicinity of Churchill Falls immediately after the accident indicated extensive patches of ice crystals west of the field extending 600 to 800 feet above ground. Above that level visibilities ranged up to 20 miles.

The aftercast indicates that it was very unlikely that any low level turbulence was present in the vicinity of Churchill Falls.

The accident occurred during the hours of darkness.

1.8 Aids to Navigation

The airport has one non-directional radio beacon "UM" on a frequency of 233KhZ. This is situated 4.5 nautical miles from the end of runway 14 and was in operation at the time of the accident. The limits for the straight-in beacon approach to runway 14 are 718 feet and 1 mile.

1.9 Communications

The VHF communications with Churchill Falls on 122.2MhZ were satisfactory (see also Appendix "A").

1.10 Aerodrome Information

Churchill Falls airport, Newfoundland is operated under public licence by a private corporation. There is a paved runway 5500 feet long by 150 wide, elevation 1442 ft asl. On the approach end of runway 14 there is a VASIS set to a 3° glidepath, and two strobe lights. (Figure 1 indicates a 2 1/2° glidepath; the angle was changed to 3° on 12 October 1977 and pilots were advised by NOTAM CYYR 417/77.) The strobe lights and VASIS were in operation at the time of the accident. There is runway perimeter lighting, a rotating beacon, and low intensity centre row and runway identification lights - all of which were operating at the time of the accident.

1.11 Flight Recorders

There was no flight data recorder on the aircraft, nor was there a requirement for one as this was a privately registered aircraft. It was however equipped with a cockpit voice recorder, a Fairchild A-100 CVR which was recovered in excellent condition. The recording was above average in quality due to the low cockpit noise and location of the cockpit area microphone on the instrument panel. The contents of the voice recorder were analysed and items with a bearing on the accident and with aviation safety implications are detailed elsewhere[1] in this report.

1.12 Wreckage and Impact Information

The first contact was with the tops of several trees; the aircraft heading at the time was about 127° Magnetic. The heading had changed to about 143° Magnetic by the time of initial ground surface impact.

A distance of about 800 feet was covered between the first tree strike and the initial impact with the ground surface. A further 250 feet was covered before the main body of the wreckage came to rest (see figure 2).

Examination of the wreckage and area showed (a) the engines were both producing power at impact; (b) the landing gear was down; (c) the flaps were in the landing position; (d) hydraulic and electrical power were available; (e) the aircraft was under control at the time it first entered the trees; (f) adequate fuel

[1] *It is the policy of the Aviation Safety Bureau not to provide complete transcripts of CVR recordings, but to publish only those portions pertinent to an understanding of the accident circumstances, or to paraphrase the spoken words. This is to protect the rights of individuals, and out of consideration for next-of-kin.*

was on board the aircraft; (g) all failures were the result of impact forces; (h) the impact attitude, decelerative forces, and destruction of the forward sections of the aircraft indicated the accident was classed as essentially non-survivable; (i) the only post-crash occupiable area was in the aft cabin.

1.13 Medical and Pathological Information

1.13.1 Pilot-in-Command (Captain)

The pilot-in-command held an Airline Transport Licence. Because of recurrent urinary calculi (kidney stones) he had been issued a special licence medically valid provided no change in this condition was noted on annual follow-up examinations. Autopsy findings revealed that kidney stones were not a contributory factor in the accident. The injury pattern is consistent with this pilot flying the aircraft from the left hand seat.

Numerous tablets in partially emptied containers were found in his pockets; these were identified as Contac C (an anti-histamine), Tuinal (a barbiturate), Anacin, ASA, (analgesics) Rolaid, Gelusil (antacids) and Hydrozide (a diuretic for kidney stones).

No carbon monoxide or alcohol were found in the tissues. Lactate determinations indicated that he was subjected to an acute stress reaction of 6 to 7 seconds. Tissue analysis showed the presence of metabolic products of acetylsalicylic acid.[1]

The Captain was considered by his peers to be a meticulous, highly-qualified pilot, very knowledgeable about his aircraft, but who would not readily admit to making an error. He took pride in being able to do an approach with minimum power adjustments.

[1] *No other of the compounds mentioned could be detected in the tissue analysis.*

1.13.2 First Officer

Medical information on this pilot shows no evidence of disease which might have impaired his flying ability. The injury pattern suggests that he was sitting on the right hand side but not flying the aircraft. His peers assessed him as competent and knowledgeable, and probably less agressive than the other pilot.

No alcohol or carbon monoxide was detected. Lactate determinations indicate that he was subjected to an acute stress reaction of approximately 15 seconds.

1.13.3 Possible Illusions Affecting the Pilots[1,2]

There were no lights on the approach side of the airport and the lights of the town of Churchill Falls were 2 or 3 miles farther away from the airport on the right side of the flight path, with no lights in between. The lights of the airport would therefore be surrounded by a dark area (black hole effect).

The prevailing weather conditions during the approach included ice crystals and light snow. Viewing the lights on the ground under such conditions could lead a pilot to believe that the airport's lights were larger and farther away than normal. He might then judge himself to be higher than he actually was and fly a lower path.

Another condition which has been known to falsify a pilot's visual cues is the illusion which occurs when flying into

1 *Donald G. Pitts, Major U.S.A.F., B.S.C.*
Visual Illusions and Aircraft Accidents

2 *The Boeing Company, Renton, Washington*
Document D6-22996
Flight Deck Load and Night Visual Approach Performance

gradually thickening fog on approach. The pilot feels he is climbing and to compensate descends too low. The absence of lights around the airport, especially on the approach side, would amplify the effects of such illusions.

The Captain had a history of mild hypothyroidism; this condition may have produced a slowing of his mental activities. Also, since he had taken some ASA tablets he may have been suffering from some discomfort such as a headache, a cold, a toothache or other pain. The Contac C in his pocket would suggest that he was suffering from a cold. Any of these discomfort factors could reduce his attention and alertness during the approach, especially under the prevailing circumstances.

1.13.4 Passengers

Alcohol determinations revealed that some of the passengers were drinking during the flight; alcohol levels in various tissues of one passenger, who according to the CVR was in the cockpit area until after beacon passage on final, show a recent ingestion of alcohol. This suggests that he was drinking while in the cockpit talking to the pilots since the CVR reveals his presence there for at least part of the last 30 minutes recorded. It is noteworthy that biochemical determinations showed that this passenger, who was also a pilot, had an acute stress reaction of 4 seconds.

Autopsy findings reveal that all passengers were wearing seatbelts and that all but 2 died at impact. Most of the injuries were more prevalent in the upper parts of their bodies and on their left sides. This confirms that the final aircraft impact was nearly inverted and toward its left side. All passengers had seatbelt imprints. One passenger had two such imprints indicating that there were two major impacts of approximately equal force.

The seatbelts of two passengers who had been in the rear of the cabin on a bench type seat had been undone; their bodies were found outside the aircraft near the main part of the fuselage. The autopsy findings indicate that both these passengers had survived the impact. When the aircraft finally stopped they evidently undid their seatbelts and in a probable state of confusion, hastily evacuated the aircraft, fell out of the wreckage and further injured themselves. They died of exposure to cold.

1.14 Fire

There was no fire.

1.15 Survival Aspects

See Para 1.13

1.16 Tests and Research

1.16.1 Instrument Examination

The cockpit instruments recovered from the wreckage were subjected to laboratory study. Pertinent results included the determinations that both the Captain's and the First Officer's altimeters were operating and showed no gross errors, and that the radio altimeter had been operating properly. (Report LP 303/77 refers.)

1.16.2 Light Bulb Analysis

Evidence obtained from the condition of the recovered light bulb filaments generally confirmed the expected operating conditions at impact. Of interest was the fact that the two bulbs of the "dome light" were illuminated at the time of impact. (Report LP 304/77 refers.)

1.16.3 Flight and Simulator Tests

The flight path was studied by means of a helicopter equipped with a video camera. Subsequently tests were carried out in a HS-125 flight simulator and in a HS-125 aircraft. The simulator was set up for Churchill Falls airport; the procedure in the aircraft was flown on another beacon, but using the Churchill Falls headings and altitudes.

The test programs were planned to duplicate the accident flight as closely as possible, using standard operating procedures and incorporating the timing and other information obtained from the cockpit voice recorder tape. The power settings were those determined from analysis of sounds on the CVR tape. Experienced HS-125 pilots were at the controls.

The pattern of "beeps" from the altitude alert system on the CVR tape was studied in flight.

The conclusions of the series of tests were as follows:

a) The aircraft must have crossed the Churchill Falls NDB on final approach about 400 ft below the published altitude;[1]

b) The frequent power adjustments during the final approach indicate that the pilot was unsure of his distance, proper altitude, and approach angle in relation to the runway threshold environment lights;

c) The aircraft was never on a stabilized approach path;

[1] *This conclusion was reached because in repeated simulations it was found necessary to cross the NDB 400 ft below the published altitude in order to duplicate the final flight profile.*

d) It is unlikely that the VASIS and strobe lights were visible throughout the final approach;

e) No excessive sink rate or airspeeds developed during the approach;

f) The crew had used the altitude alert system for the approach.

1.16.4 Appropriate computer searches were made of aviation safety and medical literature, and information from these sources is incorporated in this report. A number of HS-125 undershoot type accidents were studied; these revealed no pattern indicating operating problems or the need for special techniques for landing approaches with the HS-125.

1.17 Additional Information

1.17.1 Although the accident occurred only two miles out on the extended centreline of the runway, the wreckage was not located for two days due to extreme weather conditions. A searching helicopter had flown over the site within 15 minutes of the crash with a receiver tuned to a distress frequency. The two aircraft emergency locator transmitters had been removed in compliance with an Airworthiness Directive (CF-77-11) issued because of malfunctioning (exploding) lithium batteries experienced in other aircraft.

1.17.2 The "dome" referred to by the Captain in his exclamation about 12 seconds before impact is considered to be the dome light which is in the entranceway behind the pilots. There is only one switch to this light, and it is not accessible to the pilots when they are at their posts. There had been reports of radar "domes" coming off in flight on other HS-125 aircraft; this possibility was considered but rejected following examination of the intact radar dome found in the wreckage.

1.18 New Investigation Techniques

A video camera was used to record details and actions at the site and also to study the flight path from the air. This simplified later briefings and analysis.

1.19 Witnesses

There were no witnesses to the crash. Information was obtained from various persons concerning departure details, communications, training and flight checks of the pilots, and the aircraft status; this has been incorporated in this report.

2.0 ANALYSIS

2.1 The Approach

From study of the flight plan, the timing of the flight and the crew conversations during the descent phase, it was apparent that the descent was well planned from the point of view of fuel economy and that the crew had adequate weather and other information to conduct the approach. Contrary to accepted good practice however, there was no approach briefing given by the Captain to the First Officer; a passenger was allowed in the cockpit area until the approach was well in progress; there were no altitude calls during the approach; the flight instruments were not adequately monitored.

Following a procedure turn the aircraft was flown toward the non-directional beacon for the final approach. The simulator and flight studies concluded that crossing the beacon was done about 400 ft below the published altitude. This could have been because the pilots made the station passage visually rather than on indications from their ADF equipment and reverted to a visual approach; they could have been unsure of exact station passage due to poor ADF indications caused by precipitation static (see 1.6);

perhaps they were depending on their altitude alert system, which, according to the analysis of the "beeps", may have been set incorrectly. As can be seen on the simulated flight profile, Figure 3, and in the cockpit voice recorder report, Appendix A, the altitude alert system was being used during the approach. It is possible that the pilots were placing undue reliance on this system, normally intended to be used before the final approach phase is entered. The analysis provided by flight test duplication indicates that the altitude alert system may have been used as low as the MDA (minimum descent altitude).

Although the Captain had a reputation for precision and particularly prided himself on being able to make an approach with a single power setting - in this case he made a number of power adjustments, and the approach could not be called a stabilized one. This might be a confirmation that on the day of the accident the Captain was below par, as indicated by the medical evidence. At the same time it is apparent that the First Officer was distracted at least twice during the approach; first when the passenger left the cockpit, and second when the Captain made an exclamation and complained about the dome light. It appears to be significant that when the matter of the dome light upset the rhythm of the flight the First Officer became quite concerned, as indicated by his lactate profile revealed by aeromedical studies. Whether this dome light had been on for some time or was simply switched on at the time the Captain complained (see Appendix A), could not be determined. If it had been on for some time, it is possible that it only became bothersome to the pilot when he was attempting to see the runway lights in the latter stage of the approach. The First Officer may have attempted to draw the cockpit curtain to alleviate this problem. Shortly after this distraction the aircraft was allowed to descend to the point where the approach lights would not be visible because of intervening terrain.

It appears probable the Captain was subjected to an illusion. However there are recommended flight crew coordination

procedures designed to counteract the effects of such illusions; these include altitude crosschecks, and proper monitoring of the flight instruments until touchdown (see Appendix B). Evidence indicates that three serviceable altimeters were available (one servo electric, one pressure, and one radio altimeter), yet no altitude calls were made by either pilot.

The aeromedical report indicated that the Captain experienced 6 seconds of extreme anxiety; this is consistent with the period when the aircraft was striking trees just prior to the final impact. It is interesting that the passenger who was in the cockpit area, but had returned to the cabin, was the only one among the passengers who showed an extreme stress reaction (4 seconds) - he was aware that the aircraft was on final approach and he himself was a pilot.

Even though this night approach was conducted in what might be termed visual conditions, standard operating procedures require an instrument monitored approach regardless of the existing weather. The company training, equipment, and other facilities provided to the pilots were of high quality; instrument flight check reports showed that the two pilots carried out acceptable procedures during their check flights; nevertheless on the accident flight there was poor crew coordination and poor communication between the pilots during the approach stage of the flight. This may have been due to complacency brought on by familiarity with the route and the operation, and by medical factors affecting the Captain.

3.0 CONCLUSIONS

3.1 FINDINGS

3.1.1 Cockpit discipline was inadequate as the approach entered the final phase.

3.1.2 Distractions in the cockpit degraded crew performance.

3.1.3 The pilots deprived themselves of essential altitude information by not effectively monitoring the flight instruments during the final approach.

3.1.4 The Captain, by relying on visual cues from the runway environment lighting in conditions where those cues were degraded, became exposed to visual illusions.

3.1.5 The pilots permitted the aircraft to deviate below the safe approach profile until it struck the terrain.

3.1.6 On the assumptions that there had been at least one serviceable ELT on board, that it had been activated as a result of the impact or by other means, and that there was the capability at Churchill Falls of homing to the point of origin of the ELT signal, the rescue activity may have been expedited.

APPENDIX "A"

COCKPIT VOICE RECORDER INFORMATION

The aircraft was equipped with a Fairchild A-100 CVR, Serial No. 4082. The recorder was in excellent condition.and the recording was above average in quality, due to low cockpit noise and to the location of the Cockpit Area Microphone on the panel in front of the right seat. It was not difficult to transcribe most of the speech on the cockpit area microphone track. The speech recorded on the Captain's and First Officer's audio tracks was also of good quality, and it seemed that most of the time the two crew members were wearing boom microphones which picked up cockpit conversations.

The tape's duration was 31 minutes, 4 seconds.

ENGINE POWER DETERMINATION

24 (1)

ANALYSIS OF OTHER RECORDED SOUNDS

24 (1)

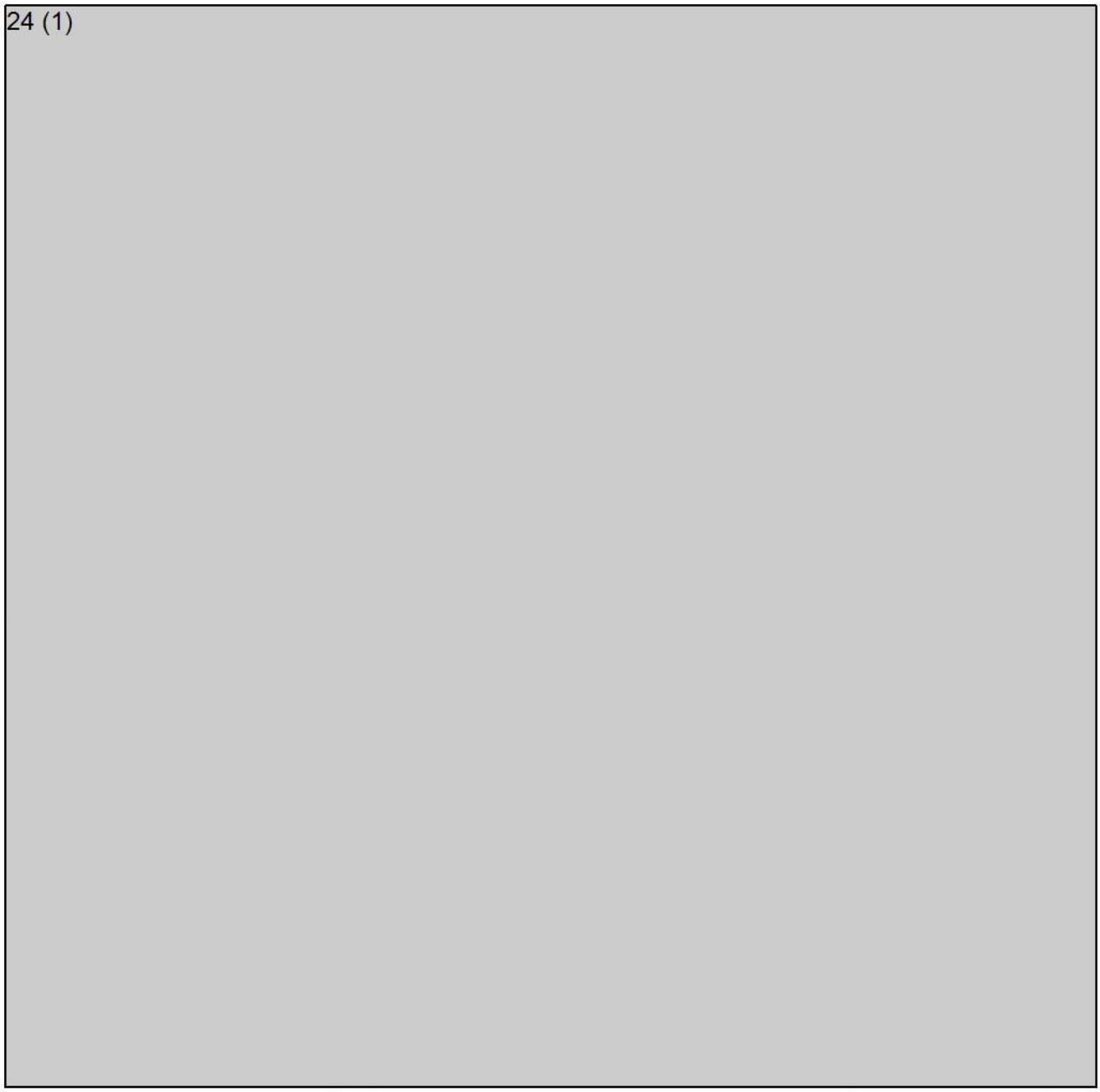
* *This is flight data recorder running time, an arbitrary time covering the last 31 minutes, 4 seconds of the flight.*

24 (1)

24 (1)

24 (1)

A4



APPENDIX "B"

Typical Recommended Flight Crew Procedures

The National Transportation Safety Board (U.S.) carried out a study in 1976 (#NTSB-AAS-76-5). Information from this study and from the operations manuals of a number of Canadian air carriers indicates that the following procedures represent recommended good practice:

1. Sterile cockpit environment - all persons other than flight crew members are barred from the cockpit from about 8 minutes (typical) before the approach is commenced until the landing is completed. Conversation is limited to approach briefing, altitude callouts and position reports.

2. Approach briefing - the Captain briefs the flight crew as to his intentions and the pilot flying reviews the procedures for the approach.

3. Instrument cross-checks - altitude callouts are made at specific points during the approach. (These should be standard for both visual and instrument approaches and the callout procedures should be detailed in the air carrier's operations manual.)

4. Monitoring of flight instruments - flight instruments are continuously monitored during the approach from the outer marker (beacon) to landing. One crew member is specifically detailed to monitor and advise of deviations from briefed procedures.

Applying these recommended procedures to the accident flight would call for the following actions:

(a) Eight minutes before the estimated arrival at the Churchill Falls beacon all non-crew members would be excluded from the cockpit area.

(b) The Captain would brief the First Officer; "This will be a standard beacon approach to runway 14, procedure turn 2900 ft, beacon inbound 2500 ft...The minimum descent altitude 2160 ft; call me 100 above, and when you have the approach lights in sight...The timing will be 2 min and 15 sec; missed approach is climb to 2900 ft on runway heading with a right turn back to the beacon.

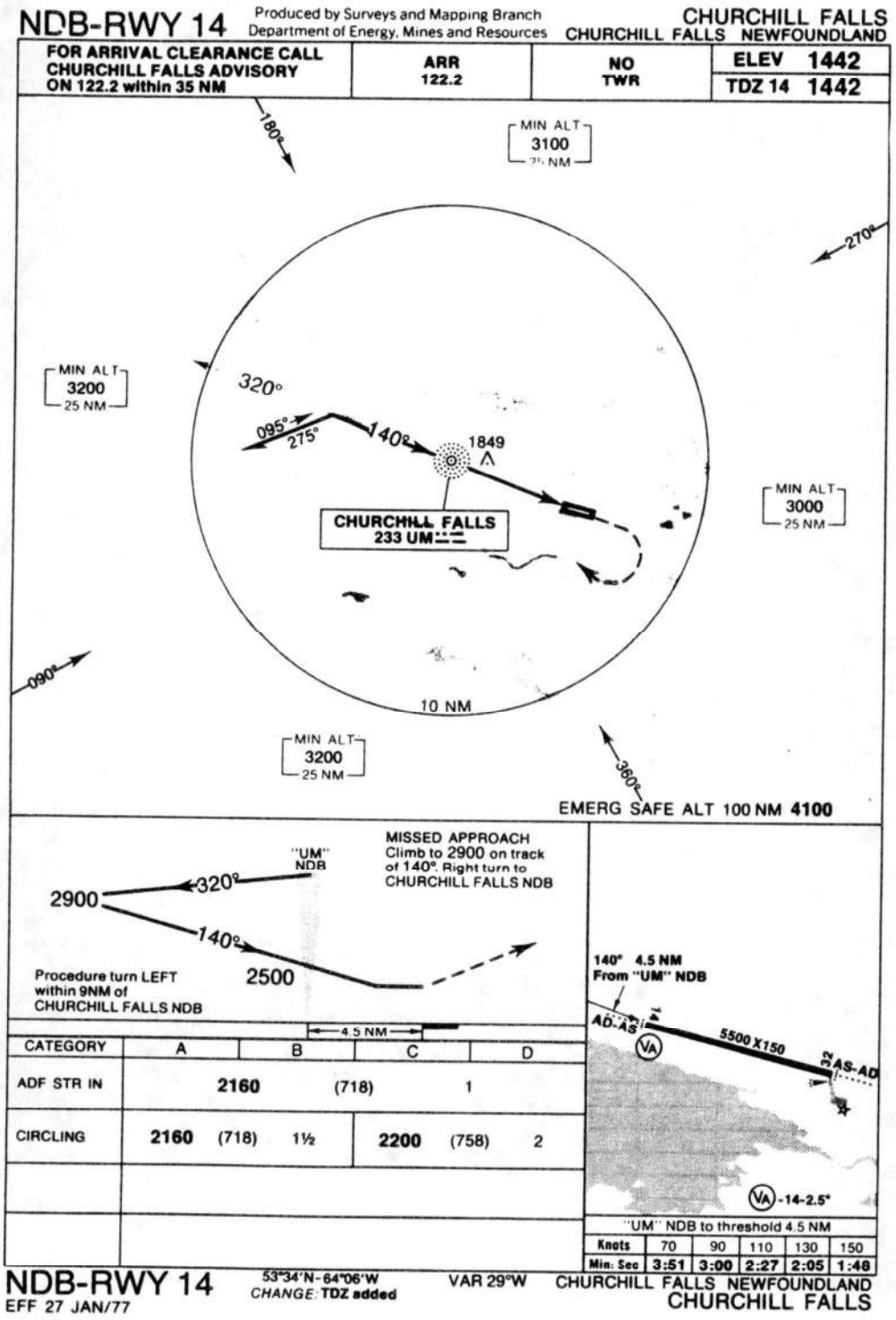
(c) Verbal instrument cross-checks would be performed:

- beacon outbound (altitude, heading)
- procedure turn (altitude, heading, timing)
- beacon inbound (altitude, heading, timing)

(d) During final approach the pilot not flying would:

- monitor the flight intruments and call out any deviations from the planned approach;
- call out reaching 100 ft above the minimum descent altitude;
- call out reaching the minimum descent altitude; with the time to go, and whether runway in sight;
- continue monitoring airspeed, altitude, vertical speed, until touchdown, or a missed approach commenced.

FIGURE 1



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