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FOREWORD

General

1. The purpose of the Aircraft Accident Digest is to disseminate accident report information to Contracting States. Publication of the Digest began in 1951. Over the years States have reiterated their interest in the Digest not only as a valuable source of information for accident prevention, but also as a training aid for investigators and educational material for technical schools.

Selection of accidents

2. The Digest contains accident reports selected by the Secretariat from those sent by States. Reports were selected on the basis of:

a) their contribution to accident prevention; or

b) the successful employment of useful or effective investigative techniques; and

c) compliance with Annex 13 provisions including the format of the Final Report.

The Digest should not be seen as being statistically representative of the world distribution of accidents.

Editorial practices

3. The Final Reports are usually published as received. Accordingly, some deviations from standard ICAO editorial practices may occur. Lengthy reports may be abbreviated by omitting redundant information, appendices, attachments or diagrams. Minor changes in presentation and terminology may be introduced to ensure compliance with Annex 13 provisions.

States' co-operation

4. States are encouraged to send to ICAO those Final Reports which meet the criteria of 6.14 in Annex 13. The reports must be submitted in one of the working languages of ICAO, and in the format presented in the Appendix to Annex 13.

Digest publication

5. The Digest is produced once each year and includes accidents and incidents which occurred during a one-year period.

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TABLE OF CONTENTS

No. 1

Cessna 404, HK-2685, accident at San Juanito, Colombia on 24 February 1984. Report released by the Civil Aviation Administration, Colombia

Aviation Accident Report

Aircraft: Type Cessna, Model 404, Serial No. 4040685, Registration HK-2685

Owner: Taxi Aéreo del Guaviare, Tagua Ltda.

Operator: Same

Place of accident: San Juanito (Meta)

Date of accident: 24 February 1984 (1220 local time)

1. FACTUAL INFORMATION

1.1 History of the flight

The aircraft, HK-2685, with a pilot-in-command and co-pilot, took off from the Eldorado Airport, Bogotá, at 1158 (local time) to make a positioning flight to Villavicencio.

According to the Control Centre's Signals Logbook at 1230 (local time) the pilot reported an emergency (a feathered engine) when level with the Aname intersection; the report of the Villavicencio tower indicates that the aircraft crossed this point at 1214 (local time) and that three minutes later the pilot reported an emergency, saying that the aircraft was losing altitude among clouds and that it was flying over the station; then contact was lost. Subsequently several aircraft (see the Search Report) performed sweeps of the whole area from that same afternoon up until the 28th, when the aircraft, HK-2685 was found smashed against a rock face 11 000 feet above sea level in the Serranía de los Farallones, 6 minutes flying time from San Juanito (Meta), on a bearing of zero degrees. The bodies of the crew and of four unauthorized passengers were found completely charred. It should be noted that the search lasted until the 28th because of bad weather in the area and because operations initially centered on the airway between Aname and Villavicencio until reports from people living in the San Juanito area suggested that area as a possibility. The same sources together with the meteorological report made it possible to establish that the accident occurred in daylight and in atmospheric conditions of rain and thick fog.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	4	-
Serious	-	-	-
Minor/none	-	-	-

1.3 Damage to aircraft

As a result of the explosion upon impact against the mountain and subsequent fire, the aircraft was totally destroyed. It cannot be repaired.

1.4 Other damage

None.

1.5 Crew information

The pilot of the aircraft was Colombian, 34 years of age. He had obtained his licence on 21 April 1973 with privileges and limitations for single-engine landplanes up to 5 670 kg.

According to his file, he had experience on C-150, C-172, TU-206 and PA-34 aircraft. His last annual flight rating test was performed on 19 April 1983 on a Cessna 404. He also had a medical certificate valid until 30 April 1984.

His total flying time, as recorded with the DAAC (Civil Aviation Administration) up to 27 February 1983, was 3 978:15 hours. The company, TAGUA, provided information, at the request of the undersigned, indicating that the pilot had flown 1 421:45 hours in the aircraft and in the last 90, 30 and 3 days he had flown 95:50, 48:10 and 3:20 hours respectively.

Further an analysis of the background information in his file showed that on 5 August 1979 he had an incident with HK-2025, where the landing gear broke due to material fatigue; later on 29 March 1980 he had an accident with HK-1768, the cause being determined to be a combination of the pilot-in-command factor and the meteorological conditions factor; finally in November 1983 he had been fined by the DAAC for exceeding capacity on a flight and for fuelling with passengers on board.

The co-pilot was Colombian, 23 years of age. He had obtained his commercial pilot's licence in June 1983 with privileges and limitations for single-engine landplanes up to 5 670 kg.

According to his file, on the day of the accident, he had the appropriate medical certificate, valid until 30 May 1984.

His last flight rating test was the one he had when qualifying as a commercial pilot in June 1983 on a TU-206 aircraft; therefore it can be stated that the co-pilot was not technically qualified on the Cessna 404.

The records in the Aviation Personnel Office up to December 1983 indicate that he had flown a total of 778:52 hours, of which 573:40 as a single pilot in C-152 and TU-206 aircraft. The company, TAGUA, did not certificate him for hours flown within the company.

1.6 Aircraft information

The aircraft, HK-2685, a Cessna 404, serial number 4040685, equipped with Continental engines, model GTS10-5 20 M, serial numbers 606655 and 606750 and McCauley propellers, model 3FF32 C501-904 MB, serial numbers 804286 and 804440, was registered with the DAAC under the code SIN on 3 March 1982.

The Certificate of Airworthiness (0188) issued by the DAAC on 23 February 1983 was no longer valid on the day of the accident. Moreover the Villavicencio Technical Control Unit had suspended the aircraft for deficiencies in log-keeping and in order that it undergo the annual technical inspection.

It was for this reason that on the day of the accident the pilot requested in writing from the Directorate General of Air Operations the authorization to make the flight in question. This was given in Message 241616 MCBOYADO.

It should be made clear that both in the request signed by the pilot as well as in the message mentioned above authorizing him to make the flight, it was stated that the flight was a positioning flight (for maintenance reasons) and that passengers would not be carried; however, the aircraft took off with three adults and a girl in addition to the crew.

As regards the flying time of the aircraft it should be said that since the most recent maintenance logbook disappeared in the accident and since the data which could be checked contained continual errors, the information obtained is not the exact information for 24 February 1984; according to the data found in the documents which could be recovered, it was stated that up to 21 January 1984 the aircraft had a total flying time of 1 471:57 hours; the calculation is the same in the case of the two engines, while the propellers have a total figure of 656:56 hours.

With respect to the continual errors in the flight logbooks, both in contradiction to and in support of the real data, to this report is attached a photocopy of Flight Report 0373 of 14 February 1984 (taken from the records of the Villavicencio Technical Control Centre) in which there appears a note from a DAAC inspector which reads: "DAAC Report 15-II-84. Logbook checked. Statistics overdue since 02-II-84. TA. (Signature) Note. The aircraft has shown deficiencies and flights have been cancelled, but there are no reports. (Signature) (Stamp of the DAAC Inspector)".

This note shows that maintenance was not adequately and efficiently documented. As regards the weight and balance for the flight in question, it was determined that they were within the specific limits for the aircraft.

1.7 Meteorological information

The report of the Meteorological Section indicates that on the date and at the time of the accident the satellite picked up "major activity in the area of intertropical confluence" which was marked "primarily by an extensive band of clouds, cumulus, stratocumulus, altocumulus and altostratus at altitudes varying between 1 500 feet (over the lower parts) and the ground surface (over the mountain range) and approximately 10 000 feet. There was rain and drizzle in various parts of the area".

This coincides with the reports of the people living in the area and also with the climatic behaviour in the days following the accident.

1.8 Aids to navigation

Although the aircraft had VOR and ADF equipment, how they were functioning in flight is unknown. On the ground there were the VOR and NDB aids at Bogotá and Villavicencio which were functioning normally.

According to the Flight Plan the route planned was that established for VFR conditions; however the site of the accident was 25 miles north-east of the last reporting point and in addition, when the emergency was reported the pilot indicated that he was descending through clouds.

1.9 Communications

Both the aircraft and the ground had VHF and HF equipment which was functioning normally. The last report of the pilot to Villavicencio (Vanguardia Airport TWR), reporting the emergency, was made three minutes after crossing the Aname intersection.

1.10 Aerodrome information

Not applicable. The accident occurred during the "en-route - cruise" phase in a steep, rocky area of the Serranía de los Farallones at approximately 11 000 feet above sea level.

1.11 Flight recorders

Not applicable to the type of aircraft involved in the accident.

1.12 Wreckage and impact information

The aircraft was totally destroyed and the remains were not scattered because of the abundant undergrowth of the site. The impact occurred against an almost perpendicular rock face and according to on-the-spot observations the aircraft was flying at a well-defined angle of descent.

1.13 Medical and pathological information

The crew satisfied the psycho-physical requirements to make the flight in question. They died in the accident as a result of the impact and subsequent fire. Their bodies were completely charred. Attached to this report are the death certificates which indicate that death was due to "multiple traumatisms".

1.14 Fire

The fire obviously occurred as a result of fuel spilling out when the tanks were breached at the moment of impact with the ground.

1.15 Survival aspects

Not applicable. According to the information above, the occupants of the aircraft must have died instantaneously; the search for the aircraft lasted four days firstly because of the prevailing atmospheric conditions in the area and secondly because initially the operations centered on the airway between Aname and Villavicencio and it was only at the suggestion of the people living in the area of San Juanito who said they had heard the aircraft and the explosion upon impact that an aerial sweep of the area was made which ended in the site of the accident being found.

1.16 Test and research

The investigation procedure followed was the one used routinely and although special attention was given to the flying time of the aircraft and its components, since there was a lack of documentation the only figures that could be established were those corresponding to 21 January 1984.

1.17 Additional information

None.

1.18 New investigation techniques

None required.

2. ANALYSIS

From an evaluation of the information given above, it is possible to establish several factors which together form a well-defined hypothesis: basically, the fact that there were continual errors in the log-keeping of the aircraft's operations and the fact that a note was specifically made by an inspector about the continual deficiencies of the aircraft without note been taken of them and appropriate corrective action given to them, detract from confidence in the airworthiness of the HK-2685, particularly when the expiry date for the technical inspection had been the previous day and the flight in question had to be authorized only as a positioning flight. This leads one to believe that if one engine were lost while flying over a particularly rough area, it is possible that if the pilot following emergency procedures tried to maintain the required flight level, the other engine may not have responded adequately.

Further it should be considered that although the aircraft had a capacity of fourteen people, the fact that six people were on board instead of only the two crew also influenced the possibility of maintaining the aircraft in flight with only one engine.

The other aspect to be borne in mind is the fact that minutes before the emergency the pilot reported that he had crossed the Aname intersection which puts him over the required airway but the accident occurred 25 miles north-east at an altitude of 11 000 feet, a fact which casts doubt on the accuracy of the report over Aname. In other words it may be said that the flight was not being made over the airway established for VFR conditions, which increased the risk of operating on only one engine, with the known consequences.

3. CONCLUSIONS

Findings

The pilot satisfied the requirements in terms of documentation, technical knowledge and experience to make the flight in question. The co-pilot did not.

The aircraft had a Certificate of Airworthiness which was out of date. The flight was being made under specific authorization as a "positioning flight". However passengers were being carried.

The maintenance of the aircraft and log-keeping of its operations were being performed in a deficient manner.

The pilot reported an emergency as a result of the loss of one engine and he believed that he was crossing the station (VVC).

The aircraft was found smashed 25 miles north-east of the last reporting point at an altitude of 11 000 feet above sea level.

Causes

Aircraft factor, power-propulsion unit - undetermined failure of one engine, as a result of which the pilot could not maintain the flight level required to reach the station.

Human factor, pilot-in-command, operational decisions and procedures - the Rules of the Air were not followed and an airway was used different from that established.

4. RECOMMENDATIONS

- A copy of this investigation report should be sent to the Operating Agency so that it be analysed and commented upon by its staff of pilots, thereby making a positive contribution to the campaign to prevent the risk of accidents.

- The Operating Agency should be reminded of its obligation to keep correct and up-to-date statistics on the maintenance of its aircraft, noting in the appropriate logbooks all cases of malfunctions and appropriate corrective action taken.

ICAO Note: Names of personnel were deleted. Attachments were not reproduced.

ICAO Ref.: 031/84

No. 2

McDonnell Douglas DC-10-30, LN-RKB at
John F. Kennedy International Airport,
New York, United States, on 28 February 1984.
Report No. NTSB/ARR-84/15 released by the
National Transportation Safety Board, United States

SYNOPSIS

On February 28, 1984, Scandinavian Airlines System Flight 901, a McDonnell Douglas DC-10-30, was a regularly scheduled international passenger flight from Stockholm, Sweden, to New York City, New York, with an en route stop at Oslo, Norway. Following an approach to runway 4 right at New York's John F. Kennedy International Airport, the airplane touched down about 4,700 ft (1,440 meters) beyond the threshold of the 8,400-foot (2,560-meter) runway and could not be stopped on the runway. The airplane was steered to the right to avoid the approach light pier at the departure end of the runway and came to rest in Thurston Basin, a tidal waterway located about 600 ft from the departure end of runway 4R. The 163 passengers and 14 crewmembers evacuated the airplane safely, but a few received minor injuries. The nose and lower forward fuselage sections, wing engines, flaps, and leading edge devices were substantially damaged at impact.

The weather was ceiling 200 ft overcast, 3/4-mile visibility, with light drizzle and fog. The temperature was 47° F with the wind from 100° at 5 knots. The surface of the runway was wet, but there was no standing water.

The National Transportation Safety Board determines that the causes of this accident were the flightcrew's (a) disregard for prescribed procedures for monitoring and controlling of airspeed during the final stages of the approach, (b) decision to continue the landing rather than to execute a missed approach, and (c) overreliance on the autothrottle speed control system which had a history of recent malfunctions.

1. FACTUAL INFORMATION

1.1 History of the Flight

On February 28, 1984, Scandinavian Airlines System (SAS) Flight 901, a McDonnell Douglas DC-10-30 of Norwegian Registry, was a regularly scheduled international passenger flight from Stockholm, Sweden, to New York City, New York, with an intermediate stop at Oslo, Norway.

Before leaving Oslo for New York at 1239 Greenwich Mean Time (GMT), 1/ the flightcrew reviewed weather information for John F. Kennedy International Airport (JFK) which were pertinent to the Oslo - JFK segment of the flight. Because the weather conditions in New York for the scheduled arrival time of Flight 901 were forecast as marginal, with low ceiling, limited visibility, light rain and fog, additional fuel was placed on board at the captain's request. There were 202,826 pounds (92,000 kilograms) of fuel on board; the takeoff weight was 543,217 pounds (246,398 kilograms). Philadelphia International Airport was listed as the alternate airport. The Atlantic crossing was routine and without incident.

1/ All times herein are Greenwich Mean Time based on the 24-hour clock. (Subtract 5 hours to obtain Eastern standard time.)

At 2005, Flight 901 arrived in the vicinity of the Kennebunk VORTAC 2/ and SAS operations at JFK requested ARINC 3/ to advise the flight that runway 4R was being used currently for approaches and landings at JFK and that no inbound delays were expected. ARINC also was requested to advise Flight 901 of the latest JFK and Philadelphia weather. The 2000 weather observations for JFK were transmitted to Flight 901 at 2028.

About 2040, Flight 901 called the SAS dispatcher at JFK to advise him that the estimated arrival time was 2105 and to confirm receipt of previous messages from ARINC. The flight was also advised at this time of the latest weather which had been received on the Aviation Weather Display System (AWDS) at 2039. The weather given at that time was: measured 300 ft broken, 600 ft overcast, visibility 1.5 miles in light rain and fog, wind 090° at 8 knots, altimeter 29.15 inches. The dispatcher heard Flight 901 make its initial radio contact with JFK approach control and noted that the flight had the most current ATIS 4/ information. Information Whiskey was most current and was as follows:

> Information whiskey, two zero five one Greenwich measured ceiling three hundred overcast, visibility one light drizzle, fog temperature four five, dew point four four, wind zero eight zero at four, altimeter two niner one four, approach in use ILS four right, departure runway four left, notice to airman, important information sigmet alpha one four is valid, -- from moderate to occasional severe turbulence between one seven thousand and flight level three eight zero, New York center weather at five three is valid with strong low level wind shear potential, for further information, contact New York flight service station, in the interest of noise abatement, Runway 4R preferential use runway, advise you have whiskey.

The systems operator 5/ had prepared the landing data card and had entered the data contained in ATIS information "uniform" on it. The flightcrew stated that they were aware that ATIS information "uniform" and "whiskey" mentioned potential low level wind shear.

On arrival in the New York area, the crew found the weather better than expected. Because it was his route segment to fly, the first officer performed the landing/approach briefing for a category I instrument landing system (ILS) 6/ approach to runway 4R. During the approach, both autothrottles were engaged. The No. 2 "auto pilot engaged" switch was selected to the command position. The ILS switch on the directional control panel was armed for capture and approach with the control wheel steering (CWS) mode to be used for the landing. The captain and first officer agreed to use 35° of flaps rather than 50° because of the possibility of encountering wind shear.

2/ VORTAC - Very high frequency omnidirectional range/tactical air navigation - A navigation aid which provides both VOR and TACAN azimuth and distance measuring equipment at one site.

3/ ARINC - Aeronautical Radio Incorporated; a telecommunications company which provides nationwide communication services for the air transport industry.

4/ ATIS - Automated Terminal Information Service provides current, routine information to arriving and departing aircraft by means of continuous and repetitive broadcasts throught the day or a specified portion of the day. Each time the information is updated a sequential phonetic alphabet letter is assigned, i.e., information alpha, bravo, etc.

5/ Systems operator is the SAS designation for flight engineer or second officer.

6/ Instrument Landing System is a precision instrument approach system which normally consists of electronic components defining the localizer, glideslope, outer marker, middle marker, and high intensity approach lights.

During the initial approach, however, the runway visual range (RVR) 7/ for runway 4R went below category I landing minimums. According to the captain, because the airplane and crew were both qualified for category II landing minimums, he informed the crew that he would make a category II 8/ approach. He recalled setting his radio altimeter to category II minimums and believed the first officer did the same. Shortly thereafter, however, the RVR increased, and the captain instructed the cockpit crew to "go back to normal." Postaccident examination of the cockpit showed that the radio altimeter bugs 9/ were set at 115, the decision height for a category II approach.

The systems operator calculated a landing weight of 172 metric tons (378,400 pounds), entered the weight on the landing data card, and gave it to the captain and first officer who then obtained precalculated V_A and V_{TH} 10/ speeds of 154 and 149 knots, respectively, based on a landing weight of 175 metric tons (385,000 pounds) and 35° flaps from an SAS DC-10 performance chart.

None of the three flightcrew members could recall precisely the airspeed associated with the initial and final approach or landing segments. The captain did recall seeing an airspeed of 180 knots or slightly lower on his airspeed indicator at some point during the initial approach. He also recalled dialing 168 knots into the autothrottle speed select window but did not recall whether he obtained the speed he selected. Neither the captain nor the first officer recalled selecting a lower speed. During the postaccident examination of the cockpit, the autothrottle speed selected was found to be 168 knots.

During the approach, the crew switched to the performance page on the command display unit (CDU). At about 1,000 ft radio altitude, the captain recalled a tailwind component of about 20 knots displayed on the CDU. The first officer believed he observed winds out of the west - southwest at 23 knots between 2,000 ft and 1,500 ft on the approach. The systems operator could not observe either the wind direction or speed display on the CDU because of his seat position. The flightcrew stated that the autopilot kept the airplane on the localizer and glideslope and that the approach was smooth. They detected no wind shear or significant precipitation.

The captain stated that everything seemed stabilized until just before making visual contact with the runway environment at about 100 ft above minimums (300 ft). At this point, he noted that the airspeed was "high" and called out to the first officer "speed high." Shortly after this callout, the captain said that he considered going around, but he decided not to. He said his decision was influenced by his confidence in his copilot, the deteriorating weather conditions, and anticipated delays for a second approach.

Once over the runway, the flightcrew recalled that the airplane floated for some distance after the initial landing flare. The systems operator said that he made the required 50-, 40-, 30-, and 20-ft callouts from reference to the left radio altimeter. He called out 20 ft three times. Thereafter, the captain told the first officer to "put it down."

7/ Runway visual range is the maximum distance in the direction of takeoff or landing at which the runway or the specified lights or markers delineating it can be seen from a position above a specified point on its centerline at a height corresponding to the average eye-level of pilots at touchdown.
8/ ILS Category II - An ILS approach procedure which provides for approach to a height above touchdown of not less than 100 ft and with runway visual range of not less than 1,200 ft.
9/ Bug is a moveable pointer on the radio altimeter which can be set to a preselected radio altitude; when the aircraft descends to this altitude, an aural and visual warning is activated.
10/ V_A is the SAS designation for approach speed; V_{TH} is the SAS designation for threshold speed.

The captain believed that a normal touchdown was made at least one-third of the way down the runway; the first officer described it as gentle and believed that the airplane landed halfway down the runway; the systems operator described the touchdown as harder-than-normal and believed it to have been made within three-eights to halfway down the runway. Performance calculations based on digital flight data recorder and aircraft integrated data system (AIDS) information show that the initial touchdown point was about 4,700 ft (1,433 meters) beyond the threshold of runway 4R, or about 3,700 ft (1,128 meters) from the runway's end. None of the flightcrew could see the end of the runway at the point of touchdown.

The captain said that he told the first officer to use all three thrust reversers 11/ and full braking. He recalled seeing the amber transition lights of the three thrust reversers. The first officer believed that he deployed the three reversers "right away" and that maximum reverse was used until just before going off the end of the overrun, at which point he selected reverse idle; he said that his application of brakes was initially light to moderate. As the airplane continued down the runway centerline, he began increased braking. The captain said that he also applied brakes when he first saw the end of the runway. He believed that he first saw the end of the runway between taxiway F and A. He said that when he the applied brakes, the pedals went down farther. According to the flightcrew, braking was not as effective as they had anticipated. In their opinion, this may have been due to water on the runway. It was not until just before impact that the flightcrew realized the airplane could not be stopped on the runway overrun.

Once near the overrun, the captain used nose wheel steering to direct the airplane to the right in order to avoid colliding head on with the approach light structure located at the end of the overrun area. After leaving the overrun area, the airplane came to an abrupt stop with the cockpit in the water.

The forward section of the airplane fuselage came to rest in Thurston Basin, a tidal waterway about 600 ft (182.88 meters) from the runway 4R departure end. The airplane was damaged substantially. The captain immediately began to execute the memory items of the "On-Ground Emergency Check List." However, neither he nor the systems operator could move the engine fire selectors or fuel cutoff levers to their full off positions.

The captain switched on emergency power, took the public address (PA) handset, and shouted words to the effect: "This is an emergency, evacuate the airplane without delay." He did not hear any side tone in the PA handset, indicating that the handset was inoperable. He then used the radio communication microphone in an attempt to alert JFK tower; this microphone was also dead. When he prepared to activate the evacuation signal, he found that it was already on. He recalled hearing the signal as did the other cockpit crewmembers. The flightcrew remained in the cockpit for about 1 minute after the airplane came to a stop. The JFK Port Authority of New York and New Jersey emergency crews received initial notification of the accident from the tower at 2119 and responded immediately.

The captain said that when he entered the cabin from the cockpit, it was almost completely evacuated. With the aid of the systems operator, he assisted a passenger out of the airplane through the right side emergency overwing exit. He then re-entered the cabin and asked the flight attendants if they knew if anyone was still on

11/ SAS procedure for use of reverse thrust states: The engine 2 reverser shall normally not be used except when landing at Copenhagen. If, however, runway conditions are such that Pilot-in-Command deems that all engine reverse thrust may be required, there is no restriction on the use of engine 2 reverser.

board. They said, "it is only we." Afterward, he told the flight attendants to leave the airplane. He then left the airplane through the rearmost exit on the right side where a ladder had been placed over the deflated slide. The captain was the last person to leave the airplane.

The accident occurred at 2118:41 during daylight hours at 40°38' north latitude and 73°46' west longitude.

1.2 Injuries to Persons

Injuries	Crew Cockpit	Crew Cabin	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	0	1 12/	0	1
Minor	2	1	8	0	11
None	1	10	154	0	165
Total	3	11	163	0	177

1.3 Damage to Aircraft

The airplane was damaged substantially.

1.4 Other Damage

The approach light structure for runway 22R was damaged substantially from contact with the left wing.

1.5 Personnel Information

The flightcrew was qualified for the flight in accordance with regulations of the Norwegian, Swedish, and Danish Civil Aviation Authorities and the Federal Aviation Administration and had received the required training. The flightcrew members indicated that they were not fatigued before the accident and that they had had the required rest periods before the flight.

1.6 Aircraft Information

The airplane, a McDonnell Douglas DC-10-30, Norwegian Registry LN-RKB, was operated by SAS of Denmark, Norway, and Sweden. The airplane had been maintained in accordance with applicable regulations. At the time of the accident, the airplane autothrottle speed control and related systems had a history of intermittent malfunctions as follows: Because a previously reported mechanical irregularity with the autothrottle speed command system, SAS Maintenance in Copenhagen changed the autothrottle speed command computer on January 18, 1984. No specific reference was made as to which computer or if both computers were changed. On February 25, 1984, LN-RKB operating as Flight 901 from Copenhagen, Denmark, to Gottenburg, Sweden, experienced an autothrottle problem wherein the autothrottles, with both systems on, would not throttle back in the speed mode. The autothrottle speed system kept the speed 30 knots high. On the same day during an approach into JFK, the autothrottle system on LN-RKB, kept the speed 20 to 30 knots too high with either one or both of the systems on. At times, the throttles moved back and forth +/- 1 cm. The crew commented that the autothrottle speed was not reliable on descent, but was reliable during takeoff, climb, and cruise. On February 26, 1984, the autothrottle control panel on LN-RKB was replaced by SAS Maintenance in Stockholm.

12/ A female passenger with a cardiac condition was hospitalized for over 48 hours for observation which required classification of "serious injury" in accordance with 49 CFR 830.2 definitions.

On February 26, the crew of LN-RKB, on a flight from JFK to Stockholm, reported that the No. 1 stall warning system was unserviceable during the preflight. After interchange of the No. 1 and No. 2 stall warning computers, a ground check found that both systems operated normally; however, after liftoff from JFK, both speed flags appeared once. During slat retraction, the stall warning came on with autoslat extension. The crew reported that the stall warning cycled on and off with autoslats extended. A circuit breaker was pulled to silence the warning and to make retraction of the slats possible. The circuit breaker was reset during cruise and no further abnormalities with the stall warning system were noted for the remainder of the flight. On February 26, SAS Maintenance replaced the No. 1 angle of attack sensor to correct the cause of the last four discrepancies.

On February 27, the crew of LN-RKB, on a flight from JFK to Stockholm, reported that either one or both autothrottles kept a speed 20 knots above that which had been selected for the approach. On February 27, the crew of LN-RKB, on a flight from Stockholm to Oslo and Oslo to JFK, noted the same problem with the autothrottle system.

The airplane, operated as Flight 902, returned to Stockholm via Oslo on February 28. SAS Maintenance in Stockholm replaced the No. 2 autothrottle speed control computer. This was the last recorded entry in the airplane log that addressed the autothrottle speed control system. The airplane had accumulated about 34,941 hours in service since new.

The airplane's calculated gross weight at landing was 385,000 pounds (175 metric tons). The airplane was powered by three CF-6-50-C high bypass ratio turbofan engines. A review of the inspection records for the airplane and engines and the airplane's logbook for the last 90 days preceding the accident disclosed no significant deferred maintenance items.

1.7 Meteorological Information

The 2100 National Weather Service (NWS) surface analysis prepared by the National Meteorological Center in Camp Springs, Maryland, showed a low pressure area (985 millibars) located in central Pennsylvania, with a weak occluded front extending east from the low across Long Island. The 0000 NWS surface analysis showed the low pressure area (982 millibars) in northeastern Pennsylvania, with the occluded front extending eastward into Connecticut.

The following was determined from surface weather observations from JFK, Farmingdale, New York, Islip, New York, and Westhampton Beach, New York:

About 2100 the surface occluded front was north of Westhampton Beach and south of Islip, Farmingdale, and JFK. At 2125, the front was still south of JFK and the surface wind at JFK was 100° at 6 knots. At 2142, the front was due north of JFK and the surface wind had changed to 180° at 5 knots. At 2150, the front was north of Farmingdale and Islip. From the 2100 NWS surface analysis, it was determined that surface winds were from a southerly direction south of the front and an easterly direction north of the front. From the 2100 and 0000 NWS surface analysis, it was determined that the occluded front was moving north about 20 knots. Since the occluded front was moving north about 20 knots and assuming that the front passed JFK around 2142, it was determined that the surface front was about 8 nmi south of JFK at the time of the accident. Based on the AIDS static air temperature data, Flight 901 penetrated the top of the frontal zone below 1,000 ft above ground level.

The terminal forecast for JFK issued by the NWS Forecast Office in New York City at 1440 was as follows.

1500 to 2100: 500 ft scattered, ceiling 1,000 ft overcast, visibility --2 miles, light rain, fog, wind--090° at 20 knots gusting to 35 knots, low-level wind shear, occasional ceiling 500 ft overcast, visibility--3/4 miles, moderate rain, fog, chance of a thunderstorm, moderate rainshowers.

2100 to 0200: 400 ft scattered, ceiling 800 ft overcast, visibility--3 miles, light rain showers, fog, wind--150° at 20 knots gusting to 35 knots, low-level wind shear, occasional ceiling 400 ft overcast, visibility--3/4 mile, fog, chance of indefinite ceiling 200 ft sky obscured, visibility 1/4 mile, fog.

According to the surface weather observation for JFK, the amount of rainfall measured by the NWS at JFK from 1745 to 2352 was 0.23 inch. From 1915 to 2240, light drizzle was reported at the airport. Review of the NWS rain gauge record for JFK indicated that from 2000 to 2130 less than .05 inch of rain was recorded. The rain gauge is located on top of the International Arrivals Building.

Review of the record for the NWS wind gust recorder for JFK indicated that at 2113 the wind speed was 6 knots, at 2118 the wind speed was 5 knots, and at 2123 the wind speed was 6 knots. The highest wind speed recorded from 2113 to 2123 was 6 knots.

Winds Aloft

NWS upper wind readings from Atlantic City, New Jersey, (about 75 nmi south of JFK) about 2300 were as follows:

Altitude (ft above sea level)	Wind Direction (° true)	Wind Speed (knots)
973	222	30
1,825	231	36
2,685	233	44
3,580	226	48
4,439	219	45
5,268	211	44
6,078	205	46
6,869	205	47
7,710	204	49
8,649	201	47
9,512	202	43

The Brookhaven National Laboratory, Brookhaven, Long Island, New York, located about 45 nmi east of JFK has an instrumented meteorological tower. Wind direction/data from this tower provided by this facility for 2100 to 2120 and wind speed data for 2110 are as follows:

Altitude (ft above sea level)	Wind Direction (° true)	Wind Speed (knots)
117	180 to 210	2
370	180 to 210	8

Surface weather observations for JFK made by the NWS were as follows:

1951 Record Special - Measured ceiling 800 ft broken, 1,200 ft overcast, visibility 2 miles, light drizzle, fog, temperature 45° F, dewpoint 44° F, wind 060° at 15 knots, altimeter setting--29.16 inHg.

2018 Special - Measured ceiling 400 ft broken, 800 ft overcast, visibility 2 miles, light drizzle fog, wind 080° at 10 knots, altimeter setting--29.15 inHg.

2039 Special - Measured ceiling 300 ft broken, 600 ft overcast, visibility 1 1/2 miles light drizzle, fog, wind 090° at 08 knots, altimeter setting--29.15 inHg.

2051 Record Special - measured ceiling 300 ft overcast, visibility--1 mile, light drizzle, fog, temperature--45° F, dewpoint--44° F, wind--060° at 6 knots; altimeter setting--29.15 inHg., runway 4R visual range greater than 6,000 ft.

2109 Special - Measured ceiling 200 ft overcast, visibility--3/4 miles, light drizzle, fog, wind--100° at 7 knots; altimeter setting--29.15 inHg.

2121 Local - Measured ceiling 200 ft overcast, visibility--3/4 mile, light drizzle, fog, temperature--47° F; dewpoint--46° F; wind--100° at 5 knots; altimeter setting--29.15 inHg., aircraft mishap, runway 4R visual range--2,400 ft variable to 2,600 ft.

Information pertinent to the area of the accident contained in the NWS area forecast, issued on February 28 at 1740 and valid until February 29, 0600, was:

- Flight precautions for [instrument flight rules] IFR, icing and turbulence.
- Occasional moderate mixed icing in clouds and in precipitation below 12,000 to 14,000 ft.
- Severe turbulence across the forecast area. (See SIGMET Alfa series for high level turbulence and SIGMET Charlie series for low-level turbulence.)
- Low-level wind shear potential across the entire forecast area due to strong cyclonic circulation associated with a West Virginia low pressure center.
- Occasional moderate turbulence below 17,000 ft due to wind shear. . . . Strong low-and mid-level winds.
- Occasional moderate turbulence between 17,000 to 38,000 ft due to wind shear aloft and jetstream.
- Ceilings occasionally below 1,000 ft overcast, visibilities occasionally below 3 miles, light rain, light snow, fog with intermittent light freezing rain, light freezing drizzle, light ice pellets.
- Isolated light rainshowers, thunderstorm, light rainshowers until 2300.

SIGMET Charlie 9 was issued by the National Aviation Weather Advisory Unit in Kansas City, Missouri, at 1815 and was valid until 2215. The area covered included JFK and indicated moderate occasional severe turbulence below 10,000 ft because of wind shear and strong low-level winds.

SIGMET Alfa 15 was issued by the National Aviation Weather Advisory Unit in Kansas City at 2050 and was valid until 0050. The area covered included JFK and indicated moderate to occasional severe turbulence between 17,000 to 38,000 ft because of wind shear aloft and jetstream.

A Center Weather Advisory was also issued by a New York ARTCC Weather Service Unit meteorologist at 1900 valid until 2100. The advisory advised of strong low-level wind shear potential within the New York Center area, northeast of a Slate Run (SLT)/Atlantic City (ACY) line, especially from Elmira through New York City, Long Island, and Connecticut.

At 1100, high wind warning was issued for all metropolitan New York airports by the NWS forecast office in New York City. The warning was valid until 0000. The warning called for winds east-southeast 15 to 25 knots with gusts 35 to 40 knots. The high wind warning was transmitted to the JFK Weather Service Office on AWDS, and the warning was transmitted to the tower by the Weather Service Office at JFK on the AWDS at 1140.

The AIDS recorder installed on board SAS Flight 901 recorded parameters during the approach to JFK, including wind direction and wind speed. Wind data recorded were as follows:

Radio Altitude (ft above the surface)	Wind Direction (° true)	Wind Speed (knots)
2,000	226	33
1,500	235	32
1,400	230	26
1,300	228	25
1,200	229	24
1,100	233	21
1,021	233	19
908	231	15
819	212	12
704	202	13
592	195	13
498	185	13
405	166	10
307	161	11
212	144	8
101	137	7
53	143	5
30	124	6
20	131	8
12	126	2
3	136	6

Wind components relative to a track of 40° magnetic were derived from AIDS data as follows:

Approximate Height (ft above the surface)	Computed Wind Speed (knots) (tailwind)
2,000	31.4
1,500	28.5
1,021	17.2
819	12.0
714	13.9
619	13.7
524	11.0
423	9.5
325	6.1
231	3.9
138	2.3
40	1.7
16	1.0
8	.1
3	1.9

1.8 Aids to Navigation

ILS approach procedures (categories I, II, and IIIA) serve runway 4R at JFK. The procedure is begun at an altitude of 3,000 ft, and a distance of 15.5 miles, distance measuring equipment (DME), from the departure end of runway 4R. The altitude profile positions the airplane at 1,500 ft at 6 miles DME from the departure end or 4.4 miles from the approach end of the runway on an inbound heading of 43° magnetic. Class-D category airplanes (such as the DC-10) require 200-ft ceilings and 1/2-mile visibility. The missed approach point is 0.4 mile from the approach end of the runway. The touchdown zone altitude is 12 ft m.s.l. The Airport/Facility Directory in effect at the time of the accident indicated that "temporary localizer needle aberrations may be experienced on ILS approaches to runway 4R or 22L due to heavy jet aircraft in vicinity."

1.9 Communications

There were no communications problems identified.

1.10 Aerodrome Information

John F. Kennedy International Airport in Jamacia, New York, is certificated by the Federal Aviation Administration under 14 CFR 139. Its runways are at an elevation of 12 ft m.s.l. The landing surfaces include four main runways: 13R/31L which is 14,572 ft long and 150 ft wide, 13L/31R which is 10,001 ft long and 150 ft wide; 4L/22R which is 11,351 ft long and 150 ft wide; and 4R/22L which is 8,400 ft long and 150 ft wide. Runway 4R is grooved and equipped with high intensity runway edge lights, centerline lights, a high intensity approach lighting system with sequenced flashing lights (category II configuration), and touchdown zone lights. The runway edge lights are white until the last 2,000 ft of the landing runway, which is marked by aviation yellow lights. The runway centerline lights also are white until the last 3,000 ft of runway, at which point the lights are alternating white and red. The centerline lights change to all red 1,000 ft from the runway end. The runway edge lights, the centerline lights, and touchdown zone lights for runway 4R were all set to their brightest illumination at the time of the accident. The approach light structures are not frangible.

There are no runway distance markers installed. The airport is also equipped with a low-level wind shear alert system (LLWAS) which was operational on the day of the accident.

Runway surface friction tests were conducted under Safety Board direction during both wet and dry runway conditions using the Saab and Mu Meter friction test units. Friction readings derived from both test units were well above the minimum acceptable value.

1.11 Flight Recorders

The airplane was equipped with a Sundstrand Data Control Model 573 digital flight data recorder (DFDR), serial No. 2891. The tape was in good condition and was examined at the National Transportation Safety Board's laboratory in Washington, D.C.

The airplane was also equipped with an aircraft integrated data system. Since the Safety Board's laboratory has no AIDS readout equipment, the readout of these data was accomplished at the facilities of SAS in Copenhagen, Denmark; Sundstrand Data Control, Redmond, Washington; and McDonnell Douglas Corporation, Long Beach, California.

Following the accident, Lufthansa, German airlines examined the flight recorders from one of its DC-10 and one of its Boeing 747 aircraft which landed before Flight 901 and provided the Safety Board with comparative performance data.

The airplane was also equipped with a Sundstrand Data Control Model AV-577B cockpit voice recorder (CVR), serial No. 7043. The tape was in good condition. Interpreters listened to the tape and translated it into English. The SAS Flight 901 flightcrew reviewed the transcript with the Cockpit Voice Recorder Group for accuracy and made corrections and/or additions as necessary. The CVR tape began with the normal approach briefing. The transcript began with the reception of ATIS information "whiskey."

1.12 Wreckage and Impact Information

The airplane came to rest about 35 ft to the right of the extended runway centerline on a 12° slope leading down to Thurston Basin. At high tide, the shoreline of Thurston Basin begins about 60 ft beyond the 500-ft runway overrun area. The basin is a shallow, mud-based estuary with its bottom about 10 to 15 ft below runway level, and it is subject to tidal changes. The nose of the airplane was about 160 ft beyond the end of the runway overrun area. The airplane's heading was 55° magnetic at impact. The leading edge of the airplane's left wing was partially embedded in a wooden pier structure which supported the approach lighting system.

The aft portion of the fuselage remained generally intact. There was major damage at the lower nose area, to the radome, and to the forward pressure bulkhead at fuselage station (FS) 275. The nose landing gear structure had collapsed under the fuselage. The drag braces were fractured and had separated from their attachment fittings. The interior of the forward fuselage area was deformed and exhibited fractures at the flight deck and galley floor locations. Several floor beams below the galley floor were fractured and twisted.

The wings, leading edge slats, and flaps sustained moderate damage from impact with the wooden pier structure. The leading edge slats were extended fully and the trailing edge flaps were extended to the 40° position.

The No. 1 engine pylon structure was buckled and twisted; the No. 2 and 3 engine pylons exhibited no major structural damage. The No. 1 and No. 3 engines sustained major impact and salt water damage. The No. 2 engine sustained no impact damage. All three fan and turbine thrust reversers were in the fully deployed (reverse thrust) positions.

All three engines and APU fire extinguishers were intact; examination of their discharge cartridges disclosed that none had been electrically activated or that any of the extinguishing units had been discharged. Systems components relative to the autothrottle speed control were examined and functionally tested.

Both Mach/airspeed indicators were found to be free of defects. The captain's attitude direction indicator had evidence of water contamination and corrosion. The copilot's unit was clean. Both indicators were tested for the slow/fast function and were found to function normally. The thrust rating computer had been contaminated by water and sand and was corroded. The computer was cleaned in a freon bath and tested. The computer failed to operate, and no further testing could be accomplished.

The duplex throttle servo also had been contaminated by water and was corroded. When tested, both drive motors were seized. Further testing resulted in the freeing of drive motor No. 2, which functioned normally and produced the proper torque output. The gear train moved freely. All coils to the drive motors and tachometers tested normal. Both autothrottle speed control computers had been contaminated by water and sand and were corroded. Both computers were cleaned in a freon bath and tested. Computers No. 1 and No. 2 exhibited multiple failures. All failed areas were examined closely. Four of the failures of computer No. 1 were in the areas of speed mode operation. When repeating the tests in this area, the failures could not be duplicated. Failures in computer No. 2 were so numerous that the computer would not function normally. Both computers were tested further, but results were inconclusive.

The left and right angle of attack sensors exhibited some light internal corrosion. The pickup was replaced in the left angle of attack sensor and tested. The left angle of attack sensor then functioned normally. The probe on the right angle of attack sensor had been bent during the accident and could not be tested.

Examination of the proximity electronic unit disclosed internal contamination and corrosion from salt water immersion; after cleaning, the unit passed all functional tests except for the left main landing gear "down" function.

The two digital air data computers exhibited internal contamination, corrosion, and impact damage to the circuit boards. The damage to the circuit boards prevented a functional testing of the computers. The flap position transmitters disclosed no internal damage and performed normally during functional testing.

The cockpit was damaged by impact. The glareshield and instrument panel were displaced aft and down several inches. All flight deck crew seats were intact and undamaged except for the second observer's jumpseat which was loosely attached to the cockpit floor. That seat was similar in design to the free-standing jumpseat used by flight attendants; the unit has a fold-down seat pan and an integral four-point restraint system. The observer seat was flush against the cockpit/cabin bulkhead and mounted to the floor with four bolts. The front attachments were intact. However, the two aft bolts were found loose but in place. Microscopic inspection disclosed that the threads on both bolts were stripped; the nuts to these bolts were not recovered.

The cabin was deformed only in the floor and ceiling area around doors 1L and 1R between the forward three galleys and the two lavatories. Additional damage was noted just aft of forward lavatories A and B. The airplane flooring in these areas was disrupted and displaced upward, exposing the supporting structure. The ceiling panels in the area were disrupted by the displaced galley units. Additionally, the vertical panel near door 1R, which covered the door mode selecter and control levers, was buckled and split in the area of these controls.

The cockpit/cabin bulkhead, at the junction of the floor and the left side of the cockpit door, was displaced upward 2 1/2 inches and forward about 1 inch. The upper piano hinge of the cockpit door was pulled away from the door edge. The right side of the cockpit/cabin bulkhead was displaced downward about 5 inches at the cockpit door frame.

The left galley unit, aft of the cockpit/cabin bulkhead, was tilted inboard about 2 inches at the top. The galley unit also was tilted aft. At the cockpit floor, the galley unit was displaced forward and upward about 2 inches and in contact with the observer's jumpseat. The center galley unit, G3, was displaced upward and was tilted aft. The floor and the forward bottom edge of the galley unit were displaced upward about 7 inches. All galley equipment remained stowed. However, the storage doors of the G3 galley unit were bowed out about 1 inch. The aft door lock had disengaged, but the interlocking right door lock kept the galley doors closed.

The remainder of the cabin interior structure aft of row 1 generally was undamaged. All of the overhead panels and stowage bins were intact. No sidewall or floor disruption was evident aft of the first row of seats.

The airplane was equipped with slide/rafts. The 1L door was found open and the slide/raft was deployed and inflated; the 1R door was found closed. The mode selector lever was in the manual position, and there was extensive damage to the forward panel covering the door handles. The 2L door was open and the slide/raft had been detached at the girt. The detached slide/raft was inflated and found floating near the approach light pier. Door 2R also was found open and the slide/raft had been detached at the girt. The slide/raft was found inflated and floating in the basin near the shore. Both slide/rafts from doors 2L and 2R were used as rafts. However, neither slide/raft had been converted from a slide to a raft configuration.

The 3L door was closed, and the mode selector lever was in the manual position. When the selector lever was placed in the emergency position and the control lever pulled, the door retracted and the ramp and slide/raft deployed and inflated. The 3R door was open. The ramp and slide/raft had deployed and were inflated.

The aft left door, 4L, was open, and the mode selector lever was in the emergency position. The slide/raft had deployed and was partially resting on the ground with the half ties intact and had not been inflated. Six-foot-tall marsh grass, up to 1/4 inch in diameter, was underneath and around this slide/raft and the slide/raft at the 4R door. The slide/raft was inflated by pulling the manual inflation handle. The aft right door, 4R, also was open; the mode selector lever was in the emergency position. The slide/raft had deployed but was not inflated. The cylinder was discharged and the manual inflation handle was in place. The slide/raft was stretched out on the ground. The examination of the slide/raft at door 4R disclosed that the supplemental restraints, known as quarter ties, located on the inside of both upper side chambers, were attached. The half tie and the orange frangible link had separated. The link is designed to separate at 129 lbs., ± 6 lbs. of tensile load. A fabric tear was discovered on the bottom of the lower right side chamber. The tear was located 36 inches from the top of the slide and near the locator light battery pack. The tear measured 12 inches laterally and 26 inches longitudinally. Twigs and debris were found in both aspirator inlets. The slide/raft was checked for additional leaks after the tear was patched and the aspirators were cleaned. Two small puncture holes were found in the outboard left upper chamber between the second and third canopy posts. It also was noted that the slide surface had a hole about 3/4 inch in diameter, about 3 ft from the top upper chamber and 12 inches right of the slide centerline.

Both aft slide/rafts were examined at the manufacturing plant. The slide/raft at door 4L was not tested under pressure since it was inflated at the site. There was no evidence to indicate that the inflation lanyard had been misrigged or that any other condition existed which would have inhibited the inflation bottle from freely dropping and automatically discharging to inflate the slide/raft.

1.13 Medical and Pathological Information

The captain sustained bruises to his right hand and left leg and was admitted to the hospital; the first officer sustained a minor back injury; and the flight attendant at 1L sustained a sprained knee. A total of nine passengers sustained minor injuries, including a contused knee during the evacuation, and were treated at the airport medical facility. One person sprained an ankle. Five passengers were treated for exposure and/or hypothermia. The remaining three passengers were treated for anxiety, hypertension, and unstable angina, respectively. One of these, a female passenger with a cardiac condition was hospitalized for over 48 hours for observation which required classification of "serious injury" in accordance with the definitions in 49 CFR 830.2.

1.14 Fire

There was a localized, small fire confined to some electrical wiring adjacent to pneumatic ducting under the cabin floor. The fire self-extinguished almost immediately.

1.15 Survival Aspects

Evacuation

After the airplane came to rest, the evacuation in the cabin was initiated inadvertently by the purser stationed at door 2L. He heard no command from the flightcrew to evacuate, and although the emergency evacuation signal was activated, he did not hear it. The flight attendants at doors 4L and 4R had no awareness of an emergency situation and momentarily waited until they saw actions by the forward flight attendants before opening the doors and initiating the evacuation of the last section of the airplane.

All of the cabin doors except for 1R and 3L were opened by the flight attendants. All of the combination slide/rafts deployed automatically, and except for the slide raft at 4L, all inflated. The 1L door initially was hung up retracting into the ceiling. Subsequently, the door retracted properly and the slide/raft fully deployed and inflated. However, no one used this exit. The attendant at door 1R attempted to open his door. He pushed the handle all the way up, but nothing happened. The two slide/rafts at doors 2L and 2R were detached and used as rafts without being converted from a slide to a raft configuration. Each raft was estimated to have had about 20 passengers and crewmembers on board. The flight attendant at door 3L opted not to open her door after observing smoke from the left engine. She directed the passengers on her side across to the 3R door. Most of the passengers in the economy section went out this door. At door 4L, the slide/raft deployed but did not inflate automatically. The flight attendant chose not to inflate the slide since the door opening was close to the ground. The slide/raft at door 4R, which had deployed, was hung up and did not inflate properly after the door was opened. The flight attendant said the slide was folded in half and he kicked it open. The slide deflated shortly after it was kicked open. About 40 passengers exited through door 4R.

The flight attendants at the four forward doors did not observe that the emergency lights were illuminated during the evacuation. Most of the others said that the emergency lights were illuminated. All flight attendants stated that the emergency evacuation was controlled and the passengers were calm. They estimated that the evacuation of the airplane was completed within 60 to 90 seconds, despite some difficulties evacuating two intoxicated passengers who refused to leave the airplane and had to be bodily removed from the cabin by the flightcrew.

Crash/Fire/Rescue Response

The JFK Port Authority of New York and New Jersey emergency crews were notified initially at 2119 hours, when the call came that an SAS 747 "was lost on ground radar" on runway 4R near runway 14/32. This call came from the JFK Tower on the emergency conference circuit. Crash/fire/rescue (CFR) units responded from both CFR garages with six CFR trucks and 12 firefighters. The first two CFR trucks from the satellite garage arrived on the scene in slightly over 1 minute. The crew chief, who was aboard truck No. 1, stated that he had seen the aircraft off the end of the runway and partially submerged in the Thurston Basin. He notified the police desk to upgrade the emergency at 2121. No fire was visible. About 80 percent of the passengers had exited the aircraft. He observed a number of passengers and crewmembers forward of No. 1 engine, two of whom were in the water. The crew chief entered the water and assisted about 12 passengers who were in a slide/raft in the basin at the end of the approach lighting system pier. Several firefighters escorted passengers on the end of the pier over the left wing and back onto the pier and away from the aircraft.

Shortly thereafter, the crew chief proceeded to the right side of the aircraft and observed another slide/raft adrift in Thurston Basin forward of the No. 3 engine. He then entered the water with a line and swam to the raft; he and the raft were then pulled to shore by fellow firefighters on the other end of the line. After leaving the water, the crew chief observed a cockpit crewmember inside the aircraft at door 4R and advised him to exit expeditiously.

The crew chief estimated that all passengers were on land and safely clear of the aircraft within 5 to 7 minutes of the initial alarm. Within approximately 20 minutes after the accident, all passengers had been boarded on mobile lounges. Those without injury were taken to the International Arrivals Building at JFK. Those who were injured or appeared injured were transported initially to the airport medical clinic. Persons requiring further medical attention were transferred to a nearby hospital.

Upon completion of passenger evacuation operations, airport CFR vehicles remained in strategic positions around the aircraft. New York City Fire Department fire equipment also stood by on the north side of Thurston Basin with suction pumps placed in Thurston Basin to provide additional water if required.

1.16 Tests and Research

1.16.1 Time of Touchdown

The time of touchdown was established by relating the events that can be associated with an airplane approaching and coming in contact with the runway surface. Based on the data from the AIDS and the DFDR, touchdown was determined to be at 21:18:21.6. About 1.5 seconds before touchdown, the elevators deflected significantly to an aircraft noseup position, which is indicative of a flare to cushion the touchdown. At 21:18:21.6, the vertical acceleration had nearly reached a peak, longitudinal acceleration began decreasing, the spoiler handle and the panel were retracted, thrust reversers on engines Nos. 1 and 3 were stowed, the wheel brake switches were off, the nose gear strut switch was in the air position, and the radio altimeter read about zero ft. At 0.7 second after touchdown, the vertical acceleration peaked and the longitudinal acceleration continued to decrease. Immediately upon touchdown, the spoiler handle and panel were in the extend position, and the nose gear strut switch was recorded in the ground position.

1.16.2 Point of Touchdown

The point at which the airplane touched down on the runway was calculated as follows:

1. The AIDS recorded inertial navigation system (INS) ground speed for the time period from the middle time of the recorded outer marker (OM) signal to the recorded sound to the touchdown was integrated to compute distance traveled after passage of the outer marker. This computed distance was compared with the actual distance from the OM to the approach end of the runway.

2. Similar calculations were made using passage of the middle marker (MM) as the position reference.

The integration of groundspeed from the middle time of OM reception to time of touchdown was 20,793 ft. The actual distance from the OM to the approach end of the runway is 16,196 ft. Therefore, the calculated position of touchdown using this method was 4,597 ft down the runway. The integration of the groundspeeds from the middle time of the MM reception to the time of touchdown was 7,539 ft. The actual distance from the MM to the approach end of the runway is 2,610 ft. Therefore, the calculated position of touchdown using this method was 4,929 ft.

1.16.3 Approach Profile and Configuration from 2,000 Feet to Touchdown

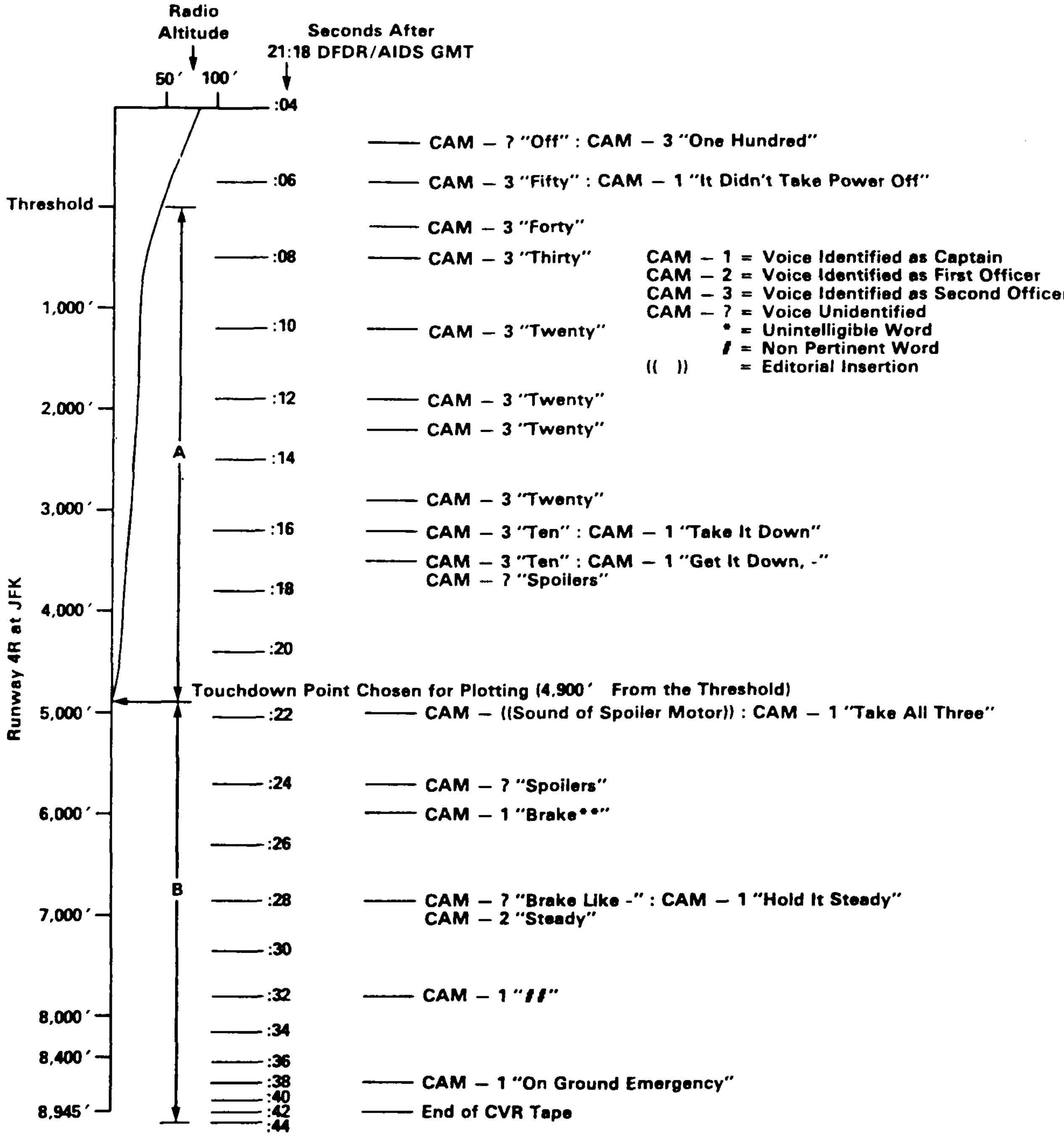
About 4 minutes before touchdown, the aircraft was about 2,000 ft above ground level (AGL), tracking 015° true at about 180 knots indicated airspeed. Autothrottles No. 1 and No. 2 were engaged in the speed mode, No. 2 autopilot was in the command mode, No. 1 autopilot was off, and the flaps were set at 15°. During the next minute, the aircraft descended to about 1,500 ft AGL and the autopilot ILS mode was selected. About 3 minutes from touchdown, the autopilot switched to the localizer capture and tracking mode, the aircraft began turning toward runway heading, pitch increased slightly, and N_1 fan rotor speed began to increase. (N_1s representing all three engine rpm percentages were used in these calculations.) The aircraft remained level for the next 1.5 minutes at a nearly constant indicated airspeed of 180 knots and an inertial navigation system groundspeed of about 210 knots, indicating about a 30-knot tailwind. About 1.5 minutes from touchdown, the flaps started down to the 22° position, the autopilot switched to glideslope capture and tracking mode, N_1 began to decrease to flight idle, the aircraft pitched over, and the aircraft began to descend. The AIDS data showed that the difference in the airplane's airspeed and the speed selected on the autothrottle system had reached at least 10 knots, which is the maximum difference measurable by the recording system.

During the first 30 seconds of descent (from 1,500 ft to about 870 ft AGL), the throttle position and engine N_1 went to flight idle, indicated airspeed increased to 190 knots and then began to decrease, and the flaps started down to the 35° position. During the next 10 seconds (from 870 ft to 700 ft), the throttles and engine N_1 came up to about 84 percent, the indicated airspeed began climbing from 180 knots, and the flaps reached the 35° position. For the next 32 seconds, until about 18 seconds from touchdown (from 700 ft to 70 ft), the throttle position and N_1 stayed about 84 percent while indicated airspeed continued to climb to a peak of 209 knots. As the airspeed increased past about 193 knots, the flap limiting system on the aircraft began to retract the flaps.

The flaps continued up to about 27° at an indicated airspeed of 209 knots about 15 seconds before touchdown. About 20 seconds before touchdown, the autopilot was switched from the command to the control wheel steering mode. Three seconds later, the throttle position was reduced to flight idle at a faster rate (about 9.5° per second) than the autothrottle programming allows (2° to 3° per second). About this time, the captain stated, "It didn't take power off." (See figure 4.) At 15 seconds before touchdown, the aircraft was about 50 ft radio altitude, pitch began increasing, the airspeed began decreasing, the flaps began to extend back to the 35° setting, and the autothrottles went from the speed mode to the retard mode.

About 5 seconds before touchdown, the flaps arrived at the 35° setting, the airspeed had decreased to 185 knots, and the radio altitude was about 20 ft. At touchdown, the indicated airspeed and the groundspeed were about 179 knots.

A correlation was made between the CVR cockpit conversation, radio altitude, and position over and on the runway. (See figure 4.) Because CVR times are listed to the nearest second, this correlation is only approximate.



"A" Distance Is Based on AIDS INS Ground Speed Integration From the Middle Marker to Touchdown.

"B" Distance Is Based on the DFDR Longitudinal Acceleration Integration From the Assumed Time of Impact Back to the Time of Touchdown. This Distance Is Anchored at One End to the Approximate Final Position of the Aircraft.

Figure 4.—CVR/AIDS Integration/Runway/Altitude Correlation.

1.16.4 Summary of Landing Roll

Within 0.7 second after what was determined to be touchdown (21:18:21.6), the spoiler handle came out of the retract position, the spoiler panels that were measured by the AIDS system (5 left and 3 right) came out of the zero degree position, the vertical acceleration peaked, the nose gear strut switch remained in the "air" position, the longitudinal acceleration began a decreasing trend, and the Nos. 1 and 3 thrust reversers were recorded in the stowed position. At 2.0 seconds after touchdown, the nose gear strut switch was recorded in the ground position, the wheel brakes were still in the off position, the spoiler handle was recorded in the extend position, and the spoiler panel reading was about 60°. About 2.8 seconds after touchdown, recorded data showed both wheel brakes on and the No. 1 thrust reverser in the stowed position. N_1 on all three engines during this time (from 14 seconds before touchdown) was about 40 percent (equal to flight idle). Five seconds after touchdown, the N_1 began to decrease from flight idle to ground idle. About 6.4 seconds after touchdown, the No. 1 thrust reverser registered in the deployed position (these data are sampled once every 4 seconds). The No. 3 N_1 began increasing from 35 percent at 8 seconds after touchdown, and passed 90 percent at 12 seconds after touchdown. The No. 1 N_1 began increasing from 30 percent about 12 seconds after touchdown and attained 88 percent at 15.4 seconds after touchdown where the data ended. The No. 2 engine thrust reverser was in transit for 3.4 seconds and was fully deployed 7.4 seconds after touchdown but showed only a slight momentary increase in N_1 from 32 percent to 41 percent and then back to 32 percent where it remained to the end of recorded data, which for this engine was 16 seconds after touchdown.

A listing of significant events after the time established for touchdown follows:

Time from Touchdown (21:18:21.6) (Seconds)	Events
0	Radio Navigation 1 groundspeed from AIDS (interpolated 179.0 knots).
0	Indicated airspeed from DFDR (interpolated 179.5 knots).
0.1	Longitudinal acceleration began decreasing trend (from DFDR).
0.7	Vertical acceleration peaked (from DFDR).
0.7	No. 3 thrust reverser last recorded in stowed position (from AIDS).
1.2	Pitch attitude reduced to nose on the runway value (from DFDR).
1.6	Spoiler panel first recorded in extended position (from AIDS).
1.7	Spoiler handle first recorded in extended position (from AIDS).
2.0	Nose gear strut switch first recorded in ground position (from AIDS).
2.7	No. 1 thrust reverser last recorded in stowed position (from AIDS).

Time from Touchdown (21:18:21.6) (Seconds)	Events
2.8	Both wheel brakes first recorded on (from AIDS).
6.7	No. 1 thrust reverser first recorded in deploy position (data sampled every 4 seconds) (from AIDS).
8.45	N_1 on all three engines last recorded at about 40 percent (from 14 seconds prior to touchdown) (from AIDS).
8.7	No. 3 thrust reverser first recorded in deploy position (data sampled every 4 seconds) (from AIDS).
9.45	No. 3 engine N_1 began increasing above 40 percent (from AIDS).
9.7	Rudder input recorded greater than -5° (from AIDS).
11.9	No. 1 engine N_1 began increasing above 40 percent (from AIDS).
12.0	No. 3 engine N_1 passed through 90 percent (linear interpolation) (from AIDS).
15.8	No. 2 engine N_1 showed no increase past 41 percent from 12 seconds prior to touchdown to the last recorded point (from AIDS). (Throttles were not moved past 41 percent position.)
18.45	Magnetic heading deviated from runway heading (from DFDR).
18.9	No. 1 engine N_1 attained 91.9 percent at last recorded time (from AIDS).
20.7	Aircraft began pitch down (from DFDR).
21.2	Pitch attitude reached -5.89° at last recorded value (from DFDR).
21.60	Last recorded longitudinal acceleration (from DFDR).
21.63	Last recorded point from DFDR before synchronization was lost (lateral acceleration).

1.16.5 Runway Friction

Runway friction measurements were taken on 4R at JFK using a friction tester on February 29, 1984, when the runway was dry and on March 5, 1984, when the runway was wet.

The dry test, performed at a speed of 48 mph, showed an average friction value of 0.945 14/ from the approximate point of touchdown to the approximate end of the runway. Friction was not measured on the hard-surface overrun.

The wet tests were performed at three different speeds with the following averages for the portion of the runway after the approximate point of aircraft touchdown:

Speed	Average Friction
22 mph	0.88
47 mph	0.81
65 mph	0.78

The Saab handbook defines aquaplaning (hydroplaning) as "the speed at which the friction value has dropped to 0.25."

Calculations made by the Douglas Aircraft Company show calculated effective braking coefficient of friction (Mu prime) as a function of groundspeed for the landing ground roll. (See figure 5.) The force attributed to braking was derived using deceleration data from the DFDR and calculating the drag, lift, and thrust forces on the aircraft. (The effective braking coefficient cannot be directly equated to friction values as measured with the Saab equipment.)

The FAA-approved field length for Flight 901 with a 35° flap, slats extended configuration at the prevailing pressure and temperature on a wet surface was about 7,000 ft. This field length is based upon the safety margins required by regulation to be applied to the certification landing performance of the airplane.

Figure 6 shows calculations performed by the Douglas Aircraft Company for wet and dry stopping distances for a normal landing sequence and for the accident scenario. These stopping distances are those theoretical distances which are required to bring the airplane to a full stop from the point of touchdown using the deceleration devices as indicated with the assumed braking coefficients attainable on dry and wet runways.

1.16.6 Wind Shear

From about 3 minutes to 1.5 minutes before touchdown, the AIDS INS calculated winds acting on the aircraft. These calculations revealed that the winds were from about 225° to 235° true at between 26 and 32 knots, producing a tailwind of approximately the same magnitude. Aircraft true heading during this time period was between 12° and 22°.

About 1.5 minutes before touchdown, the recorded wind speed began to decrease and during the following 30 seconds, lessened to about 15 knots. About 1 minute before touchdown, the wind direction began to change gradually counterclockwise, while speed continued to decrease. By 20 seconds from touchdown, the wind acting on the aircraft was recorded to be from 144° at 8 knots, resulting in a slight tailwind of less than 3 knots. At touchdown, the winds were recorded to be from about 135° at 6.5 knots.

14/ Friction value is an index number relatable to friction coefficient.

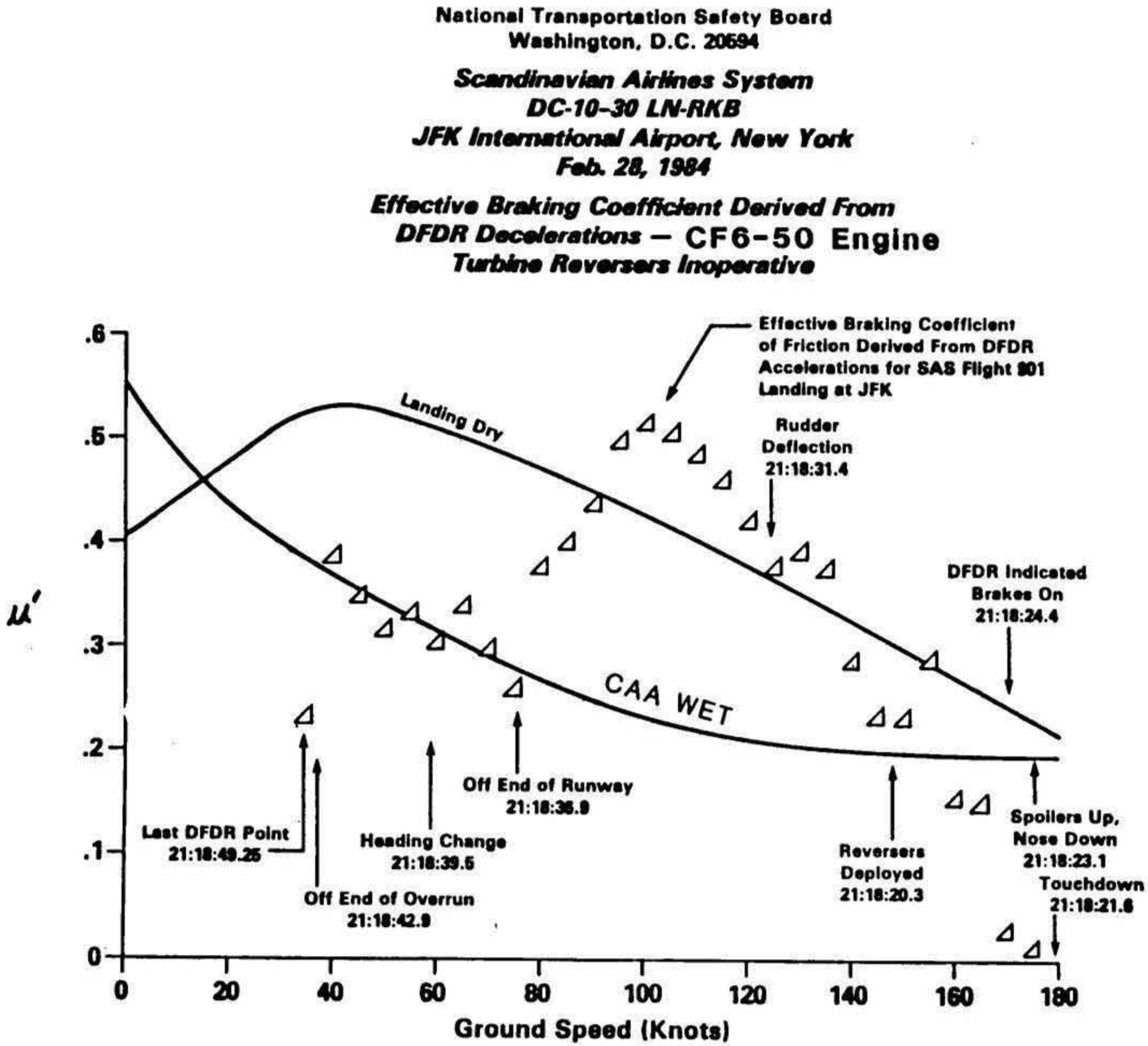


Figure 5.—Effective Braking Coefficient Derived from DFDR.

Assumptions used in analysis:

1) Aircraft weight = 172,800 kg = 380,959 lb
2) Aircraft c.g. = 18.7% MAC
3) Runway headwind = 1.2 knots
4) Turbine reversers connected and deployed
5) H_p = 700 ft, T = 7°C
6) Performance handbook = MDC-J6805
7) 35° landing flaps

(A) Performance Handbook Landing
Time from contact to:

		Stopping Distances (ft)	
Nose down	: 3 sec	Dry	2318
Spoiler Actuation	: 0 sec		
Full Spoilers	: 2 sec	Wet	4206
Brake Actuation	: 1.5 sec		
Full Brakes	: 3.5 sec	CAA Wet	3003
Reverse Detent	: 2 sec		
Max reverse	: 8 sec		

Max reverse to 80 KIAS
Stow reversers at 60 KIAS
V_{TD} = 1.27 V_S = 142.8 KEAS

(B) Performance based on AIDS
Indicated pilot actions
Time from contact to:

Nose down	: 1.4 sec	Dry	3774
Spoiler actuation	: 0 sec		
Full spoilers	: 1.0 sec	Wet	6545
Brake actuation	: 1.8 sec		
Full brakes	: 3.8 sec	CAA Wet	4744

(assumed 2 sec after actuation)
Thrust (including reverse) based on AIDS trace of N_1 vs speed and reverser deployment vs speed
V_{TD} = 178.2 KTGS
V_{TD} = 179.6 KEAS

Hp = pressure altitude
V_{TD} = touchdown speed
V_S = FAA specified stall speed
KEAS = equivalent airspeed
KTGS = ground speed

Wet distance is based on Douglas wet Mu prime.
CAA Wet distance is based on British Civil Aviation Authority wet Mu prime.

Figure 6.—DC-10-30 Calculated Stopping Distances for SAS Accident Analysis.

1.17 Other Information

1.17.1 Scandinavian Airlines System Operational Procedures

The following information is extracted from the Scandinavian Airlines System's Aircraft Operations Manual and pertinent SAS-issued bulletins.

(1) Speed Selection Procedures For Approach Phase of Flight

Old Procedure - Prior to October 13, 1983

Neither pilot had specific duties regarding selection of speed, but both pilots were required to check.

Revised Procedure - Effective October 13, 1983

Autopilot In Command or CWS Mode - the flying pilot selects speeds, the nonflying pilot checks speeds.

Autopilot Off - the nonflying pilot selects speeds, the flying pilot checks speeds.

Latest Revised Procedure - Effective February 23, 1984

Autopilot in command mode: The flying pilot (1/P) 15/ selects speed, the nonflying pilot (2/P) checks. Autopilot In Command Wheel Steering (CWS Mode) or off -- the nonflying pilot selects speed; the flying pilot checks speed.

(2) Callout Procedures

Figures 7 and 8 contain a reproduction of pertinent section of Aircraft Operations Manual.

(3) Speed Control

During the entire approach, it is important to keep the correct speed with as little throttle manipulation as possible. However, the power setting must be promptly adjusted as soon as it becomes apparent that an adjustment is required.

Never go beyond the recommended speed tolerances for each phase of an approach as stated in the AFM/AOM and corrected for wind component and/or gust value, as applicable depending on aircraft type. Whenever a wind shear effect is anticipated, the speed shall be increased to compensate for the expected wind shear effect.

(4) Approach - Wind Shear

Decreasing headwind is the most dangerous. If reported or experienced before the outer marker, there is normally adequate altitude to compensate provided minimum speeds are increased accordingly.

15/ 1/P = Pilot flying the airplane
2/P = Nonflying pilot (Assisting Pilot)
S-O = Systems operator or (flight engineer).

FLIGHT PROCEDURES
Flight Performance — Let—down and approach

3.3.4. Call-out procedures

It is of utmost importance that standard procedures are followed. Any intentional deviation from a standard procedure shall be clearly announced by 1/P in order to facilitate the monitoring function of 2/P. In general, internal pilot to pilot communication shall ascertain that the pilots are in full agreement regarding the progress of the flight.

However, it is important to avoid any unnecessary conversation which can distract attention.

Callouts in a normal approach

Callouts made by a 2/P or S/O that require correcting action by the 1/P shall be answered and/or reacted upon by him, indicating that he is aware of the situation.

Failure to respond and continued failure to react shall be treated as pilot incapacitation.

The following callouts are mandatory and shall be made by the pilot specified. Callouts marked "P" shall normally be made by 1/P. If for some reason the callout is not made by 1/P, the callout shall be made by 2/P or S/O.

CALLOUT	BY	CALLOUT INDICATES
"RADIO HEIGHT" e.g. "ONE ZERO ONE TWO"	R/P* L/P*	Radio Altimeter passing 2500 ft. during letdown. Actual altimeter setting. *DC-10 and A300: P
"LOCALIZER COMING"	P	Localizer bar moving from full deflection.
"LOCALIZER CAPTURE"	P	A/P or F/D has captured localizer
"GLIDE PATH COMING"	P	Glide Path bar moving from full deflection.
"GLIDE PATH CAPTURE"	P	A/P or F/D has captured glide path.
"OUTER MARKER, ..." or "OSCAR ALFA, ..." or "FIVE MILES, ..."	P	Outer Marker or equivalent position plus actual crossing altitude.
"SINK RATE, ..."	2/P	Actual sink rate at approx, 1000 ft. RH after landing flaps have been set and final letdown started.
"PLUS HUNDRED"	2/P	Passing minimum plus 100 ft. and "Contact" not yet called by 1/P.
"APPROACH LIGHTS" or "RUNWAY" plus direction	2/P	Approach lights - or runway - in sight and "Contact" not yet called by 1/P.
"CONTACT"	1/P	Able to continue approach by visual reference.
Actual radio heights	2/P or S/O	Actual radio heights as required according to respective AFM/AOM in order to assist in assessment of safe threshold crossing and flare.

Figure 7.—SAS Callouts in a Normal Approach.

Other callouts

CALLOUT	BY	CALLOUT INDICATES
"SPEED HIGH"	P	Desired indicated airspeed is exceeded by more than 10 kts, or final approach and threshold speed by more than 5 kts.
"SPEED LOW"	P	Indicated airspeed below: - Pattern speed minus 10 kts - Approach speed minus 5 kts or - Threshold speed minus 0 kts.
"SINK RATE"	P	Rate of descent more than 1000 ft/min below 2500 ft. RH.
"GLIDE PATH"	P	Flight path deviates from ILS Glide path by more than one dot.
"NOT STABILIZED"	2/P	Aircraft not stabilized according to definition in FOM 3.1.8. para 3.3.1. at or below 1000 ft RH.
"NOT STABILIZED, PULL-UP"	2/P	Aircraft not stabilized according to definition in FOM 3.1.8. para 3.3.1. at or below 500 ft RH.
"MINIMUM, PULL-UP"	2/P	Reaching decision altitude/height in a precision approach and "Contact" or "Pulling-up" not yet called by 1/P.
"MINIMUM"	2/P	Reaching minimum altitude/height in a non-precision approach and "Contact" or "Pulling-up" not yet called by 1/P.
"DECISION POINT, PULL-UP"	2/P	Reaching Decision Point in a non-precision approach and "Contact" or "Pulling-up" not yet called by 1/P.
"PULLING-UP"	1/P	Starting a pull-up.

Figure 8.—Other SAS Callouts.

When a wind shear is reported or anticipated after the outer marker, or whenever the wind component on the ground differs from that noted or reported at the outer marker indicating a headwind decrease of more than 20 knots, the following action must be taken:

- Add 15 knots to approach and threshold speed and disregard increment requirements in AFM/AOM with regard to wind component and wind gust.
- Be prepared to pull up if sink rate increases rapidly. Make sure that pull-up procedures have been reviewed in detail prior to commencing the approach and be aware that a successful pullup may need full power and a determined rotation.
- Request ATC to keep you informed of the latest pilot reports.

(5) Use of Automatic Systems

- Use of autopilot and autothrottles need careful monitoring. Hand on wheel and hand on throttles must be stressed, with alertness for quick manual inputs. Respective AFM/AOM gives information on limitations.

(6) Stabilized Approach

An approach is stabilized when the aircraft is lined up with the runway and flown at the desired approach speed in the landing configuration maintaining an acceptable rate of descent. Only small power changes should be necessary to maintain such a stabilized approach.

ALL APPROACHES must be stabilized not later than approximately 500 ft RH. It is the duty of the nonflying pilot to monitor that the aircraft is stabilized on the approach and to warn the flying pilot if stabilization has not been attained.

(7) Pull-Up--General

A pull-up occurs when an aircraft abandons its approach to a selected runway.

In order to achieve maximum safety, it is important that the decision to abandon an approach is made as early as possible.

A pull-up, once commenced, must be completed and no attempt shall be made to reestablish an abandoned approach. The nonflying pilot and system operator, if carried, shall carefully monitor that the pull-up is performed in accordance with established procedures.

In case the nonflying pilot has taken over the controls from flying pilot in order to make a pull-up, no further change of control shall be made until the pull-up is completed.

A pull-up should not be made once the aircraft has touched down as the performance requirements cannot always be ascertained. However, training flights with a qualified flight instructor as pilot-in-command may make touch and go landings during scheduled training flights.

(8) Pull-Up On ILS or Precision Approach Radar (PAR) Approaches

The approach shall be abandoned and a pull-up be commenced if:

- The official visibility is below the applicable company minimum at or after passing the outer marker or equivalent position,
- the approach is not stabilized at approx. 500 ft RH,
- at DA/DH the pilot is unable to make a landing by use of visual guidance,
- visual guidance is lost after passing DA/DH,
- at CAT I minimum on approaches to CAT II min, if requirements for CAT II are not fulfilled and visual guidance not obtained.

(9) Autothrottle

Autothrottle shall be used according to recommended procedures in respective AFM/AOM. It is an effective means of reducing pilot workload and facilitates precise speed control.

Due regard must be paid to the limitations of the Autothrottle System. The 1/P (pilot flying) shall monitor its function and immediately disconnect it if discrepancies or uncomfortable operation is observed.

The throttles shall always be guarded below 1,500 ft to permit the pilot to promptly counteract ineffective or erratic throttle control. This is especially important in wind shear and turbulence conditions to prevent programming of excessive thrust reductions.

(10) Duties and Responsibilities - Flight Personnel

During flight the systems operator (S/O) shall:

Operate and monitor the S/O Panel according to valid procedures and immediately inform the pilot-in-command of any irregularities and malfunctions, or if normal operating limits are exceeded.

Assist the Pilots in communication and navigation including preselection of VHF COM frequencies, change of ATC transponder codes and resetting of the altitude preselect system according to the pilot-in-command's discretion.

Receive weather broadcasts and currently keep the pilot-in-command informed of changes.

Assist the Pilots in keeping look-out during VMC, particularly in terminal areas.

Act as relief pilot during cruise from top of climb to top of descent, including change of flight level.

In cooperation with the other crewmembers prepare applicable reports.

Partake by use of applicable charts in the navigation of the aircraft and monitor Descent/Approach and Take-off/Climb procedures when other duties permit.

Assist in keeping the passengers informed of the flight's progress through loudspeaker announcements, as directed by the pilot-in-command or copilot.

2. ANALYSIS

2.1 General

The flightcrew was properly certificated in accordance with existing regulations of Denmark, Norway, and Sweden; there was no evidence that any physical factors affected their performance.

The airplane was properly certificated, equipped, and maintained in accordance with existing regulations and approved procedures of the State of Registry. All three engines and reversers functioned normally and reverse thrust was produced in proportion to the flightcrew's demand on the engines on which reverse thrust was selected. The airplane's autothrottle speed control system and related systems had repeated discrepancies reported since January 8, 1984. The discrepancies involved the system's failure to reduce throttle setting to maintain airspeed at the selected value. Corrective actions, in the form of component replacements, were accomplished through the morning of February 28, 1984, when the No. 2 autothrottle speed control computer was replaced at the termination of the aircraft's flight into Stockholm. The system again malfunctioned on the first leg of the accident flight into Oslo when the captain selected a 50-knot airspeed reduction and the autothrottle did not retard to the selected speed.

2.2 The Accident

The investigation disclosed that the landing approach was conducted in weather characterized by a low ceiling, low visibility, and light drizzle and fog. Although the runway was wet, there was no standing water.

The examination of data from the airplane's digital flight data recorder and the aircraft integrated data system recorder indicated that the approach was normal as the airplane descended to about 800 ft AGL. Although the groundspeed showed that the airplane was experiencing a tailwind component, the indicated airspeed was stable and the airplane was following the ILS glideslope.

After descending through 800 ft, however, the airplane's indicated airspeed increased to the point that the airplane passed over the runway threshhold at about the proper crossing height, but about 50 knots faster than the prescribed reference speed. Thereafter, the airplane floated, touching down on the runway at least 4,000 ft beyond the threshhold. The theoretical stopping distance for a DC 10 configured as Flight 901 was for the touchdown exceeded the length of runway remaining even for dry runway conditions. The Safety Board, therefore, concluded that runway condition was not a factor in the accident and has directed its attention toward reasons for the long and fast touchdown and the flightcrew's decision to continue the landing rather than initiate a missed approach.

Since the autothrottle speed control system (ATSC) was used throughout the approach for airspeed control, the Safety Board examined the following factors as they may have led to the long and fast touchdown:

- The performance of the ATSC system before and during the approach.
- The flightcrew's decision to use and rely on the ATSC system.
- The flightcrew's role in monitoring the performance of automated systems and related operating procedures and training.

The Board also sought to determine:

- o The flightcrew's knowledge of touchdown position on the runway and the airplane's stopping performance.

Autothrottle Speed Control System.--The ATSC system components had been damaged and contaminated during the accident. Thus, the system's preaccident condition could not be established. However, the previously reported discrepancies in the system and the flightcrew's observation that the system had malfunctioned on the previous leg of the flight indicate the possibility that an intermittent fault was affecting the system's performance during the accident approach.

The flightcrew recalled dialing 168 knots into the autothrottle speed select window, a selection which was verified during the postaccident examination of the module. A properly operating ATSC would have modulated the position of the airplane's throttle in order to decelerate to and maintain the selected speed. The recorded data show that the throttle positions did retard and the engines went to flight idle rpm as the airplane began to descend from 1,500 ft. The airspeed did begin to decrease in response to the reduced power. However, as the airplane descended through about 800 ft, the throttles moved toward higher power and the engines responded by increasing rpms to about 84 percent N_1. The airspeed began to increase, but there were no indications of appropriate throttle corrections by the ATSC system. The flightcrew recalled that the ATSC did not retard the throttle as expected when the airplane descended below 50 ft. The evidence provided by the recorded ATSC mode and throttle position parameters verifies that the throttles were not responding to ATSC commands.

The Safety Board considered the possibility that wind shear could have affected the airplane's flightpath and the ATSC performance. At the outer marker, the airplane was experiencing a 30-knot tailwind component which diminished between 1,500 ft and the surface at a nearly linear rate with change of altitude to a 2-knot tailwind at the surface. This type of wind condition would initially cause the ATSC to command a lower engine power setting than that which would be commanded in a stable wind condition in order to produce an inertial deceleration needed to maintain the stabilized selected airspeed and the ILS glideslope. On the other hand, while the average engine power required would be lower throughout the approach, the constantly decreasing groundspeed as the airplane decelerated would require gradually increasing power in order to keep the airplane on the ILS glideslope at the selected approach airspeed. The wind shear calculated to have existed at the time of this accident, however, was mild and did not exceed an average change of 3 knots in the longitudinal wind component for each 100 ft of altitude change. The certification approval for airborne navigation instrument and flight control systems for category II approaches requires that the systems demonstrate the capability to track the glideslope and maintain airspeed within specified tolerances while penetrating a wind shear having 4 knots per 100 ft variation from 500 ft to the surface. Further, during a previous accident investigation, 16/ the Safety Board had examined the performance of a DC-10 autopilot system in an emergency simulation when the airplane was subjected to a decreasing tailwind shear in excess of 4 knots per 100 ft. The simulation showed that the ATSC performs satisfactorily under these conditions. Therefore, the Safety Board concludes that the nonresponsive performance of the ATSC on the SAS flight was not caused by wind shear.

While the evidence is conclusive that the airplane's ATSC system was faulty, the Safety Board considered the intended role of such systems in its assessment of accident cause. The ATSC is required aboard the airplane only to conduct category III approaches. Although it is extensively used to reduce pilot workload, it is not required to be installed for this purpose. As with other aircraft systems, the possibility of erratic

16/ Aircraft Accident Report: Iberia Airlines McDonnell Douglas DC 10-30 EC CBN, Logan International Airport, Boston, Massachusetts, December 17, 1973. (NTSB-AAR-74-14.)

operation caused by a component malfunction is present and pilots are expected to monitor and disconnect or override such systems when unacceptable flightpath or speed deviations are apparent. Since the flightcrew of Flight 901 was able to disconnect or override it, the Safety Board cannot conclude that the ATSC system's malfunction caused or even directly contributed to the accident.

Flightcrew Performance.--The flightcrew had been aware that the ATSC system had performed erratically before commencing the approach. It had, in fact, performed erratically on the previous leg of the flight and although subsequent operation was normal, the crew knew that there had been no intervening maintenance. There is no evidence that the flightcrew considered this previous erratic operation in its decision to use the ATSC for the approach. Had they considered its previous faulty operation and intentionally decided to use the ATSC regardless, the pilot should have been prepared to revert to manual throttle control if erratic throttle movement or unacceptable airspeed excursions occurred. Detection of these excursions, however, was dependent upon vigilant monitoring of the airspeed instrumentation by the crew.

The flightcrew, in preparing to use the ATSC for the approach, calculated the approach reference speed to be 154 knots. The last speed dialed into the ATSC command module, however, was 168 knots. The flightcrew's postaccident statements and recorded cockpit conversation imply that the difference was an intentional compensation for a potential wind shear encounter. While an airspeed additive is appropriate for some wind shear conditions, it was not an appropriate action for the frontal type of wind shear that was present during this approach. In fact, the SAS Flight Operations Manual states that 15 knots must be added to the approach and threshhold speeds "when a wind shear is reported or anticipated after the outer marker, or whenever the wind component on the ground differs from the noted or reported at the outer marker indicating a headwind decrease of more than 20 knots." While the flightcrew had reason to anticipate a wind shear condition after passage of the outer marker, it had sufficient information to deduce that the wind shear would produce an effective headwind increase (tailwind decrease) during the approach. The airplane's INS system was indicating a tailwind in excess of 20 knots as the approach was started while the reported surface winds were light. Under the actual conditions, a speed additive would compound rather than alleviate the effect of the wind shear.

The flightcrew's actions to add the 15 knots to compensate for potential wind shear without first considering the type of wind shear condition indicated by the prevailing weather and INS measurements concern the Safety Board. The Board has been a strong proponent of the adoption of comprehensive classroom and simulator training programs to increase the awareness of air carrier pilots of the wind shear hazard. The Safety Board has noted that most of the recent research regarding wind shear and most of the related material which has been circulated throughout the aviation community in the aftermath of accidents have emphasized the extreme dangers of the convective downburst or microburst type of wind shear. In an encounter with that type of wind shear, it is essential that an airspeed margin be available to compensate for a sudden reduction in the airplane's headwind. Far less emphasis has been given to the frontal system wind shear in which the airplane may encounter an increasing headwind (or decreasing tailwind) which does not challenge the airplane's performance capability but can present other subtle dangers. It is possible that the greater exposure to training material related to the convective type of wind shear has caused some pilots to believe that adding a speed margin is the safest reaction to reported wind shear without further analyzing the existing wind shear condition.

Although the flightcrew's intentional addition of 15 knots to the approach reference speed was not appropriate, the Board concludes that this also was not a factor in the accident since the approach almost certainly could have been flown to a successful landing had airspeed been controlled to the selected value of 168 knots.

The flightcrew's recollections following the accident indicate that neither the captain nor his copilot was totally aware of the airplane's increasing airspeed during the final approach. Since airspeed management, particularly during final approach, is an essential element of basic airmanship, the Safety Board must conclude that the performance demonstrated by this crew was either aberrant, or represents a tendency for the crew to be complacent and overrely on automated systems.

The Safety Board, therefore, must address the reasons why the flightcrew allowed the autothrottle system to control the airplane to an airspeed nearly 40 knots higher than the selected value. The Safety Board is concerned that an experienced, apparently well-trained flightcrew whose previous record of performance was unblemished had a lapse in which they overlooked the basic airmanship function of airspeed control on approach. Two factors which probably affected the crew's performance were (1) its habitual reliance on the proper functioning of the airplane's automatic systems, and (2) a degradation of crew coordination and nonadherence to related procedures when the first officer is flying the airplane.

At about 100 ft above minimums, the captain noted that the airspeed was high, and he brought this to the attention of the first officer, who was flying the airplane. This appears to be the only reference made to airspeed during the approach; no other required airspeed callouts were made. The captain and first officer had two direct reading instruments to alert them that the ATSC was not maintaining the selected airspeed--the airspeed indicator itself and the "fast slow" indicators of the speed control system located on the left side of each attitude direction indicator. The airspeed indicator has a movable marker or "bug" to remind pilots of approach speed. A difference between indicated airspeed and "bug speed" should alert a pilot to any discrepancy. Neither pilot of Flight 901 noted the bug position, and SAS does not require that they do so.

Another instrument that pilots are expected to crosscheck during an approach, especially a precision approach, is the vertical speed indicator (VSI). If a greater than normal descent rate is required to maintain glideslope, either the aircraft is on a "false" glidepath or the groundspeed is higher than normal. Higher than normal groundspeed could be a result of poor airspeed control or a tailwind. The crew indicated that the autopilot kept the aircraft on localizer and glidepath. They were aware of a tailwind during the approach when they called up the performance page of the command display unit and it indicated a tailwind in the vicinity of 20 knots. However, even taking into account a tailwind of this magnitude, indications of a vertical speed of 1,640 ft per minute (fpm) on the glideslope should have alerted the crew that an abnormal condition existed. A normal vertical speed would be about 800 fpm, about one-half of that actually shown. The ILS to runway 4R has a 3° glideslope and even with a groundspeed of 188 knots (168 V_A + 20-knot tailwind), the rate of descent should have been less than 1,000 ft per minute.

Even though they should have been concerned about the faulty performance of the ATSC on the previous flight, the flightcrew apparently had been conditioned by repeated successful use of the system to rely upon its performance to the extent that neither adequately monitored essential airspeed and vertical velocity instruments.

Reliance on Automated Systems.--Since the introduction of sophisticated automation that accompanied the wide-body generation of aircraft, there has been much controversy and concern over the resulting relationship between man and machine. As more computers have been added to the aircraft and control of tasks has been transferred to autopilot and autothrottle systems, the pilot's role in the aircraft operation has changed dramatically. His workload as far as physical handling of the aircraft was reduced, and in some phases of flight, totally eliminated. According to one researcher, "As computers are added to the cockpit, the pilot's job is changing from one of manually flying the aircraft to one of supervising computers which are doing navigation, guidance, and energy management calculations as well as automatically flying the aircraft." 17/

However, with increased automation, overall pilot workload has not necessarily been reduced; in most cases, it merely has shifted from performing tasks to monitoring tasks. Because increasingly more systems have been automated, a proliferation of components has resulted and the pilot "has many more indicators of component status to monitor." 18/ There is convincing evidence, from both research and accident statistics, that people make poor monitors. For example:

1. Kessel and Wickens did a laboratory study to compare failure detection performance between manual and automated systems. In the manual mode, participants were actively controlling a dynamic system and in the automatic mode they were monitoring an autopilot that controlled the system. It was found that "detection performance was faster and more accurate in the manual as opposed to the autopilot mode". 19/ These results were attributed to the fact that in the manual mode, the participants remained in the "control loop" and they benefited from additional proprioceptive cues derived from "hands-on" interaction with the system. These findings were in agreement with a research study by L. R. Young. 20/

2. In the 1972 Eastern Airlines L-1011 crash into the Everglades, 21/ the crew was distracted by a malfunctioning landing gear light and failed to monitor the autopilot which was flying the aircraft. The autopilot was accidentally disengaged and the aircraft gradually descended from the holding pattern. Without an autopilot, one crewmember would have been forced to fly the aircraft and the disaster would have been avoided.

3. In 1979, the crew of an Aeromexico DC-10 stalled the aircraft on climbout over Luxembourg. The crew either intentionally or inadvertently programmed the autopilot for the vertical speed mode rather than the procedurally directed airspeed or mach command mode. The aircraft maintained the programmed climb rate throughout the climbout, but at the sacrifice of airspeed. As thrust available decreased with altitude, the engines' thrust became insufficient to sustain flying airspeed for that climb rate and the aircraft stalled, losing approximately 11,000 ft of altitude before recovery. The Safety Board concluded, "The flightcrew was distracted or inattentive to the pitch attitude and airspeed changes as the aircraft approached the stall." The probable cause of the incident was listed as "the failure of the flightcrew to follow standard climb procedures and to adequately monitor the aircraft's flight instruments." 22/

17/ Palmer, E., Models for Interrupted Monitoring of a Stochastic Process. NAS TM-78, 453, 1977, p.1.

18/ Wickens, C.D., Engineering Psychology and Human Performance. Columbus, Ohio; Charles E. Merril Publishing Company, 1984, p. 490.

19/ Kessel, C. and Wickens, C.D., The Internal Model: A Study of the Relative Contribution of Proprioception and Visual Information to Failure Detection in Dynamic Systems. NASA CP-2060, 1978, pp. 85-86.

20/ Young, L.R., On Adaptive Manual Control. IEEE Transactions on Man-Machine Systems, Vol. MMS-10, 1969, pp. 292-331.

21/ Aircraft Accident Report: Eastern Airlines L-1011, Miami, Florida, December 29, 1972 (NTSB-AAR-73-14).

22/ Aircraft Incident Report: Aeromexico DC-10-30, XA-DUH, Over Luxembourg, Europe, November 11, 1979 (NTSB-AAR-80-10).

4. Another incident, almost identical to that which occurred on the Aeromexico flight, is cited in a NASA Aviation Safety Reporting System (ASRS) report:

> The aircraft was climbing to FL 410 with the right autopilot and autothrottles engaged and controlling the aircraft. At approximately FL 350 the airspeed was observed to be below 180 knots and decaying. The autopilot was disengaged and the nose attitude was lowered. At this point the stickshaker activated and a slight buffet was felt. Application of full power and a decrease in pitch attitude returned the airspeed to normal. Remainder of the flight was uneventful.
>
> During the climb portion of the flight the pilot stated that he believed the autopilot was in the Flight Level Change Mode (max climb power and climbing while maintaining a selected airspeed/mach). Looking back he felt that the autopilot must have been in the Vertical Speed mode, and not Flight Level Change. If this were the case with 2,500/3,000 ft per minute up selected, then the airspeed would be near normal to about FL 300 at which point the airspeed would bleed off as the autopilot maintained the vertical speed.
>
> Prevention of this incident: the pilot must at all times be absolutely sure what mode the autopilot is operating in. A continuous crosscheck of the primary flight instruments would have indicated decreasing airspeed before it became a serious problem. 23/

The examples above and the performance of the crew of SAS Flight 901 give credence to the contention that humans tend to be poor systems monitors. Kessel and Wickens attribute this to the fact that man has been removed from an active role in the man-machine control loop with the subsequent reduction in available performance cues.

In 1976 a technical paper entitled "The Automatic Complacency" was presented by an SAS captain. (See Appendix G.) The summary of the paper follows:

> This paper discusses the man-machine problem that faces the pilot in his role as a programmer and supervisor in an environment that provides automatic systems to do the work but where the redundancy concept requires the man to be in a "continuous loop" function.
>
> The paper recognizes the problem as "normal," human-engineering wise but a problem that has to be solved by giving the pilot strong incentives to interface himself with the functions of the automatics and to subordinate himself to the requirements of tedious monitoring routines and stringent flight deck procedures which he may feel as superfluous in view of the normally excellent performance of the automatic systems.

23/ Lauber, J.K., Cockpit Resource Management in New Technology Aircraft, presented at International Aeronautical Symposium sponsored by Japanese Air Line Pilots Association, August 16-18 1982, p. 11.

Researchers claim that the reliability of the automated equipment may account for the reduced vigilance of pilots using automated systems. Very unreliable equipment would lead pilots to expect malfunctions and to be proficient at handling them. A system that never fails would not pose a problem, but one with an intermediate level of failure may prove "quite insidious since it will induce an impression of high reliability, and the operator may not be able to handle the failure when it occurs." 24/

The captain of SAS Flight 901 knew that the ATSC had malfunctioned on the first leg of the flight. However, 10 hours had elapsed since the malfunction and the captain had over 5 years experience with successful autothrottle operation.

In fact, the excursion from a stabilized condition might be exaggerated even after a system anomaly is detected, because of the period required for a pilot to transition from system monitor to system controller. Time is needed to "ascertain the current status of the airplane and assess the situation," 25/ before the pilot can reenter the control loop and take corrective action.

In this accident case, about 20 seconds before touchdown, the first officer switched the autopilot from the command to the control wheel steering mode, a mode in which he manually controls the airplane's attitude. This action placed the copilot into the control loop but apparently did not prompt him to recognize or correct the excessive airspeed. The Safety Board believes that the copilot's performance illustrates the difficulties in the transition from a monitoring to a control function as described by the researchers.

Researchers also have concluded that "prolonged use of a system in the automatic mode may lead to a deterioration of manual skills and a loss of proficiency, which may degrade performance on a manual system." Thus, even after detection of anomalous performance of an automatic system, the pilot's ability to precisely control an airplane after he reenters the control loop is degraded. Another researcher noticed that "many crewmembers have discovered this [proficiency loss] on their own and regularly turn off the autopilot, in order to retain their manual flying skills." During its investigation of this accident and associated interviews with crewmembers, the Safety Board learned that SAS and other airlines, as well as airplane manufacturers, teach and encourage the use of automated systems such as the autothrottle.

While the Safety Board believes that on balance automation has greatly improved safety and has reduced pilot workload and fatigue, there is an ever-increasing need to reemphasize to crews the need to effectively monitor critical flight instruments and systems. This requirement may be satisfied in part by introduction of procedures and training specifically designed to enhance crew awareness of excursions from programmed performance.

Crew Coordination, Procedures, and Training.--A comparison of the CVR transcript with SAS airspeed and altitude callout procedures disclosed that the crew omitted several required calls during the ILS approach to JFK. Altitude callouts were not made for "Glide Path Coming" and "Glide Path Capture." An unintelligible comment made near the OM (1614:16) may have been the required call for this point on the approach.

Required airspeed callouts were neglected even more than altitude calls, and this may have contributed to the crew's lack of airspeed awareness, been symptomatic of it, or both. The second pilot (nonflying pilot) is required to state the flap configuration

24/ Wiener, E.L., and Curry R.E., Flight-Deck Automation: Promises and Problems, NAS TM-81206, p. 10.

25/ Boehm-Davis, D.A., Curry, R.E., Wiener, E.L., and Harrison, R.L., Human Factors of Flight-Deck Automation - NASA/Industry Workshop, NASA TM-81260, January, 1981, p. 6.

airspeed at about 1,000 ft radio height or the point where the landing flaps are set. If the airplane is not at the desired approach speed at or below 1,000 ft radio height, the second pilot was required to call out "not stabilized." At 1,000 ft radio height, Flight 901 actually had 190 KIAS rather than the commanded airspeed of 168 KIAS. No callout was made. At or below "500 ft radio height and not at desired speed," the nonflying pilot is required to say, "Not stabilized, pull up." Flight 901 had an airspeed of about 190 KIAS at 500 ft radio height and no callout was made. At 1618:01 (about 150 ft radio height), the captain called "high." "Speed High" is a required callout for a V_{TH} more than 5 knots high. At 150 ft radio height, the speed of Flight 901 was about 208 KIAS rather than 168 V_A. Although the systems operator (flight engineer) has no specified airspeed calls to make, he is required to monitor "all Descent/Approach. . . procedures when other duties permit." In this case, it does not appear that the systems operator had other duties that would have precluded his noticing and commenting on excessive airspeed during the approach.

The speed callout procedure set forth in the SAS Flight Operations Manual, requiring only a callout of "Speed Low" or "Speed High" if the final approach and threshold speed deviate more than 5 knots from the target speed, may not be sufficient to alert a crewmember to a dangerously low, or as the case may be, high speed condition. The Board believes that in addition to low or high, the actual deviation above or below reference speeds should be a required callout, i.e. +10, +20, -10, -20, etc.

The purpose of airspeed and altitude callouts is to provide checks and balances between flightcrew members. Verbalizing selected performance parameters not only reinforces each crewmember's perception of aircraft performance, it also enables pilots to better assess each other's situational awareness.

In another accident investigated by the Safety Board, the adverse effects of neglecting required callouts on crew coordination and performance also was illustrated. On July 9, 1978, the pilot of an Allegheny Airlines BAC 1-11 flew an uncoupled ILS approach 61 knots above reference speed and landed about half-way down runway 28 at Monroe Airport, New York. The aircraft came to rest over 700 ft past the departure end of the runway. In its report of the accident, 26/ the Safety Board stated:

> The National Transportation Safety Board determines that the probable cause of the accident was the captain's complete lack of awareness of airspeed, vertical speed, and aircraft performance throughout an ILS approach and landing in visual meteorological conditions which resulted in his landing the aircraft at an excessively high speed and with insufficient runway remaining for stopping the aircraft, but with sufficient aircraft performance capability to reject the landing well after touchdown. Contributing to the accident was the first officer's failure to provide required callouts which might have alerted the captain to the airspeed and sink rate deviations. The Safety Board was unable to determine the reason for the captain's lack of awareness or the first officer's failure to provide required callouts.

26/ Aircraft Accident Report: "Allegheny Airlines, Inc., BAC 1-11, N1550, Rochester, New York, July 9, 1978" (NTSB-AAR-79-2).

Several airlines have instituted simulator training programs to emphasize crew coordination and provide assertiveness training for copilots and flight engineers. Many of these programs emulate the "Line-Oriented Flight Training" (LOFT) concept developed by Northwest Orient Airlines and the National Aeronautics and Space Administration (NASA). 27/ The emphasis of LOFT training is not on individual performance, but rather on the development of effective crew interaction skills. SAS has had LOFT programs in effect prior to the accident. The captain had received the last such training on December 15, 1983, the first officer on February 2, 1984, and the systems operator on September 3, 1983.

In the Allegheny Airlines accident, the captain was flying and the first officer was responsible for monitoring the approach. In the SAS Flight 901 accident, the flying roles were reversed, a situation in which crew coordination tends to be degraded as evidenced by NASA/ASRS incident reports. One study of such data concluded: "The belief that the flightcrew operates more efficiently when the captain is flying than when he is performing PNF (pilot-not-flying) duties is given a measure of support with these incidents." 28/ This finding is attributed not to a lack of flying competence by first officers, but rather to the lower efficiency of captains in the monitoring role. The failure of the crewmember monitoring "consists of either a failure to detect the departure from expected performance in time to prevent the unwanted occurrence; a failure to communicate the detection in a timely and effective manner; or less frequently, a failure to take effective action when an adequate and timely monitoring communication does not elicit an appropriate response." In addition, it was found that while crews performed better when the captain is flying, "there was considerable evidence that the importance of the monitoring function was not well understood by either pilot or, if well understood, was frequently neglected."

Because of the increased potential for a breakdown in crew coordination when captains and first officers customarily exchange flying duties, the Safety Board believes that training programs must highlight the responsibility of the nonflying crewmember for monitoring pilot's performance, especially in light of the influences of automation on the extent of monitoring tasks.

Runway Touchdown Position/Stopping Performances.--Another area of concern regarding the flightcrew's training stems from the crew's decision to continue the landing approach rather than go around and from the actions taken by the first officer once the aircraft touched down.

The FAA-required field length criteria provides that the airplane's demonstrated dry runway performance would allow it to pass 50 ft over the runway threshold at its reference speed, be landed, and stopped fully (without using reverse thrust) within 60 percent of the total effective runway length. For a wet runway, an additional 15 percent margin is arbitrarily added to compensate for the reduced braking coefficient. The airline data provided to flightcrews so that they can determine the suitability of a destination runway in accordance with this required field length criteria is presented in terms of the maximum airplane weight at which a landing is permitted under the prevailing condition. These data showed that a DC-10-30 may land on runway 4R at JFK with either wet or dry surface conditions with 35° flaps at all weights up to the airplane's structural maximum landing weight of 186.4 metric tons. With this information, the flightcrew would have recognized that the safety margin available on runway 4R in

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27/ Lauber, J.K., and Foushee, H.C., Guidelines for Line-Oriented Flight Training, Vols. I and II, NASA CP-2184, August 1981.

28/ Orlady, H.W., Flight Crew Performance When Pilot-Flying and Pilot-Not-Flying Duties Are Exchanged. NASA CR166433, June 1982, p. 4.

Flight 901 was greater than the safety margins required since the airplane was over 10 metric tons below the maximum permissible landing weight. The crew does not routinely compute the actual runway length needed to comply with the required field length criteria if the airplane weighs less than that permitted. However, such a computation would have shown that the airplane could have landed on a 7,000-ft-long runway with the required safety margin. Thus, the criteria would indicate that the airplane could be landed and stopped on a wet runway in about 4,200 ft, about 50 percent of the length of runway 4R, without using reverse thrust. The McDonnell Douglas Corporation more conservatively calculated that the airplane would take as much as 4,200 ft to stop on a wet runway after the touchdown using reverse thrust. Assuming a normal touchdown 1,500 ft beyond the runway threshold, the airplane would be stopped with 2,700 ft of runway remaining. Thus, it is reasonable to assume that the flightcrew believed that a considerable runway safety margin existed. However, they should also have recognized that the safety margin will be reduced by a long touchdown and high speed. Flight 901 touched down at 179.5 KIAS, 36 knots fast and about 4,700 ft beyond the runway threshold.

The captain estimated that the aircraft made a normal touchdown "at least one-third down the runway," and the first officer estimated that the aircraft landed halfway down the runway. One-third of the runway length is 2,800 ft, leaving only 5,600 ft on which to stop the aircraft. Given a stopping distance of about 4,200 ft, the captain was somewhat optimistic about his ability to stop the aircraft, even if he was under the impression that he landed on speed, one-third down the runway. Had he been alert to the 36-knot speed additive, he should have been concerned about the available stopping distance and ordered a go around. Actually, the aircraft had only about 3,700 ft (8,400 ft minus 4,700 ft at touchdown point) remaining from touchdown to the end of the runway.

Admittedly, precise calculations are difficult, if not impossible, to make while flaring the airplane, and the absence of distance-remaining markers on runway 4R made it difficult to estimate the point of touchdown. The lack of a requirement for runway distance markers has been of continued concern to the Safety Board and has been the subject of numerous recommendations to the FAA over the past 14 years. This concern was reiterated again in the case of the World Airlines DC-10 accident at Boston; the case of the Air Florida accident at Washington, D.C.; and the Safety Board Safety Study, "Airport Certification and Operations" (NTSB/SS-84-02). The latter report states in part that distance markers "would provide to flight crews, on landing, a way of quickly ascertaining the amount of remaining runway . . . . ." As of this date, distance markers are not mandatory; however, FAA policy on runway distance-remaining markers has been reevaluated and their use is now "permitted" on any runway. Moreover, these markers now are eligible for funding under the Airport Development Assistance Program (ADAP) for runways used by turbine-powered airplanes. The Safety Board also strongly supports simulator training programs to provide a better appreciation for the magnitude of the increased stopping distances required at higher than design touchdown speeds.

After Flight 901 touched down, the captain instructed the first officer to use full braking and to use all three engine thrust reversers. However, the first officer initially used only "light to moderate" brake application; full reverse power on engines 1 and 3 was approached only about 12 seconds after touchdown. As the landing roll progressed, the first officer began to brake harder. When the captain saw the end of the runway, he got on the brakes and the pedals went down farther. Neither pilot recalled noticing the color-coded runway centerline and edge lights that warn pilots of the impending end of the runway.

The SAS flight operations manual provides, "Maximum braking (if circumstances demand) -- depress brake pedals fully and hold." This procedure will achieve maximum antiskid system effectiveness to minimize the stopping distance. The procedure is used only when needed, because of the discomfort it causes passengers and the additional stresses it places on the aircraft. However, it was a vital measure for this crew to take and the captain did call for maximum braking. Maximum braking is the type of procedure which should be practiced in the simulator where possible.

Nothwithstanding the application of less than maximum braking immediately after the airplane touched down, the airplane achieved deceleration comparable to the maximum deceleration values demonstrated during certification. The Board cannot ascertain whether higher deceleration would have been attained with fully depressed brake pedals.

Although the first officer believed that he had used maximum reverse thrust on all three engines until just before the airplane ran off the end of the runway, this is not supported by AIDS data. No. 2 thrust reverser was fully deployed, but the engine showed no increase in power past 41 percent N_1 (idle reverse rpm is about 29 percent N_1). No. 2 thrust reverser is normally not used and a lockout device prevents its use before compression of the nose gear strut. According to the SAS flight operations manual, "If, however, the pilot-in-command deems that all engine reverse thrust may be required, there is no restriction in the use of engine 2 reverser." While use of full reverse thrust on No. 2 engine would only reduce the stopping distance about 50 to 100 ft., its use in appropriate circumstances should be instinctive. It appears that the first officer was not trained either in the aircraft or in the simulator to use all three thrust reversers.

2.3 Survival Aspects

The accident was survivable. Because of the relatively low impact forces, there were no passenger seat separations or failures. The unoccupied second observer cockpit jumpseat was, however, partially separated because the galley was displaced forward as a result of an overload failure of attachment bolts. The impact forces were even lower in the aft cabin. Persons seated in that area characterized the impact as "nothing serious." For the same reason, the aft flight attendants at doors 4R and 4L apparently were not certain that an impact had occurred and they were in doubt about whether to initiate an emergency evacuation. The flight attendant at door 1L sustained the only impact-related injury, a sprained knee, when the floor beneath her ft was displaced upward by the hydrodynamic pressure generated when the airplane struck the water.

The 1R door was inoperative because the mode selector lever probably was jarred out of the emergency mode during impact. The door was opened and functioned properly in the emergency mode during postaccident tests. Although some discrepancies in equipment manifested themselves during the emergency, the evacuation was carried out expeditiously and effectively.

The first crash/fire/rescue (CFR) units arrived at the aircraft within a little over a minute from the time of the notification. Although no firefighting actions were required, the rescue efforts by emergency crew personnel were exemplary. The crew chief's action in entering the water of Thurston Basin in order to retrieve the drifting slide/raft full of passengers showed selflessness and initiative. All passengers were removed from the water within 15 minutes after the arrival of CFR personnel. The rescuers' prompt action to remove the survivors from the hostile environment was exemplary.

Although the airplane struck a rigid (nonfrangible) approach light structure, the Safety Board could not conclude that the severity of the accident would have been reduced had the approach light structure been of frangible-type construction. Nonetheless, the Safety Board continues to be concerned about the possible increased severity of these types of accidents which involve impact with rigid approach light structures. In fact, had the crew not successfully steered around the approach light structure, this accident may have been much more serious. The Safety Board has addressed this issue since 1977 and has monitored the progress in this area. In response to the Safety Board 1977 recommendation calling for nonfrangible approach light structure and the retrofit of all nonfrangible installation, the FAA indicated that a retrofit program would be initiated, the major portion of which would be completed in 5 years. The Safety Board more recently recommended the FAA initiate research and development activities to establish the feasibility of submerged low-impact resistance support structures for airport facilities, and promulgate a design standard if such structures are found to be practical.

The Safety Board realizes that developing a frangible submerged support structure is not a trivial problem and that a considerable amount of research will be necessary to erect an adequate "breakaway" system. The Safety Board is encouraged that the FAA currently is planning a project to develop a computer model for predicting the load behavior of such structures. However, we emphasize that the development of submerged low-impact resistance support structures should be completed as quickly as possible.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew were properly certificated and qualified for the flight.

2. There is no evidence that any physical factor affected the performance of the flightcrew.

3. The airplane's gross weight and center of gravity were within specified limits.

4. The airplane was properly certificated, equipped and maintained in accordance with the regulations of the State of Registry.

5. Although the runway was wet, there was no standing water which would have degraded braking action and affected the airplane's ability to decelerate within predicted parameters. Runway condition was not a factor in the accident.

6. Although there was a tailwind condition during the approach which resulted in higher-than-normal groundspeeds, wind shear did not adversely affect the airplane's performance during the approach and was not a factor in the accident.

7. The National Weather Service wind and low-level wind shear forecasts were not precise; other aspects of the terminal forecast were substantially correct.

8. Failure to include SIGMET Charlie 9 on the ATIS was not a factor in the accident, since there was no significant low-level turbulence at the time and in the area of the accident.

9. The flightcrew did not operate the airplane in compliance with applicable SAS procedures for an ILS approach. The approach was not stabilized and approach callouts required by SAS procedures were omitted.

10. Deficiencies in the SAS flight operational procedures in not requiring use of airspeed "bugs" or reminders, in not requiring monitoring and callouts of airspeed by the Systems Operator (flight engineer) during critical phases of the flight, and in not requiring callout of actual airspeed values, contributed to lack of airspeed awareness by the flightcrew.

11. The autothrottle speed control system was malfunctioning before and at the time of the accident.

12. Because of the malfunctioning autothrottle speed control system, thrust was increased when it was not needed.

13. The captain exercised poor judgment in continuing the landing approach with higher than acceptable speed rather than initiating or ordering a go-around.

14. The airplane crossed the runway threshold about 60 knots faster than the calculated V_{TH}.

15. The airplane touched down on the runway 36 knots above the programmed touchdown speed.

16. The airplane touched down about 4,700 ft from the approach end of the runway.

17. There were only about 3,700 ft of runway remaining at the point of the airplane's touchdown; insufficient distance in which to decelerate and stop the airplane.

18. Reverse thrust application was normal on the Nos. 1 and 3 engines. Reverse thrust on No. 2 engine was selected but not effectively applied. The lack of reverse thrust on the No. 2 engine did not appreciably add to the landing distance.

19. Braking and antiskid system performance was normal; however, the brake pedals were not fully depressed at the beginning of the landing roll.

20. The captain steered the airplane to the right of the runway centerline to avoid head-on contact with the approach light structure.

21. Runway 4R, the shortest air carrier runway at JFK International Airport, was designated as the landing runway because of operational factors involving traffic flow into and out of adjacent airports.

22. This was a survivable accident; the emergency evacuation was expeditious and orderly and the crash/fire/rescue response was timely and efficient.

23. The flight attendant at door 1L was injured as a result of the upward displacement and separation of the floor caused by the hydrodynamic pressure generated during impact with the water.

24. The deformation and inertia forces sustained around door 1R caused the mode selector lever to move from the EMERGENCY position.

25. The unoccupied second observer cockpit jumpseat partially separated from its floor attachments when the forward galley was displaced which in turn overloaded the seat's aft floor attachment bolts and stripped the nuts from of the bolts.

26. The flight attendants' decision not to open the 3L door was appropriate.

3.2 Probable Cause *

The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew's (a) disregard for prescribed procedures for monitoring and controlling of airspeed during the final stages of the approach, (b) decision to continue the landing rather than to execute a missed approach, and (c) overreliance on the autothrottle speed control system which had a history of recent malfunctions.

4. RECOMMENDATIONS

The Norwegian accredited representative and SAS informed the Safety Board on September 25, 1984, that SAS intends to modify its procedures due to the findings in the JFK accident investigation as follows:

a) SAS will discontinue the very liberal use of CWS during landing. However, we will still allow the use of CWS in landing, but apply a lowest height restriction of 1,000 ft for transfer to CWS. This will give the pilot ample time for the change over the CWS landing technique.

In marginal weather for landing, the height restriction will force the pilots to use the AUTOLAND as the primary choice for landing and the autopilot coupled ILS approach with manual landing as the secondary choice.

In takeoff the CWS may be used as hereto, with the recommendation not to be used in strong crosswind and on undulated runways.

b) Within SAS the autothrottle system has always been stressed to be a very useful tool in the stabilized approach concept. Correctly operated the ATS will highly contribute to a safe and accurate speed control until touch down.

It has also been stressed during all years that the ASI is the primary aid for speed control.

Many good articles have been written about the AUTOMATIC COMPLACENCY of which we intend to reprint and distribute systemwide, one of Capt. K.E. Ternhem, SAS. [See Appendix G.]

The DC-10 flight procedure will be revised as follows:

2.3 AUTOTHROTTLES

1/P (PF) shall operate the throttles with both ATS engaged. With ATS on or off, the speed on ASI is always primary. Manually backup the ATS as required - initiate power changes - to maintain selected speed. If the ATS operation is unsatisfactory, disconnect the ATS.

Below 1500' 1/P (PF) shall keep his hand on the throttles all the time except for short moments required to handle the FGS [panel.]

*ICAO Note: The term "probable cause" is not envisaged in Annex 13, nor in the Manual of Aircraft Accident Investigation (Doc 6920).

c) Until a few years ago the use of external speed bugs was not an adopted SAS philosophy. It is now up to each aircraft type to decide if the use of external speed bugs is desirable. The DC-10 group is using external speed bugs in takeoff and approach and is now introducing another speed bug at V_{TH} for landing.

We think the setting of this speed bug may be of great value as it will generate a discussion of the runway length required, flap setting, runway conditions, etc.

The speed bug will be set under Landing Data on the Descent Check List.

d) SAS has revised the reversing procedure where we are using only reversers No. 1 and No. 3.

The new procedure will call for the use of all three reversers after main gear touch down.

The above listed revisions will be available in our manuals within one to two months.

All DC-10 pilots are briefed about all changes in a circular from the DC-10 Chief Flight Instructor, and the present Recurrent Training gives our Flight Instructors opportunity to discuss details.
All DC-10 pilots are given Additional Simulator Flying according to enclosed program.

In addition to the changes being implemented by the Scandinavian Airline System the following recommendations have been transmitted to the Director General of the Civil Aviation Administration of Norway for consideration:

Several additional corrective measures are needed in SAS's operational procedures in the areas of the "speed high" callout and the System Operators (S/O) maintaining airspeed awareness. The currently prescribed "speed high" callout requires the pilots to call out "speed high" if the desired indicated airspeed is exceeded by more than 10 knots at any point before the final approach, or on final approach if the threshold speed is exceeded by more than 5 knots. While the Safety Board believes that the current "speed high" callout should trigger increased monitoring and assessment by the flightcrew of the indicated versus target airspeed, it also believes that the actual speed values, i.e., deviations from the target airspeed, if called out, would serve as a more positive warning of the need to initiate corrective measures and/or abandon the approach, whichever is applicable.

The Safety Board believes that if the captain of Flight 901 had called out that the airspeed was 40 knots too high above reference speed, or "plus 40," rather than "speed high," during the final stages of the approach, the accident possibly may have been averted.

The Safety Board also is concerned with the Systems Operator's role in assuring adherence to proper approach speed. Although the Systems Operator is charged with monitoring the progress of the approach and with warning the pilots of discrepancies which include excessive deviations from normal approach speed, the Safety Board finds that such responsibility is not clearly reinforced by SAS's mandatory operational procedures. The Systems Operators do not compute, nor are they brought into the "loop" as to what the target V_R and V_{TH} speeds will be.

> The computation and awareness of these speeds is solely a function of the captain and first officer. In the instant case, the Safety Board found that the Systems Operator had no situational awareness of what the specific approach speeds should be. The Safety Board believes that SAS's overall coordination and cockpit resource management would be greatly enhanced if each flight crewmember were made aware of target approach airspeeds.

As a result of this accident, the Safety Board made the following recommendations to the Federal Aviation Administration:

> **Apply the findings of behavioral research programs and accident/incident investigations regarding degradation of pilot performance as a result of automation to modify pilot training programs and flight procedures so as to take full advantage of the safety benefits of automation technology. (Class II, Priority Action) (A-84-123).**

> **Direct air carrier principal operations inspectors to review the airspeed callout procedures of assigned air carriers and, where necessary, to require that these procedures specify the actual speed deviations (in appropriate increments, i.e., +10, +20, -10, -20, etc.) from computed reference speeds. (Class II, Priority Action) (A-84-124).**

ICAO Note: Figures 1 to 3, Appendices A to F and Appendix H were not reproduced.

ICAO Ref.: 006/84

APPENDIX G

THE AUTOMATIC COMPLACENCY
BY
CAPT. K.E. TERNHEM S.A.S

1. THE PROBLEM

In our role as pilots in an environment that provides technology to do the work for us automatically but not always intelligently, and without qualified interface between the individual systems, we have a problem. We are faced with a man-machine interface problem we might call "automatic complacency".

To combat the problem, it must always be borne in mind that the machine, be it even the most complex computer, is but a tool, designed to aid man in performing certain specific tasks. The machine cannot think for us, it cannot work outside its rigidly defined performance envelope - it cannot even be complacent. Consequently, there is every reason for man not to let these tools work on their own and without knowing their weak spots and the limits of their capabilities.

Let us look at some examples. The Autothrottle and the Autopilot normally perform their specific assignments very well but neither system knows much of what the other is doing or plans to do and neither system knows much about operational limitations (with some exceptions e.g., on DC-10). Still we seem to lean ourselves on the automatic systems - the automatic flight control systems in this particular respect - to such a degree that we may become lax in our attention to the primary flight instruments or even revise our priorities.

Using a good Autothrottle tends to degrade speed consciousness, use of Altitude Preselect tends to degrade our height consciousness, etc. We also tend to accept an inferior or even wrong performance of a system in a kind of paralyzation and as a consequence thereof, delay our actions. We also tend to correct the systems indirectly when a direct and more positive action would be more relevant.

Some examples from real life:

- In an automatic approach, a bend on the Glide Path at 500 ft caused a very marked pitch down, resulting in excessive sink rate. The pilot, though fully aware of the situation, did not react until the situation was so critical that a very low pull-up had to be made.

- In nav. mode en route, the aircraft turned the wrong way over a checkpoint. Although the wrong behaviour was immediately noticed, the aircraft turned more than 45° before the pilot took action.

APPENDIX G

- En route during INS operation, the crew did not notice that the nav. mode selector had been switched to HDG. The aircraft proceeded on a straight course for five minutes instead of turning over the waypoint.

- In an approach, the Autothrottle became inactive. The speed dropped 15 kt below correct speed before the malfunction was noticed.

- The Altitude Preselect malfunctioned during descent. This went unnoticed by the pilots and an excessive undershoot was made.

- At level off by use of the Altitude Preselect, the throttles in idle, the speed dropped close to stall before detected and rectified by power application.

These examples, of which kind there are many, are not unnatural in a logical sense. They are fully explainable human-engineering wise but they should nevertheless not occur unless there is a breakdown of the normal routine.

What is disturbing is that we tend to defend ourselves by blaming the system (which is only a contributing factor) and considering it legitimate to trust the technique and change our otherwise sacred instrument scanning routine.

Another way to describe the problem is that we tend to fall out of the "loop". We have a problem of complacency and we as individuals may not be aware of it.

The problem is not the pilot but more so our understanding of the mechanism that creates the problem and also the lack of intelligent means to train the pilot into the concept of integration with a competing machine. We are, of course, also aware of the fact that our aircraft installations, though at the top of the state-of-the art, may not always be optimized in their function to serve man.

2. THE CURE

As stated above, we do not know all the factors that create the problem and consequently, we are not prepared to give a recipe that totally eliminates the problem.

We can, however, all agree on some sound and concrete rules that, if followed, will keep us virtually out of the problem.

But first there is a need to clarify what the machine, the black box in our case, is really supposed to do for man. We apparently make a big mistake if we believe that the machine has entered our environment for the sake of our convenience only.

APPENDIX G

These are the realities:

1. The machine does <u>not</u> relieve man of his responsibilities.

2. The machine does <u>not</u> reduce the workload of man as regards his expected achievement.

B U T

3. The machine increases the total capacity.

4. The added capacity serves
   - to improve safety
   - to balance the workload
   - to improve accuracy
   - to improve regularity
   - to reduce costs.

In this world of realities, the pilot's managing role in the man-machine teamwork can be condensed into this sequence of actions:

Plan - Program - Confirm - Monitor - Correct - Reject

if necessary.

And with these facts in mind, you may agree that when you leave it to the automatic systems:

* don't change your piloting priorities.
* be aware of the system limitations.
* be highly suspicious.
* make clear <u>beforehand</u> what the system is supposed to do.
* check what it's doing.
* don't hesitate to reject the aid of an inferior system.
* don't accept a system performance that you yourself under the circumstances could do safer or better.
* don't make the use of an automatic system en end in itself.

or to express these rules in a short sentence:

BE SYNCHRONIZED WITH YOUR AUTOMATIC SYSTEMS

or still shorter: BE IN THE "LOOP".

In this article we focused our interest on problems. This should not be interpreted as a case against the use of the automatics. We are all aware of the positive reasons for the extensive use of available automatic systems but that's the other and brighter side of the coin which was not the purpose for discussion this time.

No. 3

Sikorsky S-76, N27422 in the South China Sea, on 1 November 1984. Report No. (85)005 released by the General Administration of Civil Aviation of China, People's Republic of China

SYNOPSIS

At 0324 GMT (1124 LT) on 1 November 1984, Sikorsky Helicopter S-76, Registration No. N27422 took off from oil rig platform No. 4 in the South China Sea. One to two minutes later, its left engine failed with uncontained damage. The first and second stage turbine disks burst, with fragments penetrating the engine case. At the same time, the pilot shut down the right engine for reasons unknown. The aircraft lost all power and dropped into the sea with its floats uninflated. All three crew members and two passengers on board drowned.

Immediately after the accident, The Civil Aviation Administration of China sent an Aircraft Accident Investigation Team to the site to conduct an investigation. China Ocean Helicopter Corporation; Petroleum Helicopters Inc., USA; Sikorsky Aircraft, USA; Allison General Motors Corp., USA; Pennz Far East Oil Company, USA and Sun Orient Exploration Company, USA sent representatives to participate in the investigation in the capacity of observers. The representatives of Shenzhen and Zhanjiang Branches of The People's Insurance Company of China were also present at the scene.

The final report of the investigation was prepared by the Aircraft Accident Investigation Team of The Civil Aviation Administration of China on 22 January 1985.

1. INVESTIGATION

1.1 History of the flight

On 1 November 1984, Sikorsky Helicopter S-76, Registration No. N27422, owned by Petroleum Helicopters Inc., USA, and leased to China Ocean Helicopter Corp. was engaged in transporting personnel and material from Potou, Zhanjiang to oil rig platform No. 4 in the South China Sea and return. At 1006 (LT) the aircraft took off from Potou and at 1035 (LT) landed at platform No. 4 and then shut down the engines. At 1124 (LT) the aircraft took off from the platform and flew eastward with three crew members, two passengers and some sand sampling tools on board. The payload of the aircraft was 1470 pounds. One to two minutes after take-off, the aircraft was seen flying at a height of 60M above sea level and about 200M from the platform when eyewitnesses heard a loud "Bang", then saw a fire flash in the aircraft followed by black smoke coming out, rotor speed dropping, and the fuselage lurching to the left. Shortly after, the aircraft ditched into the sea, with the tail hitting the water first. It then sank entirely. Search and rescue vessels rushed to the site but only found some pieces of flotsam. They anchored buoys to mark the location of the accident.

The accident happened in daylight at a location N20,07,21 E109,06,01 on the sea.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3	2	-
Serious	-	-	-
Minor/None	-	-	-

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Crew information

a) Pilot-in-command

Age: 35

Validity of licence: Temporary Airmen's Licence issued by the FAA on 31 August 1984

Flying experience:
Total: 6105 hours
Total flying hours on helicopter: 6075 hours
Total flying hours on multi-engine helicopter: 2170 hours
Total flying hours on S-76: 869 hours
Total flying hours over offshore area: 3554 hours

Pathological/Effectiveness (P/E): 77379/II-84/3/7

b) Co-pilot

Age: 35

Validity of licence: Pilot licence No. 840728

Flying experience:
Total flying hours: 2012 hours 56 minutes (until the end of 1984, inclusive of 181 hours 31 minutes on fixed-wing aircraft and 1831 hours 25 minutes on helicopter)
Total flying hours on S-76: 16 hours 13 minutes

P/E: Good 84/6/2.

c) Working personnel

Interpreter

Age: 22

1.5 Aircraft information

Manufacturer's serial No.:	760139
Registration No.:	N27422
Manufacturer's date:	19 February 1981
Time since new (TSN):	2413 hours 45 minutes

Serial No. of left engine:	CAE-890597
TSN (left engine):	1340 hours 40 minutes
Serial No. of right engine:	CAE-890496
TSN (right engine):	3017 hours

Time on both engines was 37 hours 55 minutes since the last 300-hour maintenance inspection.

The aircraft was certificated, equipped and maintained in accordance with FAA regulations and the procedures of Petroleum Helicopters Inc., USA.

The maintenance personnel of Petroleum Helicopters Inc., USA, were responsible for the maintenance, inspection and maintenance release of the aircraft. The aircraft flying time since the last 500-hour inspection which was completed prior to its transfer to China was 59 hours 05 minutes. The main rotor had operated 2384 hours out of a total of 11750 hours. No significant fault was recorded in the log.

1.6 Meteorological information

Forecast for oil rig platform at 0300 GMT (1100 LT)

Wind:	35 degrees, 10-12 m/sec
Ceiling:	above 400M
Visibility:	more than 15KM
QNH:	1010MB
Temperature:	20 degrees Celsius

1.7 Navigational aids

In good operational condition.

1.8 Communications

Normal.

1.9 Oil rig platform

Clear and suitable for take-off.

1.10 Cockpit voice recorder

The cockpit voice recorder (CVR) was mounted in the aft section of the fuselage. It was recovered intact. The CVR technical inspection was entrusted to the USA which, after inspection, provided a copy of the tape to the investigation team. Because the CVR electronic system was faulty, the playback of the pertinent recording was unintelligible except for some warning signals of engines and landing gear.

1.11 Wreckage and impact information

When the helicopter ditched into the sea, the nose was facing skyward with the tail sinking into the water. Shortly after, the whole aircraft disappeared from the surface of the sea. There was a drift of about 200M from the ditching point to the location where the wreckage was found. The depth of the water was 22M. Divers reported that except for the aircraft tail, most of the wreckage was buried in the sand at the bottom of the sea with the nose downward.

Major damage

a) The first and second stage turbine disks of the left engine were broken into pieces;

b) The cabin door transparancies were broken; cargo door on the right was lost;

c) The main rotor was completely broken; the blue, yellow and black blades of the tail-rotor were broken;

d) The left engine cowling was damaged;

e) The tail boom had separated from the fuselage at the joint.

1.12 Search and rescue

Search and rescue vessels stationed at the oil rig platform rushed instantly to the scene as soon as the accident took place, but only located floating debris.

2. ANALYSIS

The weather at the time was suitable for the flight. There was no evidence of medical or psychological problems that might have rendered the flight crew unfit to fly.

Under the supervision of China's specialists, the relevant department of the United States conducted a meticulous laboratory examination of the CVR, engine wreckage and other relevant parts. After the examination, they established that the cause of the break-up of the first and second turbine disks was the result of a fracture on the turbine-to-compressor coupling shaft (pea shooter) due to fatigue. The right side engine was somehow or other shut down.

The failure of the electronic system made the CVR playback unintelligible except for some warning signals of engine failure and main landing gear.

3. CONCLUSION

The Aircraft Accident Investigation Team of The Civil Aviation Administration of China established that the main cause for this accident was the fracture of the turbine-to-compressor coupling shaft due to fatigue, resulting in the overspeed of the gas turbine disks due to loss of load and subsequent break-up. A false fire warning signal for the right engine might possibly have induced the pilot to shut down that engine in an emergency. It was possible that when the left engine exploded, the pilot was misguided by an illusion and somehow shut down the engine so that the aircraft ditched into the sea when both engines were shut down. As there was very little time to cope with the emergency, the float safety switch was not placed in the "READY" position. The flight crew did not use the float system or other survival kit, and as a result the helicopter sank to the bottom of the sea and the five lives on board were lost.

ICAO Note: Names of personnel were deleted. Minor editorial changes were made.

ICAO Ref.: 207/84

No. 4

Beechcraft B 58 Baron, TU-TGD, near Abidjan, Côte d'Ivoire, on 4 August 1984. Report No. 042 released by Côte d'Ivoire

1. SYNOPSIS

On Saturday, 4 August 1984, at approximately 2330 hours UTC*, the Beechcraft 58 Baron aeroplane bearing registration number TU-TGD, belonging to Air Transivoire, crashed in a coffee and cacao plantation, 500 metres from the centre line of the international route Aboisso-Ghana and about 3 km to the west of the village of Alaoukro (05°17N - 02°55W) in the Department of Aboisso, while on the return leg of an international non-scheduled public passenger transport flight Abidjan-Monrovia-Abidjan under IFR conditions.

The aircraft and its cargo were totally destroyed by the impact and fire.

The pilot-in-command and the five passengers on board, including a noted politician, a Liberian Deputy Minister, all died in the accident.

Finally, a number of cacao and coffee trees were destroyed in the wreckage-strewn area.

... **

3. TECHNICAL INVESTIGATION

3.1 HISTORY OF THE FLIGHT

On Saturday, 4 August 1984, at 0822 hours, a flight plan was filed by Air Transivoire with the aerodrome control reporting office at Abidjan/Port Bouet International airport, for an international non-scheduled public passenger transport flight bound for Monrovia, Liberia.

This flight plan indicated, inter alia, that the aircraft used to operate this flight was a Beechcraft 58 Baron, registered as TU-TGD; the pilot-in-command was Commercial Pilot (Aeroplane) with Air Transivoire; and the estimated time of departure was established as 0830 UTC.

The aircraft was positioned in the parking area of Abidjan/Port Bouet airport approximately one and one-half hours after the estimated time of departure.

On board the twin-engined aeroplane were a Senior Commercial Pilot (Aeroplane) with Air Transivoire, replacing at the controls, and four passengers, all travelling at the expense of AAROMET-Cl, a firm located on Boulevard Delafosse, Abidjan, which had organized the flight.

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* Times given in this report are expressed in Coordinated Universal Time. The legal time in Côte d'Ivoire coincides with UTC.

** ICAO Note: Chapter 2 - "Commission of Inquiry and Summary of its work" was not reproduced.

At 1004 hours UTC, the Beechcraft left Abidjan for Monrovia, following an IFR flight plan.

The flight took place without incident and the aircraft landed without problems on the assigned runway at Monrovia/Spriggs Payne airport.

For the Monrovia/Abidjan leg the pilot-in-command had the fuel supply replenished with 100 litres of AVGAS supplied by the Mobil agent at the airport, giving a full tank of 628 litres of usable fuel at take-off.

At 1828 hours UTC, the BE 58 TU-TGD took off from Monrovia/Spriggs Payne airport bound for Abidjan, flying under IFR conditions. Pilot-in-command and five passengers, including the Liberian Deputy Minister of Foreign Affairs, were on board the aircraft. Indicated endurance was 6 hours and 30 minutes for a return leg of approximately 2 hours and 30 minutes flying time.

At 1836 hours UTC, the air traffic control unit at Monrovia (Roberts Field) informed the Abidjan flight information centre (FIC) that TU-TGD had taken off from Monrovia, estimated MEGOT, a mandatory reporting point (Côte d'Ivoire-Liberia boundary), at 1940 hours UTC. Arrival time at Abidjan was estimated to be 2100 hours UTC at FL 070.

At 1905 hours UTC, Roberts Field again contacted Abidjan advising them that TU-TGD was flying at FL 050.

At 2033 hours UTC, the Beechcraft TU-TGD established contact with UT 838, a UTA DC-10 en-route for Niamey (Niger) which had just taken off from Abidjan at 2026 hours.

According to the transcription of the tapes from Abidjan FIC, the following radio messages were exchanged between BE TU-TGD and Abidjan FIC via a relay provided by UT 838 at 2033 hours UTC on the 118.1 MHz frequency.

TRANSMITTING STATION	RECEIVING STATION	RADIO MESSAGES
UT 838	!!	Station calling UT 838?
UT 838	TU-TGD	UT 838, I hear you 5'GD
UT 838	TU-TGD	Yes, go ahead
UT 838	TU-TGD	Uhh. . . what are your estimated points at 1828 hours and at 2035 hours?
UT 838	TU-TGD	GD What are the positions at 1828 hours and at 2035 hours?
UT 838	TU-TGD	Will you please spell out the take-off point?
UT 838	Abidjan	All right; UT 838 I am giving you a relay from GD who took off from a certain field at 1828 hours, estimates POMET at 2035 hours, Abidjan at 2105 hours at FL 70.

Abidjan	UT 838	Confirm arrival at Abidjan!
UT 838	Abidjan	2105 hours
Abidjan	UT 838	O.K.! Message received, thanks for the relay. Tell him to report POMET in two minutes.
UT 838	TU-TGD	Yes - GD, you call again over POMET

This was the last contact established with the Beechcraft TU-TGD.

TU-TGD did not contact Abidjan at 2035 hours UTC. Instead, it was Roberts that called Abidjan to ask if they were in contact with TU-TGD. Abidjan, which had been in contact with TU-TGD just two minutes earlier via relay, replied in the affirmative. Abidjan waited impatiently for several minutes and, between 2056 hours and 2105 hours, sent out several calls to TU-TGD but failed to re-establish contact with the aircraft.

At 2116 hours UTC, Abidjan FIC activated the emergency procedures in conformity with the applicable provisions of international air traffic regulations.

At 2118 hours, a PA 81 aircraft operating in the Abidjan control area also called TU-TGD at the air traffic controller's request on the frequencies 121.1 MHz, 118.1 MHz and 119.1 MHz, but without success.

The distress phase was initiated at about 23 hours UTC.

Actual search and rescue operations, directed by the Abidjan Co-ordination and Rescue Centre, began when two helicopters took off from the GATL Military Base very early the next day, 5 August.

Air Transivoire aircraft participated in these search and rescue operations.

At approximately 1100 UTC, the Police Brigade of Ehania informed Abidjan FIC by telephone that the twin-engined BE 58 TU-TGD had crashed in a coffee and cacao plantation near Alaoukro, a village about 35 km from Aboisso.

3.2 INJURIES TO PERSONS

All six occupants of the aircraft perished in the accident. The bodies were positively identified at the crash site:

Injuries	Crew Members	Passengers	Others
Fatal	1	5	0
Serious	0	0	0
Minor/None	0	0	0

3.2.1 Crew

Born 8 December 1948 at Ferkessedougou

Nationality: Côte d'Ivoire

Senior Commercial Pilot (Aeroplane) with Air Transivoire

3.3 Damage to aircraft

The aircraft was totally destroyed by the collision with the ground and the fire which broke out following impact.

3.4 OTHER DAMAGE

The accident occurred in a coffee and cacao plantation. In consequence, a number of plants were destroyed throughout the area which was strewn with wreckage over a distance of about 50 metres.

3.5 PERSONNEL INFORMATION

The crew for the whole flight Abidjan/Monrovia/Abidjan was composed of a single crew member, the pilot-in-command.

Born 8 December 1948 at Ferkessedougou (Côte d'Ivoire)
Married with 4 children
Senior Commercial Pilot (Aeroplane) with Air Transivoire since 11 November 1983.

3.5.1 AERONAUTICAL QUALIFICATIONS

- Elementary Private Pilot's Certificate (Aeroplane) No. TT 50330 issued in Paris on 10 October 1972 by SFACT (France).

- Private Pilot's Licence (Aeroplane) No. TT 1204000475 issued in Paris on 7 January 1975 by SFACT (France)

- French Commercial Pilot's Licence (Aeroplane) No. PP 8423 issued in Montpellier on 8 June 1980 by the Direction Générale de l'Aviation Civile (DGAC) - France.

- French Senior Commercial Pilot's Licence (Aeroplane) No. PPl 4172 issued in St. Yan on 18 October 1983 by the DGAC - France.

- His two French Licences Nos. PP 8423 and PPl 4172 were convalidated by Côte d'Ivoire Licences Nos. PP 05-80 and PPl 06-165 respectively.

- All these licences were valid up to 8 October 1984.

- International Radio Rating automatically renewable with licence (Certificate PTT No. 46631 issued on 27 June 1979 by SFACT - France).

- Type rating on aircraft types:

  17 November 1983 - HR 100 - All types of single-engined propeller aeroplanes - C310, N262, SN 601

  25 November 1983 - C 402

  20 December 1983 - P68B, BE 58

  6 January 1984 - C 421

  19 January 1984 - C 340.

- Private Pilot Assistant Instructor Rating TT No. 2-LAR 000381 issued on 30 April 1981 by SFACT (France).

3.5.2 MEDICAL REQUIREMENTS

At the time of the accident, he held a valid medical requirement with no waivers or limitations.

3.5.3 FLIGHT EXPERIENCE

His journey log book was kept properly up to date. Total flying time up to the date of the accident, including the outbound leg Abidjan/Monrovia, was recorded as follows:

Total flight experience:	1497 h 05
As pilot-in-command:	801 h 35
Instrument flight:	808 h 05
Night flight:	135 h 50
On aircraft type involved:	20 h 35

3.6 AIRCRAFT INFORMATION

The aircraft involved was a Beechcraft 58 Baron, Serial No. TH 315, manufactured in the United States in 1973 by Beech Aircraft Corporation.

The aircraft had a maximum take-off weight of 2 451 kg and was powered by two Continental 10-520-C engines, Nos. 125879 and 231783/R. It was ferried from the United States to Côte d'Ivoire under Special Permit No. 73-005 issued by the Côte d'Ivoire Civil Aviation Administration, and was granted Provisional Registration No. 77-272, issued on 18 May 1973, prior to being permanently entered on the Côte d'Ivoire Civil Aircraft Registry on 12 June 1973 on behalf of the State enterprise SODESUCRE, under Registration No. TU-TGD.

The airworthiness certification inspection of the aircraft was carried out at Paris/Le Bourget on 26 April 1973 after a total flying time of 33 hours 10 minutes. Following this inspection, the aircraft was classified as Standard Category with a Private Use rating on 12 May 1973.

Airworthiness Certificate No. 13004 was issued to it by the Côte d'Ivoire Civil Aviation Administration on 2 May 1973.

BE 58 TU-TGD was granted a Public Passenger Transport 2nd Category (TPP 2) rating in the last quarter of 1974, in accordance with an amendment to Certificate of Airworthiness No. 9304/Z.0 dated 24 December 1974.

On 23 July 1979 Beechcraft BE 58 TU-TGD was purchased by the company Cessna Côte d'Ivoire (Transfer of Ownership No. 457 on the Côte d'Ivoire Civil Aircraft Register).

- On 19 February 1980, Air Transivoire became the owners of the aircraft following a purchase contract (Transfer of Ownership No. 479 on the Côte d'Ivoire Civil Aircraft Register).

The aircraft had its annual inspection on 26 July 1984 and its Certificate of Airworthiness was validated up to 26 July 1985.

The aeroplane's maintenance record does not show any uncorrected mechanical malfunction which might have affected airworthiness.

On 1 August 1984, the date on which its second-to-last flight before the accident took place, the aircraft had a total of 3 517 hours of operation; i.e. 518 hours since a major overhaul and 18 hours since the last regular 100-hour service check. The engines each had a total of 1 181 hours of operation since the last complete overhaul.

Make and type of the propellers was Hartzell No. PHC-J3YF-2FU and PHC-J3YF-2FU.

Finally, as regards accidents, the maintenance record does show that the twin-engined aeroplane TU-TGD had an accident on 23 June 1973 at Abidjan/Port-Bouet Airport. Nature of the accident: sideswiping a Piper PA 25 aeroplane. Damage sustained by TU-TGD was twisting of the lower part of the rudder. The aircraft was made airworthy again shortly after.

3.7 METEOROLOGICAL INFORMATION

Meteorological forecasts issued by the Abidjan meteorological office, *inter alia* a general significant weather forecast valid from 1000 UTC to 2100 UTC for the Liberia-Guinea-Mali area, indicate 3-5/8 Cu Sc at 360 m, 3-4/8 AC at 3 300 m frequent CB, 4-6/8 CB at 500 m giving unstable conditions and storm.

For the CI-Ghana region 2-3/8 Cu Sc at 360 m, 3-4/8 AC at 3 300 m, occasionally (very infrequently) CB at 500 m capable of producing very localized storms.

However, the Abidjan meteorological observations during the day, issued by the meteorological office at 2030 UTC, 2100 UTC, 2130 UTC and 2200 UTC, show no particular meteorological indications hazardous to navigation (rain, storm, dangerous cloud conditions, squall line). All these observations record a visibility of more than 10 km. Surface wind was 4 to 7 kt from the south-west.

Moreover, according to witnesses, weather conditions were relatively good in the area, *inter alia*, at the exact place and time at which the accident occurred.

Furthermore, during the radio contact with the UTA DC-10, the Beechcraft did not mention having encountered any unfavourable weather conditions.

3.8 NAVIGATION AIDS AND COMMUNICATIONS

3.8.1 ABIDJAN/PORT-BOUET AIRPORT

Abidjan/Port-Bouet International Airport is equipped with the following navigation aids:

- VOR AD 114.3 MHz
- DME AD CH 90 X
- ILS AN 110.3 MHz
- Locator AD 327 kHz
- Locator AN 306 kHz
- Runway lighting.

Abidjan/Port-Bouet International Airport is also equipped with the following air-ground frequencies:

- The flight information centre (FIC)

  VHF: 129.1 MHz

  HF: 6673 MHz
  8861 MHz
  6586 MHz

- The aerodrome control tower: 118.1 MHz
- Approach control: 121.1 MHz.

It was established by the Commission of Inquiry that the navigation aids and air-ground radio equipment at Abidjan/Port-Bouet airport which were in use on the date of the accident were operating properly; no malfunction was reported either on the ground or in the air. In addition, aside from the usual night-time phenomena affecting reception from medium-frequency aids, no interference from outside stations was observed.

3.8.2 BEECHCRAFT TU-TGD

The aircraft was equipped with the following navigation and communications aids:

- 2 NARCO VHF transmitters-receivers
- 1 SUNAIR HF transmitter-receiver
- 2 NARCO VOR receivers
- 2 NARCO ILS (course line-glide path)
- 2 BENDIX automatic radiocompasses
- 1 ETL (Dorne and Margolin) emergency locator.

This equipment was in conformity with international standards and corresponded to the aircraft's assigned Public Passenger Transport 2nd Category (TPP2) rating for use.

BE 58 TU-TGD held Station Licence No. 118A issued on 2 May 1981 by the Director General of Communications for the installation and operation of airborne radio equipment.

At the time of the accident, TU-TGD also was in possession of Airborne Radio Equipment Operating Certificate No. 58, issued on 11 May 1981 by the Director General of Civil Aviation and renewable annually.

On 18 and 21 August 1982, ground and flight tests of the radio equipment on board BE 58 TU-TGD carried out by a CDCA agent revealed, first, that the HF transmitter/receiver and markers were inoperative and, secondly, that VOR/LOC sets 1 and 2 were unserviceable.

- As a result, the Central Directorate of Civil Aviation declined to renew the period of validity of the Airborne Radio Equipment Operating Certificate and, by letter No. 1943/DCAC/ER of 24 August 1982, asked Air Transivoire to repair the above equipment before the next technical tests.

- On 27 August 1982, in reply to this letter, Air Transivoire informed the Central Directorate of Civil Aviation that, contrary to their agent's test report, all the airborne radio equipment on board TU-TGD was operating perfectly with the exception of the HF, which established links only when the aircraft was in flight (letter No. CGTS/AT1/4307 of 27 August 1982).

- The CDCA agent therefore visited Air Transivoire to carry out another technical test. During the ground test he observed that some of the radio equipment was inoperative, and advised Air Transivoire that under these circumstances he was unable to carry out the flight test. The Radio Equipment Certificate, therefore, was not validated.

- Air Transivoire, however, continued to operate the aircraft on a regular basis with a certificate which was no longer valid.

- On 7 July 1984, Air Transivoire informed the CDCA that four of its aeroplanes were available for airborne radio equipment testing by the CDCA agent, including BE 58 TU-TGD.

- The inquiry showed that since that date no ground or flight technical tests had been carried out by the Côte d'Ivoire Civil Aviation Administration, and that Air Transivoire had operated the aircraft regularly up to the time of the accident.

- In addition, two incidents which occurred to BE 58 TU-TGD involving the aircraft's radio and navigation equipment were the subject of two separate reports transmitted to the CDCA by ASECNA:

1) On 31 October 1983, the twin-engined aeroplane TU-TGD, outbound from Monrovia, was forced to divert to Bouake Airport where it landed at 2101 hours. The investigation revealed that this incident was due to the failure of airborne radio equipment (HF and VHF) and of the Abidjan VOR.

2) On 31 March 1984, TU-TGD, arriving from Monrovia, was without radio contact. The aircraft crossed the take-off runway at Abidjan/Port Bouet airport over the control tower and came into conflict with an arriving Nigeria Airways B-747. The investigation concerning this incident showed that the radio and navigation equipment - the two VHFs, the automatic direction-finders (ADFs), the AP, and the HF - were unserviceable while VOR No. 2 indicated an error of 20°, and that the aircraft returned to Abidjan with a ferry flight clearance.

- A study of the documents relating to the maintenance of the aircraft's radio and navigation equipment revealed the existence of an internal company memorandum (a Manifold) parallel to the Equipment Report (CRM) which is an official document. A comparison between the two documents showed that airborne equipment malfunctions or defects reported on the Manifold were not fully reported on the CRM, or else the pilot simply filled in RAS (rien a signaler = nothing to report) on the CRM. According to Air Transivoire officials, the Manifold system was set up to improve the efficiency and rapidity of repairs on airborne equipment reported to be defective.

- The maintenance of radio and navigation equipment (VHF, HF and ADF) was the responsibility of the Air Afrique radio workshop. The testimony received in this connection seems to indicate the absence of a maintenance contract approved by both parties: in fact, Air Afrique had not worked on the VHF equipment since 15 July 1984 inclusive. Thus, no repairs had yet been effected on the HF which had been reported out of order since 3 July 1984.

- Finally, the following malfunctions appear on the Manifold log of pilots' complaints during the 30 days prior to the crash:

3 July 1984	HF unserviceable - PA unserviceable - VOR No. 2 weak.
18 July 1984	Alternator left warning light unserviceable.
19 July 1984	HF unserviceable - VHF 1 and 2 weak - VOR No. 2 weak. Check flaps warning light.
20 July 1984	VHF 1 and 2 very weak - VOR No. 2 weak - HF unserviceable.
31 July 1984	HF unserviceable - VHF 1 very weak reception - VOR No. 2 somewhat weak.
4 August 1984	HF unserviceable (reported by pilot on day of crash).

3.9 <u>FLIGHT RECORDERS</u>

Beechcraft 58 TU-TGD was not equipped with either a cockpit voice recorder or a flight data recorder. It was not required to have either under the pertinent regulations.

3.10 <u>WRECKAGE AND IMPACT</u>

- The accident took place in a wooded area. The wreckage was located in a coffee/cacao plantation dotted with large trees and easily accessible.

- The site was relatively clear and the wreckage had not been moved to any great extent prior to the arrival of the investigators.

- At the time of the initial impact, the aircraft was on the north-south axis, heading north, roughly at right angles to the west-east axis (radial 094° Abidjan-IVORY). The landing gear and flaps were retracted and it appeared to have been operating in almost level flight.

- While flying in this configuration, the aircraft's initial impact was with a tree trunk almost 300 cm in diameter, which it struck violently at a height of about 20 metres with the right wing tip, leaving a large and very visible mark at the point of impact.

- Thoroughly out of trim, the aircraft plunged downwards, and along the path of its fall it first struck and sheared off a tree 10 cm in diameter at a height of 3 metres, about 18 metres away from the first one; then, 10 metres further on, it crashed into the ground nose down at the foot of a third tree (40 cm in diameter at ground level). One of the right propeller blades made a deep cut in the tree trunk at ground level.

- Although examination of the wreckage was rendered exceptionally difficult by the impact and fire damage, several observations came to light in the course of the technical investigation:

- The landing gear and flaps were retracted.
- The altimeter was jammed at 400 ft (elevation of the crash site plus tree).
- The RPM indicator, the front of which was partly smashed in, indicated 1550 revolutions per minute for the right engine and 1250 revolutions per minute for the left engine.
- On the control panel:
  - the propeller controls were full forward at fine pitch
  - the throttle control was full forward at full throttle
  - the mixture control was full forward at full pitch
  - both the pilot's wristwatch and the on-board clock had stopped at approximately 2330 hours UTC.
  - however, there were none of the usual traces on the wreckage to suggest that the aircraft had been struck by lightning.

3.11 MEDICAL AND PATHOLOGICAL INFORMATION

The last medical examination undergone by the pilot to determine his fitness for the duties of Senior Commercial Pilot (Aeroplane), took place on 8 May 1984 and was performed by a doctor certified by the Côte d'Ivoire Civil Aviation Administration.

As a result of that examination, he was judged to be fit and his medical requirement was validated up to 8 October 1984 with no waivers or restrictions.

Furthermore, his medical records contain no medical information which might be such as to impair his normal flying performance. He had never evidenced any emotional or physical problems.

A doctor of the Plateau Clinic, who reached the crash site on 5 August 1984 a few hours after the discovery of the wreckage was reported to Abidjan FIC, stated, after examining the bodies of the victims, that the occupants of BE 58 TU-TGD died of injuries, particularly those resulting from the violent impact of the final collision. Examination of the bodies did not reveal any injuries that could have been caused by firearms or explosives of any kind which might have been on board the aeroplane.

The bodies of the victims were positively identified at the crash site on Monday, 6 August 1984.

3.12 FIRE

Fire broke out after the disintegration of the aircraft which resulted from the extremely violent impact caused by the final collision with the ground.

No traces of fire in flight or explosion before the final impact were found.

Several fire sites were noted. The three main sources of fire broke out at the level of the wings and cockpit.

3.13 SURVIVAL ASPECTS - SEARCH AND RESCUE OPERATIONS

- The accident was not survivable in view of the violence of the final impact with the ground and the subsequent total disintegration of the aircraft.

Therefore there were no survivors.

- BE 58 TU-TGD made its last contact with the Abidjan control service at 2033 hours. Since the aircraft did not call back at 2035 hours as arranged, the Abidjan controller waited impatiently for a few minutes and sent out several calls to the aircraft between 2056 hours and 2105 hours.

The air traffic emergency procedure was set in motion at 2116 hours. The distress phase was initiated around 2300 hours.

Actual search and rescue operations directed by the Abidjan Co-ordination and Rescue Centre (CSS) commenced on Sunday, 5 August, when two helicopters took off from the GATL military base as well as several aeroplanes belonging to Air Transivoire.

When it was reported that the wreckage of the aircraft had been found, a GATL helicopter transported CSS, ASECNA and Air Transivoire representatives to the crash location, accompanied by a doctor.

4. ANALYSIS AND CONCLUSIONS

4.1 ANALYSIS

The difficulties encountered by the Commission of Inquiry when examining the wreckage and attempting to reconstruct the flight (total destruction of the wreckage due to impact and fire, absence of flight recorder, etc.), led the Commission to formulate several hypotheses.

- The pilot held valid licences and ratings as required for the performance of his duties on the type of aircraft and flight concerned. He had considerable experience with night flying. More specifically, he was thoroughly familiar with the Abidjan control area and had flown in and out of Abidjan/Port Bouet airport at night for several years. He was accustomed to flying this aircraft without a co-pilot.

The testimony of his friends and colleagues reveals that the pilot was considered to be a gifted man whose progress was based on a solid foundation. This was evidenced by the fact that he had just been accepted for a competitive examination for Senior Commercial Pilots (Aeroplane) sponsored by Air Afrique. In view of all these declarations, the members of the Commission of Enquiry considered the hypothesis of navigational error by the pilot to be very unlikely. In addition, his medical records and his last medical examination revealed nothing which might impair his normal flying performance. Finally, he had had an adequate rest period as required by regulations and the fatigue factor was not involved.

- The aircraft had been maintained in conformity with the applicable instructions and according to an approved maintenance schedule. It had been given an annual inspection on 26 July 1984 and had been inspected by the Bureau Véritas. The aircraft held a valid Certificate of Airworthiness.

The flight log sheets did not reveal any uncorrected malfunction which might seriously prejudice the airworthiness of the aircraft. Therefore no doubt exists regarding the satisfactory mechanical condition of the aircraft, and the possibility that a failure or deficiency affecting the operation of its engines, structure or controls might have been a factor in the accident was considered by the Commission to be very slight.

- Before taking off from Monrovia/Spriggs Payne airport, the pilot replenished the fuel supply. The aircraft therefore took off at 1228 hours GMT with a full load of 628 litres of usable fuel for the return leg which should have taken 2 hours 30 minutes, giving an endurance of about 6 hours 30 minutes. With 6 persons on board, the aircraft had a theoretical overload of 124 kg on take-off, but at 2330 hours UTC, the presumed time of the crash (as indicated by the pilot's wristwatch) i.e. after about 5 hours of flying time, the loading and weight distribution of the aircraft could be considered as falling within allowable limits. Therefore, the above-mentioned overload was not considered to be the probable cause of the accident. It is true that this overload resulted in higher fuel consumption, but taking into account the history of the flight, the members of the Commission were of the opinion that the fuel starvation factor should be discounted in regard to this accident.

- The inquiry showed that the navigation aids and radio equipment in use at Abidjan/Port Bouet airport on the day of the accident had been operating properly. No malfunction was reported either on the ground or in the air. Specifically, none of the aircraft which had made use of this equipment during the critical period observed any malfunction or defect whatsoever relating to these facilities.

These aircraft include:

- The DC-10 UT 838, which took off from Abidjan at 2026 hours.

- The Ethiopian Airlines B-737 which took off from Abidjan at 2044 hours.

- The PA 181 which was flying in the Abidjan control area and which sent out several calls to TU-TGD at 2116 hours on the frequencies 118.1, 129.1 and 121.1 but was unable to make contact.

- Finally, the B-737 SA 232 which landed from Johannesburg at 2244 hours.

- Moreover, apart from the usual night-time phenomena affecting reception from medium-frequency aids, no interference from outside equipment had been observed.

In addition, according to ASECNA pilots and technical staff, assuming an extended equipment failure at Abidjan/Port-Bouet airport, which appears to be highly unlikely, the aircraft would have been able to receive either the Port-Bouet radio beacon (P 294.2 MHz) or the national radio signal on the 1493 MHz frequency, enabling the pilot to navigate correctly and land at Abidjan without any serious difficulty.

- At this point, the members of the Commission concentrated their efforts on an examination of the operating status of the aircraft's radio and navigation equipment:

- In fact, after positioning the aeroplane at Monrovia/Spriggs Payne airport on 4 August 1984, the pilot had recorded on an Air Transivoire internal memorandum that the HF was out of order. The fact that the pilot decided to take off on an IFR flight, especially at night, implies that the radio and navigation equipment must have been functioning normally. Also, according to the transcribed tape of the air/ground radio communications with Abidjan FIC, normal communications were established between the aircraft and the Monrovia control services and were carried out in accordance with approved air traffic procedures.

At 2033 hours, the pilot contacted the aircraft UT 838 which served as a relay with Abidjan FIC for the transmission of his estimated times for passing reporting point POMET, 80 NM from Abidjan (2035 hours) and arriving at Abidjan flying at FL 70 (2105 hours). It can also be observed that during this relay the pilot did not report any technical problems with his airborne equipment, or any reception difficulties with the Abidjan airport radio and navigation facilities.

- Concentrating on the part of the flight which took place between 2035 hours and the presumed time of the crash, the Commission first examined the hypothesis of a failure of the aircraft's radio and navigation equipment caused by meteorological conditions:

The enquiry showed that the meteorological conditions were relatively good on the Monrovia-Abidjan route, especially in and around Abidjan, where according to witnesses the sky was bright and clear, with the moon in its first quarter and with visibility in excess of 10 km. Similarly, none of the typical signs of lightning could be detected either with respect to the wreckage, the radio and navigation equipment, or the rear fuselage and tail fin, which are the parts most often affected in such cases.

Therefore, the hypothesis that the accident was caused by a failure of the airborne equipment resulting from unfavourable weather conditions encountered by the aircraft on its return flight after 2033 hours was considered by the Commission to be improbable.

– Next, the theory of a prolonged electrical failure was put forward. Taking into account the duration of the flight from about 2033 hours, the presumed time of such failure, the battery would have been dead and the witnesses located in the vicinity of the crash site would not have observed the navigation lights operating normally moments before the crash. This possibility was therefore discounted.

– The Commission also considered the possibility of a simultaneous failure of radio and navigation aids on board the aircraft. In fact, investigation of the incident involving Beechcraft TU-TGD on 31 March 1984 had revealed that the HF, the two ADFs and the AP were all found to be unserviceable and that VOR No. 2 was showing an error of 20°.

. This report led the Commission to conclude at this stage of the analysis that, in spite of the existence of separate COM and NAV circuits on board the aircraft concerned, the hypothesis of a simultaneous failure of these circuits was not unlikely.

Futhermore, complaints registered by pilots on the company's internal memoranda during the last 30 days preceding the accident, indicate inter alia that from 3 July 1984 to 4 August 1984 (the date of the crash), the HF was out of order; VHF 1 and 2 were weak on 19 July 1984 and very weak on 20 July 1984; VHF 1 had very weak reception on 1 July 1984; VOR No. 2 was weak on 3 July 1984 and somewhat weak on 1 August 1984. The inquiry also revealed that no action had been taken to repair the HF since 3 July 1984 or the two VHFs since 19 July 1984 inclusive, and that as regards the VOR, the Air Afrique radio workshop lacks the equipment required for adequate maintenance of this facility.

4.2 CONCLUSIONS

4.2.1 RESULTS OF THE INQUIRY

Following receipt of the various reports based on the investigation and analysis of the facts, the members of the Commission unanimously concluded that:

- The aircraft had been maintained in accordance with an approved maintenance programme and its Certificate of Airworthiness was valid at the time of the accident.

- The pilot had the required licence and ratings to operate the flight.

- The navigation and radio aids in use at Abidjan/Port Bouet airport on the day of the accident had been operating normally.

- The aircraft's Airborne Radio Equipment Certificate had expired on 12 May 1982.

- The pilot took off from Monrovia/Spriggs Payne according to an IFR flight plan and with all airborne equipment systems operative.

- The aircraft left Monrovia control area without reporting any problems whatsoever indicating that all airborne systems were operating normally.

- The pilot would not have continued his flight if any serious problems had arisen.

- 2 hours and 5 minutes after take-off, i.e. at 2033 hours, at the time of making radio contact with UT 838, all airborne systems appeared to be operating normally.

- If the aircraft had actually been over reporting point POMET, even if it had experienced a radio breakdown, it would have reached Abidjan without any significant problems by maintaining its heading since meteorological conditions were relatively favourable.

- TU-TGD was not over reporting point POMET at the time of its last radio contact with UT 838.

- TU-TGD followed a flight path which led it further away from Abidjan as it attempted to approach the latter city and finally led the aircraft to a point located over the ocean.

- The aircraft flew abeam Abidjan at an altitude and distance such that it could no longer make radio contact with Abidjan or make use of navigation aids. Only the HF band would have enabled it to re-establish contact with Abidjan, but this system was inoperative.

- When 2105 hours (the estimated time of arrival at Abidjan airport) had passed and that city had not come into view, the pilot realized that he was not flying in the right direction.

- Finally, on coming in from the ocean in search of Abidjan, BE 58 TU-TGD struck the tree with its right wing as it headed north.

- It is somewhat perplexing to note that at the time of the crash the aircraft was aligned on the marker IVORY, a reporting point which is well known to pilots (and which was operational at the time of the accident). If the pilot had aligned his flight path with reference to this marker, it is incomprehensible why he descended to such a low level, approximately 400 ft.

- In conclusion, the members of the Commission are well aware that the presumed sequence of events described above offers only a hypothetical explanation for the accident. There is no doubt that, had the aircraft been equipped with a flight recorder, supplementary data regarding the actual unfolding of events would have been available. They considered, however, that this was the most probable sequence of events.

4.2.2 CAUSE OF THE ACCIDENT:

As a result of its work, the Commission of Inquiry judged the probable cause* of the accident to be a navigational error stemming from failure of the aircraft's navigation and/or radio equipment.

Finally, the members of the Commission were unanimous in their view that night-time conditions constituted a contributing factor in this accident. In fact, in view of the pilot's flying experience, they are firmly convinced that the crash would have been avoided if the same situation had presented itself under daytime conditions.

*ICAO Note: The term "probable cause" is not envisaged in Annex 13, nor in the Manual of Aircraft Accident Investigation (Doc 6920).

5. SAFETY RECOMMENDATIONS

5.1 The Commission of Inquiry recommends that Air Transivoire go back to the standards established under the Côte d'Ivoire Civil Aviation Administration regulations relative to complaints by pilots. These should be noted solely on the Equipment Report (CRM), which is the only official and mandatory document.

5.2 Airlines engaged in public passenger transport are responsible for ensuring the continued airworthiness of their aircraft; therefore, the Commission recommends that operators make application well in advance to renew the certification of all systems installed aboard their aircraft, *inter alia*, the Airborne Radio Equipment Operating Certificate.

ICAO Note: Appendices, photographs and a diagram were not reproduced. Names of personnel were deleted.

ICAO Ref.: 147/84

No. 5

Britten-Norman BN-2A-9 Islander, DQ-FCA, at Deuba, Fiji on 13 August 1984. Report No. CA 15/2/18 released by the Civil Aviation Authority of Fiji

SYNOPSIS

The Aircraft departed Nadi International Airport at 0727 local time on a scheduled flight to Deuba Airport under Visual Flight Rules. The flight proceeded normally and on nearing the destination at 0751, an ATC clearance to descend through cloud was requested and granted. A descent was made to the North East of the airport and when below cloud the pilot in command resumed the flight to the destination under Visual Flight Rules. When approximately 3 miles East of the airport, at an altitude of 700 ft, the starboard engine began to surge. The pilot in command then applied carburettor heat, turned on the fuel booster pumps, changed fuel tanks and turned to the left to avoid high ground. Almost immediately the Port engine also began to surge and the aircraft continued to descend. The pilot in command applied carburettor heat to the port engine. Neither engine was developing any power as the aircraft descended through an altitude of 200 ft. The pilot in command force-landed the aircraft in a small clearing half a mile East of the airport. The aircraft was substantially damaged in the landing but there were no injuries to the passengers and crew who evacuated the aircraft safely.

1. PRELIMINARY

The Authority was notified of the accident by Sunflower Airlines shortly after it occurred. The Minister for Civil Aviation was subsequently informed of the details. The Authority was requested to proceed with the investigations.

2. FACTUAL INFORMATION

2.1 History of the Flight

The aircraft departed Runway 27 at Nadi International Airport at 0727 local time on a scheduled flight to Deuba Airport with five passengers on board. The flight was planned to be conducted under Visual Flight Rules with an estimated time en-route of thirty minutes. The pilot in command climbed to and cruised at an altitude of 4500ft. The flight progressed normally, however, in the later stages cloud coverage increased with tops at approximately 4500ft above mean sea level. On nearing the destination, at 0751 local time the pilot in command requested and was given a clearance for flight under Instrument Flight Rules at 5000ft to a Non-Directional Beacon located approximately 4nm to the east of Deuba Airport and to conduct a DME step descent on track to Nausori Airport until clear of cloud. At 0754 the pilot in command reported that he was continuing the flight under Visual Flight Rules.

The pilot in command turned to set course for Deuba Airport and continued descent. Approximately 3nm east of the Deuba Airport and at an altitude of 700ft the Starboard engine began to surge. The Pilot in command applied carburettor heat, turned on the fuel booster pumps and changed fuel tanks. He then turned the aircraft to the south to avoid some high ground. Almost immediately the port engine also began to surge and the aircraft continued to descend. Carburretor heat was also applied to the port engine which also did not respond. The aircraft had reached an altitude of 200ft and neither engine was developing any power. The aircraft was over the coast line at this time. The pilot decided against ditching and turned inland again and made a forced landing in an open field approximately half a mile east of the airport.

Immediately after touchdown the aircraft ran over a shallow grass covered drain. The port undercarriage collapsed rearward. The aircraft came to a stop approximately 50 metres from the point of touchdown. The crew and passengers evcuated the aircraft safely.

2.2 Injury to Persons

There was no injury to any person on board the aircraft or to anyone on the ground.

2.3 Damage to Aircraft

The aircraft suffered substantial damage during the forced landing, primarily as a result of touching down just prior to a shallow drain. Details of damage:

(a) Port main undercarriage leg collapsed rearward and damage to main spar at this point.

(b) Nose-wheel pushed back into fuselage destroying nose section, wrinkling the nose bay floor and disabling rudder control drive.

(c) Starboard main undercarriage leg mounting and adjacent spar damaged.

(d) Starboard main leg outer tyre punctured.

(e) Port propeller impact damaged at both tips.

(f) Port and starboard flaps buckled at rear of each main undercarriage leg.

(g) Ground impact damage to port wing tip and aileron.

(h) Fuselage underbelly scuffed and some warping of cabin floor and underlying stringers adjacent to port rear passenger door.

2.4 Other damage

None.

2.5 Personnel Information

Pilot in command

Age	:	36 years
Licence	:	Fiji Airline Transport Pilot's Licence No.92. First issued on 19 April 1978 on the strength of New Zealand Commercial Pilot's Licence No.2315. Current validity of Fiji ATPL 92 from 16 February 1984 to 15 August, 1984.
Ratings	:	Aircraft Ratings (1) Pilot-in-Command. BN2(Islander), Beechcraft Baron, Victa Airtourer, BAC111, PA 18, Bolkow 208, Cessnas 172/206/ Citabra, Mooney 20, MS880B, Beechcraft A23-24, Piper PA22/24/32, Aerocommander 500.
		(2) Copilot. B737, HS748, Beechcraft 65, Beechcraft 80.
		Instrument Rating - Last check undertaken on 7 September 1983 and valid until 6 October 1984.
		Instructors Rating - Valid until 15 August 1984.

Flying Experience	-	Total hours on all types	-	8700 hrs
		Total hours last 28 days	-	74 hr 52 mins
		Total hours last 7 days	-	24 hr 23 mins.

The pilot in command, a Fiji national, was employed by Air Pacific Ltd. as a First Officer (Co-pilot) on the Boeing 737 aircraft. He also occasionally instructed student pilots and conducted private pilots' flight test on light aircraft. Since December 1983 he acted as relief pilot for Sunflower Airlines when not on duty with Air Pacific Ltd. Until the date of the accident, he had flown for Sunflower Airlines on three separate periods and acquired a total of 104 hours, all on the Britten-Norman Islander. The last period of attachment to Sunflower Airlines commenced on 17 July 1984.

The subject flight on 13 August 1984 was his first flight of the day. He had not flown during the two preceeding days.

2.6 Aircraft Information

(a) Britten-Norman Islander BN-2A-9 Serial No.686
Total hours - 12034.85 No. of Landings - 31507

The aircraft was first registered in Fiji on 20 September 1973 with Fiji Air Ltd. It was purchased by Sunflower Airlines on 3 July 1981. The aircraft had a current Certificate of Airworthiness (No.65) in the Public Transport (Passenger) Category for operation under Performance Group C, valid until 19 September 1984. Maximum Total Weight Authorised - 2994 kg (6600 lbs).

(b) The aircraft also had a valid Certificate of Maintenance (No.44) in respect of the airframe and engines, following completion of Check 2 at 12024.56 hrs on 10 August 1984. The next check was due on 12 September 1984 or at 12074.56 hours.

(c) Engine Details

Starboard: AVCO Lycoming Type/Model 0-540 E4C5 S/N L19088-40
Installed in DQFCA on 14.7.1983 at 10717.28 hours.
Hours as at 13.8.1984 - Since new : 12035.25 hrs.
Since overhaul : 1291.52 hrs.

Port: AVCO Lycoming Type/Model 0-540-E4C5 S/N RL-17571-40
Remanufactured Zero-time Certificate issued on 12.6.82 by Lycoming. Fitted to DQFCA on 7.1.1984. Hours as at 13.8.1984 - Since new (remanufactured) : 715.34 hrs.

(d) Propellers

Starboard: Hartzell HC-C2YK-2CFU/FC 8477A-4 S/N AU-111
Overhauled 3.5.1982. Fitted to Starboard engine on 13.1.1984 at 10595.26 hrs.
Total hours to 13.8.1984 - 11236.46
Hours since overhaul - 640.23

Port — Hartzell HC-2CYK-2CUF/FC 8477A-4 S/N AU-6017
Fitted to port engine on 13.7.1984 with 5260.16 total hours since new and 1307.29 since overhaul.
Total hours to 13.8.1984 - 5377.35
Hours since overhaul - 1154.48

(e) Radio

Aircraft radio station licence No.2/81 issued 10.2.1981 and expired on 31.12.1981.

The aircraft does not appear to have a valid Certificate of Maintenance in respect of radios.

(f) Technical Log

On the date of the accident the Technical Log indicated that there were no outstanding defects. The record for the subject flight was unsigned and only contained information on the total number on board, the route and departure/arrival time. Technical Log for the preceeding few days was also unsigned and contained no additional information.

(g) Weight/Loading

A load sheet had been prepared for the flight and individual passenger weights recorded. The operating weight recorded was 2100 kg and the total weight of passengers was 294 kg and of baggage 51 kg. The centre of Gravity position was recorded as "WL" (within limits), however, no trim calculations were shown. The total take-off weight recorded was 2445 kg.

(h) Fuel

Prior to the flight,155 litres of fuel were uplifted. The load sheet indicated fuel on board as 30 kg (approx. 10 Imp Gals) in the two main tanks and 150 kg (approx. 50 Imp Gals) in the two outboard or wing-tip tanks. The pilot in command carried out a full pre-flight check,including a fuel check following refuelling,at Nadi International Airport prior to departure.

2.7 Meteorological Information

There is no official weather reporting station at Deuba, however, observations at the reporting station in Suva (15nm to the East North East) 0800 local time were :

Wind: Calm Visibility: 40 km clouds 2/8 at 2500ft 7/8 at 5000ft
Temperature 22°C Dew Point 18°C.

One witness on a walk along the beach at 0730 am that morning reported that she "was surprised to see the size of waves crashing on this usually quite area - the beach was practically non-existant". This would indicate the presence of some strong winds locally as the official forecast was for "little or no wind at the surface" due to a very weak pressure gradient and a ridge of high pressure extending onto Fiji from the South.

2.8 Aids to Navigation

There is no notified Instrument Approach Procedure established for Deuba Airport, however, a non-directional beacon is located some 4nm to the East which provides a fix for aircraft inbound to Nausori International Airport located 25nm to the North East. A descent procedure is promulgated for aircraft equipped with Distance Measuring Equipment and bound for Nausori Airport to commence descent from the non-directional beacon.

2.9 Communications

The aircraft was in normal communications with the appropriate air traffic control unit whilst enroute. The pilot in command requested and was issued an air traffic control clearance for flight under Instrument Flight Rules. The last communication from the aircraft was at 0754 local time when the pilot in command reported continuing the flight under Visual Flight Rules.

2.10 Airport Information

Deuba Airport is located on the South East side of Viti Levu approximately 15nm to the West South West of the capital city of Suva. The Airport is privately owned by Pacific Hotels and Developments Ltd. and serves the Pacific Harbour resort complex. The airport has a single gravel/grass runway orientated in a South East/North West direction and situated in a small valley. Hillocks up to 350ft in elevation lie on either side of the airport. The airport has a runway of 760 x 18 metres with 30 metre stopways at each end. The airport is licenced by the Authority for public use by aircraft with weights below 5700 kg. No services are provided at the airport. A small fire extinguisher is available for use by operators' staff if required.

2.11 Flight Recorders

The aircraft was not, nor was it required to be, equipped with cockpit or flight data recorders.

2.12 Wreckage and Impact Information

The aircraft touched down on a rough overgrown section of ground adjacent to and to the north of the main Suva/Nadi highway between the Pacific Harbour complex and Deuba Airport. Electrical power cables run along the South side of the road at a height of 40 feet above the surface. The section was straddled by a ditch some 10 metres from the point of initial contact with the ground. Passage across the ditch caused the port main undercarriage leg and nosewheel to collapse rearward. Due to inertia the aircraft continued forward for a further 40 metres on its port wing tip section and the fuselage. The marks on the ground and port propeller indicated that neither engine was turning at this time and neither propeller was feathered. The aircraft ultimately came to a stop on a heading of 030° in a rolled over position with the port wing-tip resting on the ground. The aircraft remained substantially intact.

2.13 Medical and Pathological Information

None. There were no injuries to the pilot or passengers.

2.14 Fire

There was no fire. A small amount of fuel spilled from ruptured lines.

2.15 Survival aspects

The accident was survivable. All restraints and seats operated satisfactorily. The pilot in command did not brief passengers or warn them of the impending forced landing. One of the passengers, however, yelled out a warning to the others just before the aircraft dipped down for the forced landing.

2.16 Tests and Research

Investigations immediately after the accident confirmed that the fuel crossfeed system allowing fuel to be fed to the engine on the other wing was closed. (See Paragraph 2.17 for fuel tank arrangement and operation). Investigations also confirmed that the tank selection switching system was functioning correctly and that at the time all electrical power was turned off, just prior to touchdown, the main tanks in each wing were selected to feed the engine on the same wing.
All fuel in the two main fuel tanks was **drained after the accident and produced slightly under 2 Imperial Gallons (approx 9 ltrs). Fuel samples were taken from the following positions in each engine and were found to be satisfactory.**

The gascolator

Auxiliary fuel pumps

Carburettor float chamber

Wing tank sump.

In addition, the fuel filters in both gascolators and auxiliary pumps were checked and were found to be free of any deposits or blockage. Fuel flow function checks from all tanks were also confirmed as satisfactory and no restrictions were evident.

Both engine carburettor heating systems were found to actuate correctly on each engine and the appropriate flap and lever movements were satisfactory.

These tests/checks indicate that neither the quality of the fuel on board the aircraft nor any defects in the fuel flow delivery systems were factors in the failure of the engines.

2.17 Additional Information

(a) Fuel System

The aircraft, DQFCA had modification MOD NB/M/364 embodied. Under this modification the wing span of the aircraft is increased from 49 to 53 feet and two additional fuel tanks (one in each wing tip) are installed. Each of these tanks has a capacity of 24.5 Imperial Gallons (111.7 ltrs). The associated fuel content indicators are fitted at the starboard side of the cabin. Approx. 1.5 Imperial Gallons (6.8 ltrs) of fuel in each tank is unusable. The capacity of each main tank is 51.5 Imperial Gallons. The unusable fuel in each of the main tanks is 2.9 Imperial Gallons (13 ltrs).

The fuel system is controlled by a set of fuel selectors on the overhead panel and an auxiliary control panel situated at the top of the windscreen central pillar. The fuel content indicators for the main tanks are also located in this position. Each engine can be served by fuel from either tank on the same wing, however, there is a cross-feed system whereby fuel may be fed from one side of the aircraft (either tank) to the engine on the other wing via main fuel cocks. Each tip tank or its associated main tank can be selected by the pilot with a two-way selection switch on the auxiliary panel. This positions an electrically actuated tip-tank cock. The actual position of this cock is indicated by green lights. The approximate time for the changeover after a selection is made is 8 seconds. The fuel system also includes several pumps. Four auxiliary pumps (in duplicated pairs) are installed in the system and assist in the flow of fuel from either the main or wing tip tanks and can be used to supplement the engine driven pumps. Fuel cannot be transferred from one tank to another.

(b) Fuel management and operating procedure

Structural limitations on this aircraft require that a minimum of 80 lbs (36 kg) of fuel (11 Imp Gals/51 ltrs) should be retained in each wing tip tank at all times. A yellow sector is marked on the tip tank contents guage to indicate this limit. During refuelling, wing tip tanks are required to be filled first before the main tanks. Either main or wing tip tanks may be used for take-off or landings except that the main tanks shall not be used during these phases of the flight when they contain less than three gallons of usable fuel. The fuel in the main tanks may be used first whilst in cruise until the tanks are empty. Between 40 and 50 seconds of warning of fuel exhaustion occurs by a drop off in fuel pressure followed by a gentle hunting of the propellers (engine surge). A placarded warning as below is displayed between the main fuel tanks content indicator.

> THIS IS A TIP-TANKED AIRCRAFT.
> TIP TANKS ARE TO BE FILLED FIRST -
> USED LAST. BEFORE TAKE-OFF CHECK
> BOTH MAIN AND TIP TANK CONTENTS.
> TAKE-OFFS AND LANDINGS ARE
> PROHIBITED ON MAIN TANKS WHEN GUAGE
> READS LESS THAN THREE GALLONS ABOVE
> ZERO.

The Company's Operations Manual reflects the above limitation as follows :

" 6.4.18. Fuel Management

Fuel is to be drawn from the mains only until only three gallons are left then tip tank selected. "

The Company's Operations Manual further requires pilots to adhere to the following procedure -

" Fuel boost pumps are 'on' for starting, taxying, take-off and landing or during loss of engine drive pump. "

" Take-off and landing will not be done on crossfeed unless an emergency exists. "

The Aircraft's Flight Manual states that :

" The Auxiliary fuel pumps should be used in the normal manner for take-off or landing with either the tip tanks or main tanks selected. In addition, the auxiliary fuel pumps should be used whenever below zero fuel quantities are indicated for the main fuel tanks and the process of transfer to the wing tip tanks is completed with satisfactory engine operation established. The pumps should also be selected when the fuel quantity falls below five gallons in the tip tanks. "

(c) Carburettor Heating System

The carburettor heat is applied by selecting the appropriate control lever in the cockpit. The levers, when selected, slot into a ratchet system of stops and any selection which may not be a positive one could result in the lever springing away from the maximum position. The end result, however, would not be of any great significance as overall variation between the adjacent ratchet teeth stops in relation to the heat flap position is very small.

2.18 New Investigative Techniques

None.

3. ANALYSIS

3.1 There were several persons on the ground in the vicinity of the airport who were witnesses to the manoeuvres by the aircraft during the final phase of the flight, however, none witnessed the actual forced landing. All witnesses confirmed that the engine function appeared to be erratic in that the sound faded and then suddenly increased several times. One expert witness reported that it sounded as though the engines were suffering from erratic fuel flow. Both engines failed within seconds of each other after a short period of rough running. This would indicate that there was a common reason for the failures.

3.2 The pilot in command had carried out the normal pre-flight check prior to departure, including the check for water in the fuel. The refuelling agents had also carried out their routine checks on the bowser prior to refuelling the aircraft.

3.3 Fuel samples taken from several points in the fuel system of the aircraft following the accident, were satisfactory. There were no blockages or deposits in the gascolators or fuel system.

3.4 The investigation immediately following the accident indicated that the crossfeed valve was not in operation. When battery power was applied both Tip Tank cocks actuated and changed to show a wing tip selection. This indicated that the main tank was selected, just before power was switched off, prior to the accident and that the tip tanks had been selected after power had been switched off.

3.5 Fuel drained from the two main tanks produced slightly less than 2 Imp Gals (9 ltrs). Fuel content indicators in respect of the two tip tanks showed that each tank was three-quarters full.

3.6 On departure from Nadi International Airport the fuel available in each main tank was approximately 4.1 Imp Gals. Unusable fuel in each tank was 2.9 Imp Gals leaving a balance of 1.2 Imp Gals of usable fuel. Under the limitations applicable, the main tank could not be used for take-off or landing. At the fuel consumption rate of 25 Imp Gals per hour this would have permitted the engines to run for approximately 3 minutes.

3.7 The pilot in command, in a written statement following the accident, stated that sometime after take-off from Nadi International Airport he changed from wing tip tanks to the main tanks with the intention of using up the fuel available in these tanks and reverting to the tip tanks for the landing. He recollects that the next tank change was made when the starboard engine started surging when near Deuba Airport. In his statement the pilot in command also stated that, when operating under Instrument Flight Rules, he normally selects the tanks to be used for the landing prior to commencing descent, in order to avoid a tank selection during the final stages of the IFR descent.

3.8 When the starboard engine began to surge, the pilot in command identified the cause as carburettor icing and advanced the throttles, actuated the fuel boost pumps and applied carburettor heat to both engines. Very shortly, thereafter, when the port engine commenced surging he noted that the carburettor heat control lever for that engine had sprung slightly up from the maximum and re-set it. A passenger on board observed the pilot flick the tank selection switch several times during the last minutes of the flight. However, as insufficient time was given for the electrically operated fuel cock to complete the change, the selections were ineffective.

4. CONCLUSIONS

4.1 Findings

(1) The pilot was properly licenced, rated and qualified.

(2) The aircraft was properly certified and maintained except that the necessary documents showing the validity of the radio station licence and the Certificate of Maintenance in respect of the radio equipment on board could not be ascertained.

(3) The aircraft's Technical Log showed no outstanding defects.

(4) The weight of the aircraft was within approved limits.

(5) The aircraft had sufficient fuel on board for the intended flight.

(6) The quality of fuel was satisfactory and the aircraft's fuel delivery systems were serviceable.

(7) The pilot in command did not brief or warn passengers of the impending forced landing.

(8) Both engines failed within a short space of time whilst they were connected to separate tanks.

(9) The carburettor heating systems for both engines were fully serviceable.

(10) Both engines were connected to their respective main tanks which contained only a small quantity of unusable fuel.

(11) The double engine failure occurred at a low altitude leaving insufficient time for the pilot to take corrective action prior to being committed to a forced landing.

4.2 Cause

The accident occurred because of the Commander's mismanagement of the aircraft fuel system in that both engines failed through fuel starvation, with ample fuel remaining in the tip tanks, whilst the aircraft was at a low altitude. Some degree of carburettor icing may have been a contributory factor in the failure to identify the cause of engine failure and take timely corrective action.

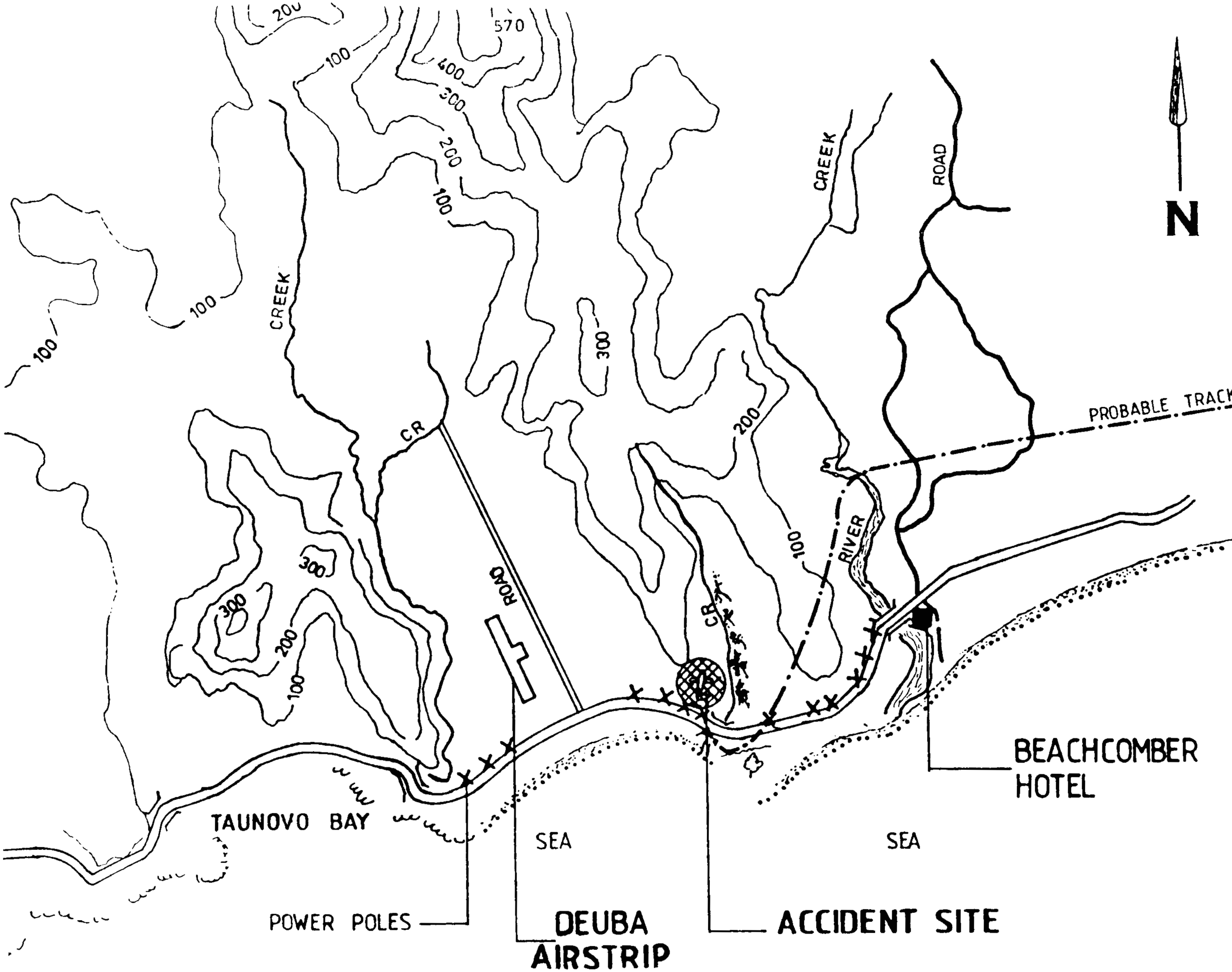
5. SAFETY RECOMMENDATION

5.1 Consideration be given to requiring aircraft to have the means, separate from the fuel gauge systems, of automatically alerting the crew when the contents of any tank capable of directly feeding an engine reaches a pre-determined low level.

5.2 Emphasis should be made on pilots, especially when operating a single pilot aircraft, to carry out checks as and when required in accordance with the check list in use in the aircraft and as per the Company's Flight Manual.

ICAO Note: Minor editorial changes were made.

ICAO Ref.: 371/84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AIRSTRIP
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No. 6

de Havilland of Canada DHC-6-100, C-FPPL
at Fort Franklin, Northwest Territories, Canada,
on 9 October 1984.
Report No. 84-H40004 released by the
Canadian Aviation Safety Board

1. SYNOPSIS

The aircraft was flying between Fort Norman and Fort Franklin, Northwest Territories on a specific point service carrying passengers and freight. While on approach in visibility reduced in fog, the aircraft struck a telecommunications tower. A portion of the right wing separated, and the aircraft slowly rolled over before striking the ground. All seven occupants sustained fatal injuries.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 9 October 1984, Nahanni Air Services Flight 97, a DHC-6 Twin Otter, C-FPPL, departed Norman Wells, N.W.T. at 1608 mountain daylight time* (MDT). The aircraft was on a specific point visual flight rules (VFR) flight to Fort Franklin, N.W.T. with an en-route stop in Fort Norman, N.W.T. On board were the pilot, seven passengers, and freight.

After take-off from Norman Wells, the aircraft followed the McKenzie River to Fort Norman, where one passenger deplaned and freight was unloaded. It was reported that while en-route to Fort Norman, the pilot had to descend very low over the river to maintain visual flight conditions. The aircraft departed Fort Norman at 1651 and arrived overhead Fort Franklin at approximately 1715. The aircraft was heard but not seen, as Fort Franklin was shrouded in fog. A local resident of Fort Franklin heard the aircraft and contacted the pilot on a portable very high frequency (VHF) transceiver in his home and advised him that there was little or no visibility. The pilot replied that he did not think he would be able to land.

* All times are MDT (Greenwich mean time (GMT) minus 6 hours) unless otherwise stated.

The aircraft then proceeded out of hearing range but returned overhead at least once and was then heard to proceed to the southeast. The resident with the radio had by this time driven to the airstrip, and when he heard the aircraft returning, advised the pilot that visibility was 200-300 feet***. The pilot then queried whether the report referred to vertical or horizontal visibility. Before a reply could be made, the aircraft was heard to strike a 200-foot-high communications tower located on the eastern edge of the hamlet. Following the sound of the collision, ground witnesses observed the aircraft emerge from the fog and slowly roll over as it descended steeply to the ground between two rows of houses on the north edge of the hamlet. All seven people on board received fatal injuries.

The crash site was located at lat 65°11'00"N, long 123°25'00" W at an elevation of 576 feet above sea level (asl). The accident occurred at approximately 1730 during the hours of daylight.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	6	-	7
Serious	-	-	-	-
Minor/None	-	-	-	-
Total	1	6	-	7

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

The aircraft struck the communications tower 12 feet from the top, 188 feet above ground level (agl), just above the attachment points of the uppermost guy wires. The top portion of the tower sustained considerable damage but remained attached to the main tower structure. Some of the tower's guy wires were loosened. A wooden sidewalk and a power line were broken when the aircraft struck the ground.

1.5 Personnel Information

Age	48
Pilot Licence	Airline Transport
Medical Expiry Date	1 March 1985
Total Flying Time	13,911 hr
Total on Type	8,766 hr
Total Last 90 Days	100 hr
Total on Type Last 90 Days	100 hr
Hours on Duty Prior to Occurrence	9.5 hr
Hours off Duty Prior to Work Period	15 hr

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

The pilot was qualified and held a valid licence. He had complied with all mandatory checks. His last pilot proficiency check was successfully completed on 17 June 1984.

The pilot had been employed by Nahanni Air Services since 28 September 1984. Upon his arrival, all company training requirements were satisfactorily completed under the direction of the chief pilot. Included in the training was a route check flown on 1 October 1984, which included a stop in Fort Franklin. On that trip, the chief pilot did point out the location of the communications tower in the village. Between 2 October 1984 and the day of the accident, the pilot completed seven flights into Fort Franklin.

Prior to his employment with Nahanni Air Services, the pilot had been employed by another northern Twin Otter operator for a period of twelve years. During this previous employment, he had earned a reputation as an excellent pilot and was acknowledged as an expert on the Twin Otter. Much of his flying had involved operations into remote unprepared airstrips in the high Arctic.

Prior to March 1984, he had not experienced any known accidents or incidents in the Twin Otter. However, on 6 March 1984 while landing a Twin Otter on rough ice at Ward Hunt Island, N.W.T., the nose ski struck the ice heavily, damaging the bulkhead to which the nose landing gear is attached. This incident was followed by another on 13 April 1984 in which similar damage occurred while taking off from an unprepared Arctic ice strip near the geographic North Pole.

On 25 July 1984, a third incident occurred while the pilot was attempting to land on an unprepared surface on Somerset Island, N.W.T. He reportedly overshot his intended touchdown point by 1,000 feet and landed on rough terrain damaging the main landing gear, aircraft tail, and the nose gear assembly.

As a result of these incidents, company management began to question the pilot's ability to make operational decisions. At the same time, the pilot requested that company management reassign him to another base of operation. Subsequently, the pilot was reassigned to flying duties in Inuvik, N.W.T., where, in the opinion of company management, the type of flying was less demanding.

On 18 August 1984, the pilot was the captain of a Twin Otter which was ditched in the Beaufort Sea when both engines failed. An investigation by the Canadian Aviation Safety Board determined that the engines failed as a result of water contamination of the fuel. The aircraft had been refuelled from barrels the previous evening by the pilot and his co-pilot. During the refuelling procedure no filter capable of trapping water was used, nor was the fuel tested for water. An extension had been added to the stand-pipe refuelling pump which allowed the barrel to be completely drained, thereby pumping any water which had settled in the bottom of the fuel barrels into the aircraft fuel tanks. Following refuelling, the aircraft fuel tanks were not sampled for water contamination.

Following this accident, company management asked the pilot for his resignation. In their opinion, his ability to make operational decisions was in question, and the safety of their operations would have been jeopardized if the pilot continued in their employ. His employment with the company was terminated on 31 August 1984.

The chief pilot of Nahanni Air Services hired the pilot based on knowledge gained as his supervisor when they flew together for another company. At the time the pilot was hired, the chief pilot was aware of the pilot's accident and incident history. He felt the pilot demonstrated a high degree of airmanship in his ditching accident of August 1984. It was further reported that no outward changes were observed in the pilot's behavior or work performance. The pilot's previous employer was not contacted for information.

1.6 Aircraft Information

Manufacturer	de Havilland of Canada Ltd.
Type	DHC-6-100
Year of Manufacture	1968
Serial Number	115
Certificate of Airworthiness	19 September 1984
Total Airframe Time	23,645 hr
Engine Type (2)	Pratt and Whitney of Canada PT6-20
Propeller Type (2)	Hartzell HCB-3TN-3BY
Maximum Allowable Take-off Weight	11,579 lb
Recommended Fuel Type	Jet B

Prior to July 1984, the Twin Otter aircraft had operated under United States of America registry. In July 1984, it was imported into Canada where an inspection, test, repair as necessary (ITRAN) procedure and other checks were performed. At this time compliance with all airworthiness directives was checked.

Nahanni Air Services took delivery of the aircraft on 18 September 1984 and placed it into service at the company's Norman Wells base. Prior to the accident, there were no known or recorded unserviceabilities on the aircraft. The weight and centre of gravity were within the prescribed limits. The aircraft was fueled with Jet B aviation fuel.

1.7 Meteorological Information

1.7.1 General

On 9 October 1984, at 1200 an Arctic front was located about 50 miles south of Norman Wells and was extending eastward toward Great Bear Lake. Upper air soundings indicated a strong low-level inversion with the air saturated from the surface to 1,600 feet agl. The overall effect of this situation was to blanket the area with low stratus cloud based at 400 feet agl and topped at 2,000 feet agl.

1.7.2 Forecasts

The area forecast for the Simpson, Great Slave, and Norman regions issued at 1130, valid for the period 1200 to 2400, indicated extensive stratus clouds north of the front with bases 400 to 1,000 feet agl and tops at 1,500 to 2,000 feet agl. Visibility was forecast to be two to five miles in light snow and fog, with conditions as low as one mile in a mixture of freezing drizzle, light snow, and fog.

The terminal forecast for Norman Wells, issued at 1030, indicated ceilings of 600 feet agl and a visibility of three miles in fog after 1500. A later forecast, issued at 1630, predicted ceilings frequently as low as 200 feet agl with visibility reduced to two miles in light snow and fog, and a risk of freezing rain.

1.7.3 Actual Weather

The actual weather in Norman Wells was generally as forecast. Throughout the day, a low overcast layer of stratus ceilings persisted, with visibility reduced in freezing drizzle, light snow, and fog. Later in the day, a gradual increase in visibility occurred, although the low ceiling persisted.

The hourly observations from Norman Wells taken at 1000 and 1600 are as follow:

1000 Sky partially obscured, ceiling (measured by balloon) 400 ft overcast, visibility 1½ sm in light freezing drizzle, light snow and fog, barometric pressure 999.6 mb, temp -2°C, dew point -3°C, winds calm, altimeter setting 29.50 in, fog 5 tenths stratus 5 tenths.
Remarks: Rime on indicator, balloon visible to 600 ft agl.

1600 Ceiling (measured by balloon) 500 ft overcast, visibility 10 sm, barometric pressure 999.9 mb, temperature -2°C, dew point -2°C, winds calm, altimeter setting 29.51 in, stratus 10 tenths,
Remarks: Visibility reduced due to low cloud.

In Fort Norman, the weather was generally the same as that reported in Norman Wells. An overcast stratus ceiling was present at about 600 feet agl, and the visibility varied between one mile and eight miles in ice crystals, light snow, and fog.

The hourly observations from Fort Norman taken by the Community Air Radio Station (CARS) operator at 1000 and 1600 are as follows:

1000 Ceiling (measured by balloon) 900 ft overcast, visibility 8 sm in ice crystals, temperature -4°C, dewpoint -5°C, winds calm, altimeter setting 29.44 in, stratus 10 tenths.

1600 Ceiling (measured by balloon) 600 ft overcast, visibility 8 sm, temperature -1°C, dew point -1°C, winds calm, altimeter setting 29.47 in, stratus 10 tenths.

No official weather reports are available from Fort Franklin as there is no accredited weather observer in the community. At the time of the accident, witnesses reported that the community was shrouded in fog. Horizontal visibility estimates ranged from 50 to 400 feet. It was reported that although the top of the communications tower (200 feet agl) was not visible, the middle obstruction light (95 feet agl) could be seen. This weather persisted throughout the day.

1.7.4 Pilot Reports

During the day, the Nahanni Air Services office in Norman Wells received several pilot reports (PIREPs) of weather conditions from company pilots operating in the area. One pilot, who took off from Norman Wells at 1143 en-route to Fort Simpson, reported that he was turning back because of poor weather encountered south of Fort Norman. Later in the day and prior to the departure of Flight 97, the office received two reports indicating clear conditions across the river to the south of Norman Wells.

During Flight 97's station stop at Fort Norman, the pilot was approached by another pilot who had just returned to Fort Norman after an unsuccessful attempt to reach Fort Franklin. He reported that he had turned back 10 miles northeast of Fort Norman when he encountered clouds down to the tree tops and near zero visibility.

At 1653 on departure from Fort Norman, the pilot of Flight 97 reported to the Fort Norman CARS operator that the cloud ceiling was 400 feet agl decreasing to 200 feet agl to the northeast.

About one hour and twenty minutes after the accident, an aircraft overflew the Fort Franklin area at high altitude, en-route to Norman Wells. The pilot reported that the Great Bear Lake area was covered with a solid fog layer that closely followed the outline of the lake. The McKenzie valley and Great Bear River valley were also filled with low cloud and fog. High points of ground were sticking up through this layer. On descent into Norman Wells, the top of cloud was 2,100 feet asl.

1.7.5 Weather Information Available to the Pilot

The area and terminal forecasts were available to the pilot and company office through the Norman Wells Flight Service Station (FSS). Similarly, the hourly observations from Norman Wells and Fort Norman were available. The pilot had been in contact with the FSS on several occasions during the day. The general weather conditions existing at Fort Franklin were passed to the Nahanni Air Services Norman Wells office by the company agent in Fort Franklin via telex and telephone.

During the morning, the agent telexed the company in Norman Wells that Fort Franklin was foggy. Early in the afternoon, a subsequent telex advised that Fort Franklin was still fogged in, with little chance for improvement as there was no wind. The pilot was also aware of this information.

The agent provided further information by telephone later in the afternoon that Fort Franklin was still foggy. No contact between Fort Franklin and Norman Wells occurred after approximately 1450. Also available and known to the pilot were the PIREPs reported to the company office.

In addition to the information available prior to departure, further information was available to the pilot from the pilot with whom he spoke in Fort Norman and via the portable VHF radio from the resident on the ground in Fort Franklin.

During the station stop at Fort Norman, the Fort Franklin agent contacted the agent in Fort Norman. He advised that Fort Franklin was still fogged in. This information was apparently not passed to the pilot.

1.8 Aids to Navigation

A non-directional beacon (NDB) is located approximately one-half mile south of the threshold of runway 24. It transmits on a frequency of 287 kilohertz (kHz) and has an identification signal of WJ. The Norman Wells FSS monitors the beacon. Following the accident the FSS operator checked the Fort Franklin NDB's identification and power source. Both were operating normally.

1.9 Communications

There was no official air-ground communications facility available at Fort Franklin. Nahanni Air Services had a company radio located in their agent's home but it was not in use. The radio and a dual altimeter unit had been installed in anticipation of obtaining authorization for a new instrument approach procedure into Fort Franklin based on the local altimeter setting. This approval was never obtained and the agent was not trained or qualified to use the equipment.

A local resident of Fort Franklin was in possession of a portable VHF transceiver. It had been purchased for the purpose of assisting the pilot of a Fort Franklin-based aircraft. On several occasions, this resident had contacted Nahanni Air Service pilots, but only for radio check purposes. It was this radio that was used to contact the pilot of Flight 97 prior to the accident.

1.10 Aerodrome Information

The Fort Franklin Aerodrome is located on the shore of Great Bear Lake about one-half mile north of the Hamlet of Fort Franklin. The aerodrome reference elevation is 576 feet asl. The gravel surface runway is 2,500 feet long by 80 feet wide and has low intensity runway edge lights. The runway orientation is 060 degrees/240 degrees magnetic (M).

The aerodrome is owned by the Government of the Northwest Territories (GNWT) who contract the Hamlet of Fort Franklin to perform routine maintenance. The aerodrome, which was constructed in 1970, is unlicensed.

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

The right wing separated from the aircraft at a point 15 feet inboard from the wing tip. The severed wing was found approximately 140 feet south of the base of the tower, left of the aircraft's ground track. The wing section had been sliced through perpendicular to the main spar.

A section of the right flap had separated from the wing and was found 50 feet west of the base of the tower, along the aircraft's ground track. The right flap was damaged considerably as a result of the impact with the tower. Both the forward and aft portions of the inboard flap section sustained direct impact damage in the collision. The leading edge of the forward inboard section was pushed toward its trailing edge, and the aft inboard section had partially folded about the tower.

After the collision with the tower, the aircraft, minus the severed portion of the right wing, continued in the direction of the village. Initial contact with the ground occurred about 885 feet from the base of the tower. The ground track of the final portion of the flight was about 265 degrees M.

The aircraft struck the ground in an inverted attitude at a descent angle of approximately 50 degrees, between a row of houses on the north edge of the village. Following the initial ground impact, the aircraft bounced and slid a distance of about 50 feet. Impact forces tore off both engines, the tail section, and the stub of the right wing. The left wing remained attached to the fuselage by the control cables.

Portions of the aircraft were scattered over an approximate 400-by-100-foot area. Aviation jet fuel soaked a considerable area of ground within the wreckage scatter area. The total length of the wreckage trail was 1,245 feet.

All aircraft control surfaces were accounted for. No structural failures were found beyond those attributable to the collision with the tower and the subsequent ground impact.

1.13 Medical Information

1.13.1 Physiological Information

The pilot's most recent aviation medical examination was performed 13 days before the accident. He was assessed fit to Transport Canada Category I standards.

Post-mortem examination and toxicological testing did not reveal any evidence of pre-impact injury, physical or physiological problems, or incapacitation.

1.13.2 Psychological Information

The pilot was described as a quiet, careful, and conservative individual with his life centred around his work and his family. There was no prior history of mental or emotional disturbance. He was not outwardly expressive of his feelings so it was difficult to discern his reaction to recent events in his life.

1.14 Fire

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

1.15 Survival Aspects

The aircraft struck the ground in an inverted attitude at a descent angle of about 50 degrees. Applied "G" forces exceeded human tolerances and the cockpit/cabin structure was almost totally destroyed. The injuries sustained by all occupants were multiple and were severe enough to cause immediate death.

Examination of the wreckage determined that all but the two rearmost seats failed at the attachment points. As well, four seat-belts had failed.

1.16 Tests and Research

1.16.1 Aircraft Engines

Both engines were recovered, identified, and forwarded to the Board's Safety Engineering Branch for detailed examination. No pre-impact failures were identified with either engine. The condition of the rotating components of both engines indicated that there were high levels of rotational energy at the time of impact.

1.16.2 Aircraft Propellers

Both propellers were recovered, identified, and forwarded to the Board's Safety Engineering Branch for detailed examination. Propeller blade pitch angles at the time of impact were not positively determined but were assessed as being in the normal operating range at relatively fine pitch.

1.16.3 Flap Selector

The engine and flap control quadrant was recovered and forwarded to the Board's Safety Engineering Branch for detailed examination. The examination determined that the flap selector was in the flaps-down (37½-degree) position at impact.

1.16.4 Flight and Engine Instruments

The flight instruments were severely damaged; a number of instruments had broken out of their mounts and were found along the wreckage trail. The engine instrumentation was also damaged but not to the same extent. Both instrument panels were shipped to the Board's Safety Engineering Branch for further investigation.

An examination did not reveal any evidence of pre-impact unserviceability of any of the aircraft flight or engine instruments. Impact readings were determined as follows:

a) left and right torque pressure gauges - 39 psi;
b) left propeller rpm - 77% rpm minimum
c) right engine gas generator rpm - 65% to 100% rpm
d) left oil pressure - 68 psi minimum
e) aft fuel quantity - 990 lb
f) altimeter (unidentified position) barometric pressure scale - 29.42 in
g) altimeter (unidentified position) barometric pressure scale - 29.43 in
h) moveable altitude alert pointer of a radar altimeter - 190 ft.

1.16.5 Rotating Beacon

The rotating beacon was recovered from the wreckage and forwarded to the Board's Safety Engineering Branch for detailed examination. Both bulbs within the beacon exhibited severe filament stretch indicative of bulb illumination at impact.

1.16.6 United States National Transportation Safety Board Special Study: Air Taxi Safety in Alaska

In September 1980, the United States National Transportation Safety Board (NTSB) issued a Special Study report entitled Air Taxi Safety in Alaska. (Report # NTSB-AAS-80-3). The report detailed the results of an NTSB study of air taxi accidents which occurred in Alaska from 1974 to 1978.

Among the report's conclusions were the following:

a) The State of Alaska is heavily dependent on its air taxi industry to transport food, medicine, mail and many other necessities of life to isolated villages;

b) Air taxi flying in Alaska is unique because of a number of factors such as whiteouts, very rapid changes in weather, a scarcity of navaids that cause most air taxi operations to be made under visual flight rules, ...; and

c) Inadequate weather observations and inadequate communication of weather observations was probably one of the factors which contributed most to the high air taxi accident rate in Alaska.

The study also identifed the "bush pilot syndrome" as a factor which probably contributed to the high accident rate in Alaska. This syndrome was described as an attitude on the part of Alaskan operators, pilots and passengers that ranges from a casual acceptance of risks to a willingness to take unwarranted risks. The study further stated that although the syndrome exists it cannot be unequivocally demonstrated by statistical data.

1.16.7 Human Factors in Aviation

In the analysis of human factors in aviation, the scientific method is applied in collecting knowledge and basing conclusions as much as possible in objectivity. Human factors knowledge is based where possible on biochemistry, toxicology, pathology, human engineering, and all fields of clinical medicine. Although scientific certainty is not always possible in dealing with mental and emotional processes, a body of clinical knowledge exists nonetheless which is described in various research papers and journals.

1.16.7.1 Accident Susceptibility

It has been observed in many industrial fields besides aviation that some individuals have more accidents than can be attributed merely to chance. However, the delineation of an "accident-prone personality" or chronic constitutional predisposition to accidents as such has not to date been successful. More recently, results of personality testing for more subtle features of personality and accident tendencies have been inconclusive and at times contradictory.

Avoidance of accidents depends on a number of complex psychological and physiological processes. Along with the more obvious influences of fatigue and alcohol, it has been found that emotions have a similar detrimental effect. Tension, anger, preoccupation with worries, and even elation can interfere with both alertness and the capacity to deal with potentially hazardous situations.

The present state of knowledge is that accident "proneness" is an acquired susceptibility dependent upon transient social, emotional, and psychophysiological stresses. Rather than a chronic life-long personality trait, accident susceptibility may be the result of acute situational factors that precipitate risk-taking behaviour during certain times of life. Additionally, certain personality characteristics render individuals less able to cope with stress and the combination makes them even more accident prone.

1.16.7.2 Stress

The term stress has a multitude of meanings varying with the nature of many disciplines, from psychiatry to engineering. In human factors research, it can be defined as a mentally or emotionally disruptive influence or change in balance.

There exist many stresses in aviation, including the physiological (fatigue from vibration and turbulence, noise) and psychological (inexperience, competence, uncertainty). The pilot develops specific adaptive mechanisms which allow him to arrive at a personal equilibrium with these inherent stresses, with such success that most pilots would not even consider their normal flying activities as stressful. Once an adaptive equilibrium is reached, a stressful event, whether perceived as undesirable or desirable, becomes one which requires the individual to undergo change, and the stress itself is the psychophysiological process of readaptation.

Too much stress in too short a time is associated not only with the onset of illness, both physical and mental, but sometimes with accidents. Personality characteristics, life changes, and more severe forms of emotional stress do not by themselves cause accidents. "High potential" for an accident is transformed into the reality of an accident through some act of commission or omission. These acts can be considered under headings such as: inattention, poor judgement, or misperception.

1.17 Other Information

1.17.1 Pilot's Notebook

A notebook located in the wreckage contained details of the aircraft's departure and arrival times at Norman Wells and Fort Franklin for the day of the accident. Located on the same page was the sketch reproduced in Appendix B.

This sketch identifies the inbound and outbound tracks and procedure turn altitude of the approved company instrument approach to Fort Franklin. The remaining figure of 850 is not associated with the approach procedure. In the sketch, this figure is located in the position where the minimum descent altitude for the approach is normally found. The correct minimum descent altitude for the approach is 1,350 feet asl (830 feet agl).

No other approach chart was located in the wreckage except the one contained in the company operations manual which was in the pilot's briefcase.

1.17.2 Radar Altimeter Procedures

The radar altimeter is an instrument which measures and displays the vertical distance between the aircraft and the terrain immediately below it. The particular radar altimeter installed in the accident aircraft incorporated a cockpit display which included a moveable alert pointer that could be set to a specific height above terrain. When the aircraft's height above terrain was at or less than the set height, a light illuminated on the instrument display as a reminder to the pilot.

The use of the radar altimeter as an approach aid in poor weather is common in Arctic flight operations. In remote locations where published instrument approach procedures are scarce, the radar altimeter is used to ensure adequate terrain clearance when attempting to acquire visual reference with the landing area. In areas of flat terrain, it is not uncommon for pilots to descend to a radar altimeter indication of 200 feet once the aircraft's position has been established with reference to a ground-based navigational aid. When conducting this type of procedure, the pilot normally sets the moveable alert pointer of the radar altimeter to the altitude to which he plans to descend.

1.17.3 Communications Tower

The communications tower that the aircraft struck was owned and operated by Northwestel Inc., Whitehorse, Yukon Territories.

The tower was constructed in 1965, prior to the construction of the Fort Franklin Aerodrome. It is located approximately 2,800 feet southeast of the threshold of runway 24 and 325 feet southeast of the "WJ" NDB. This location was selected because it provided easy access to the community and was acceptable for transmission requirements.

The tower, which is a three-leg Leblanc and Royle series 20, is 200 feet in height. It has six guy levels with the outer anchor positions located approximately 150 feet from the base. The tower was marked in accordance with the Transport Canada "Standards for Obstruction Markings" manual.

1.17.4 Flight Authorization and Dispatch

1.17.4.1 General

Flight 97 was operating under VFR in accordance with Operating Certificate Number 5272, which authorizes operations into Norman Wells, Fort Franklin, Fort Good Hope, Fort Norman, Inuvik, and Colville Lake N.W.T. Amendment No. 1 to this certificate authorized the route Norman Wells-Fort Franklin under instrument flight rules (IFR) conditions and authorized the use of an approved company instrument approach procedure at Fort Franklin. A revision to Amendment No. 1, which was awaiting incorporation into the Company Operations Manual, authorized the use of the Transport Canada, Western Region, "Inventory of Company Approved Routes and Instrument Approach Procedures", subject to certain conditions.

The use of these approved instrument approach procedures for Fort Franklin is predicated on obtaining the current altimeter setting from Ford Bay, N.W.T. which is only available for a short time during the summer. Further, single pilot IFR was not authorized in the Nahanni Air Services Twin Otter. Neither of the amendments authorized IFR flight between Fort Norman and Fort Franklin.

Nahanni Air Services operates the specific point service between Norman Wells, Fort Norman, and Fort Franklin on a scheduled basis. On weekdays, a morning flight is scheduled to depart at 1000 and an afternoon flight, Flight 97, is scheduled for departure at 1530.

The dispatch and loading of scheduled flights is accomplished at the Nahanni Air Services airport office which is located five miles from their company headquarters.

Nahanni Air Services operates a pilot self-dispatch system in conjunction with a booking coordinator. Under this system, the pilot has the sole authority to make decisions as to the initiation, continuation, delay, diversion or re-routing of the flight when conditions are such that operational decisions are necessary. Pilot self-dispatch systems are common among smaller air carriers and meet Transport Canada requirements.

Although the company operations manual requires that all commercial flights be authorized by the operations manager or his agent prior to commencement, no formal authorization of specific flights occurs. The operations manager does not take an active part in the day-to-day dispatch of flights. The decision as to whether a particular flight is dispatched rests solely with the pilot. No specific company criteria exist which refer to these dispatch decisions.

Similarly, the company operations manual requires that all revenue flights be authorized by the operations manager, dispatcher or chief pilot. This authorization may be delegated to the pilot-in-command. Specific criteria for this delegation, or how it is to be accomplished, are not identified. With the exception of the flight manifest and load sheet, which is signed only by the pilot, no other documentation exists which records the authorization and dispatch of scheduled flights.

1.17.4.2 Dispatch of Flight 97

The pilot was assigned to fly both scheduled flights to Fort Franklin on the day of the accident. The morning flight was initially delayed and then cancelled by the pilot because of the weather. The ceiling and visibility at Norman Wells did not permit VFR flight until after 1100. At that time the weather improved sufficiently to allow ATC to authorize Special VFR flight within the Norman Wells control zone. After cancelling the morning flight, the pilot remained in the vicinity of the company offices until the departure of Flight 97.

As with the morning flight, the departure of Flight 97 was delayed because of weather. The pilot initially advised the passengers that the flight would be cancelled; however, before the passengers left the terminal, he indicated that the flight would depart.

The chief pilot was aware of the pilot's decision to commence the flight. He had spent most of the day at the company's airport office and had discussed the weather with the pilot. His interpretation of the weather was that there was a possibility that the flight could get into Fort Franklin due to local weather variations. Both the chief pilot and the pilot of Flight 97 were aware of the weather information available from the FSS. Neither the chief pilot, the dispatcher, nor the operations manager advised the pilot of Flight 97 whether the flight should depart or be cancelled.

1.17.5 Aircraft Movements vs. Weather

As part of this investigation recorded aircraft movements generally at the Fort Norman aerodrome were studied in conjunction with the reported weather for Fort Norman during the same period. Fort Norman was chosen because of its proximity to Fort Franklin, its status as a VFR aerodrome only (i.e. no instrument approach procedure), and because aircraft movements and weather are recorded by the CARS. A thirty-day period commencing 9 October 1984 was selected for study.

During the study period investigators observed that it was not uncommon for aircraft to be landing or taking-off with reported ceilings of 600 feet and visibilities as low as three-quarters of a mile.

1.17.6 Human Factors Training

Human factors is a subject which does not enjoy wide acceptance in the aviation industry in Canada. Although significant gains have been made in the application of human factors knowledge in military and large air carrier flight operations, this is not the case with general aviation and smaller air carriers, nor is human factors training a Transport Canada requirement.

Aeromedical training and an awareness of human factors is not a requirement for the issue of a pilot's licence, nor is it required of company management. This lack of training and awareness was evident in testimony given at the Board's public inquiry into this accident. The importance of aeromedical training was recognized by Justice Dubin in his Report of the Commission of Inquiry on Aviation Safety. It was his recommendation that this subject be included in the training syllabus of all pilots.

1.17.7 Canada Flight Supplement

One of the aeronautical publications issued by Transport Canada is the Canada Flight Supplement (CFS). Its primary purpose is to provide pilots with aerodrome information. Each aerodrome entry in the CFS includes data on the aerodrome operator, navigation, communication, and public facilities; in addition, it usually includes a diagram of the aerodrome and its immediate surroundings.

The Fort Franklin Aerodrome listing in the CFS includes an aerodrome diagram. At the time of the accident, the aerodrome diagram did not contain any reference to the 200-foot-high telecommunications tower which the aircraft struck.

Transport Canada criteria establish the minimum information required before an aerodrome can be listed in the CFS. However, no specific criteria exist which refer to the depiction of obstructions on aerodrome diagrams. According to established guidelines, "significant" obstructions should be shown on aerodrome diagrams; however, no criteria exist to establish the meaning of "significant". The determination of what constitutes a significant obstruction is a judgement decision of Transport Canada aerodrome inspection personnel. Obstructions, which under VFR weather conditions are considered a hazard to navigation, are identified as significant and shown on the aerodrome diagram.

A review of other aerodrome diagrams in the CFS found numerous cases where obstructions below 200 feet agl were shown. In some instances obstacles less than 30 feet in height were depicted.

Included in the aerodrome diagram is an obstacle clearance circle. It is a guide for pilots operating under VFR within proximity to aerodromes. The circle is divided into quadrants and indicates for each quadrant the height above sea level of the highest obstacle plus 1,000 feet.

1.17.8 Company Instrument Approach Procedures

Transport Canada employs a process whereby commercial air carriers may be authorized to use specific IFR routes and instrument approach procedures other than those published and on instrument navigation charts in the Canada Air Pilot. Prior to 1983, this authority was granted on an individual route and approach procedure basis. Amendment No. 1 to the Nahanni Air Services operating certificate which authorized the route Norman Wells/Fort Franklin under IFR conditions and the use of the company instrument approach procedure at Fort Franklin is an example of a specific approval of this type.

By 1983, the administration of this process became difficult due to the volume of individual requests. As a result, in October 1983, the approved routes and approach procedures which existed in a specific Transport Canada region were incorporated into a Route Manual. Carriers could then request authority to use the routes and approach procedures contained in the Route Manual. Each Transport Canada region produces such a manual. These manuals are updated and amended on a 56-day cycle. The revised Amendment No. 1 to the Nahanni Air Services Operating certificate, which authorized the use of the Transport Canada, Western Region, "Inventory of Company Approved Routes and Instrument Approach Procedures", reflected this change in the authorization of company routes and instrument approval procedures.

During the course of this investigation, the Fort Franklin instrument approach procedure found in the Western Region Route Manual was examined. The following observations with respect to the presentation of the procedure were made:

a) no aerodrome diagram was provided;

b) the inbound track indicated on the profile view differed by 30 degrees from the one presented in the plan view;

c) the plan view incorrectly depicted the location of the NDB near the threshold of the runway;

d) the plan view incorrectly depicted the final approach track as crossing the threshold of the runway;

e) there was no information regarding the 200-foot-high obstruction which was located about one-half mile from the runway and on the final approach track; and

f) there was no information regarding the runway orientation or its distance from the approach aid.

Other approach procedures in the manual contained numerous inconsistencies in the quantity of information provided, the method of presentation, and the overall quality of the presentation.

No specific Transport Canada standards exist for the depiction and presentation of company instrument approach procedures; in general, the format used in the Canada Air Pilot is followed. Guidelines for the Canada Air Pilot are contained in an undated draft document entitled "Proposed Specifications for Canada Air Pilot."

Transport Canada officials acknowledged that inconsistencies and variations from the guideline document were present in the Western Region Route Manual. They reported that efforts were being made to standardize the presentation of the approach procedures in the manual.

With respect to the Fort Franklin approach procedure, the 30-degree difference in final approach track was described by Transport Canada officials as an undetected typographical error. The absence of an aerodrome diagram was described as an unexplained omission. The erroneous location of the NDB with respect to the runway which resulted in the incorrect depiction of the final approach track was also unexplained. The absence of information regarding the telecommunications tower and runway was in accordance with the established guidelines.

1.17.9 Arctic Air Facilities Policy

In 1974, the federal government adopted a policy to accelerate the establishment of an air transportation infrastructure in the Arctic. This Arctic Air Facilities Policy (AAFP) recognized that the existing transportation infrastructure in the Yukon and Northwest Territories was inadequate to provide the minimum transportation services required to achieve the government's social and economic objectives. Levels of service were the prime considerations in the development of this policy. Inherent in the development of the policy was the recognition that given the vast distances between communities, the severe climate, and the difficult terrain, air transport was the only practical mode for providing the required transportation services.

The AAFP classified Arctic communities according to population, community role, air services route structure, and the availability of other means of transportation. Minimum standards for facilities and services were established for these classes of communities. Under the terms of the policy, Fort Franklin was identified as a community requiring airport development. The development standards established for community aerodromes such as Fort Franklin included:

- Air-ground and point-to-point communications; and

- Meteorological observations on request, communications links through which requisite meteorological information for pre-flight planning can be obtained on request.

When the policy was adopted in 1974, a five-year implementation plan was developed. However, no specific development timetable was established. Early in the implementation phase, it became evident that construction would not be complete by the 1979 policy termination date. The program was subsequently extended for a further five years, until 31 March 1983. On that date, the authority to construct new airports expired.

At the time of the accident, 13 of 51 sites which were identified as requiring development had yet to have development started; Fort Franklin was one of those 13 sites. In the case of Fort Franklin, aerodrome development had been scheduled on several occasions but was delayed and then cancelled due to financial restraint and a lack of agreement over aerodrome boundaries.

1.17.10 Community Air Radio Stations

Under the terms of a Memorandum of Understanding signed by Transport Canada and the Territorial Governments, it is the responsibility of the Territorial Governments to operate community aerodromes like Fort Franklin. One aspect of that responsibility is the provision of communications and meteorological services to the standard identified in the AAFP. In the Northwest Territories, communications and weather services are provided through CARS's.

In accordance with published standards and procedures a CARS provides: air-to-ground and point-to-point communications service; related advisory and safety services; hourly and special weather observations; and access to weather information at other locations.

Originally, it was felt that a CARS would only be established as part of the overall airport development associated with the AAFP. However, where airport development had either been phased or delayed, the GNWT had in some cases requested that Transport Canada advance the provision of funds for CARS's. As a result, CARS's have been established at 7 of the 13 sites where overall aerodrome development has not commenced.

In 1981, the GNWT formally requested that Transport Canada advance the provision of funds for a CARS at Fort Franklin. Despite what appeared to be initial Transport Canada support for this request, the GNWT did not receive confirmation that the required funds would be provided. With the expiry of the AAFP in March 1983, Transport Canada reported that funds for this purpose were no longer available.

1.17.11 Public Inquiry

The Canadian Aviation Safety Board conducted a three-day public inquiry into this accident in Yellowknife, N.W.T. beginning 19 February 1985. Participants in the inquiry were the CASB technical panel, Nahanni Air Services Ltd., Mrs. Lynn Platt, Transport Canada, Government of the Northwest Territories, Hamlet of Fort Franklin, Northwest Telecommunications Inc., and the de Havilland Aircraft Co. of Canada. As part of the inquiry process the members of the board of inquiry visited Fort Franklin on 18 February 1985 where they inspected the accident site and met with residents of the hamlet.

2.0 ANALYSIS

2.1 Introduction

The investigation revealed that the aircraft struck the tower while in level controlled flight. There was no indication of any defect with regard to the aircraft's mechanical condition prior to impact. The nature of the impact damage sustained by the flap sections of the right wing and the position of the flap selector retrieved from the cockpit indicate that the flaps were fully extended at the time the aircraft struck the tower.

The primary objective of the investigation was to discover the reason the aircraft struck the tower. Weather, the pilot's decisions, human factors, operational control, and the aeronautical information and facilities available to the pilot were examined.

2.2 Weather

There is little doubt that weather conditions prevailing at the time of the accident precluded the pilot from seeing the tower. Weather information from various sources indicated that the visibility at Fort Franklin was well below that required for VFR flight. Had the visibility been adequate, a successful landing should have been completed.

With the exception of the post-accident PIREP and the information provided by witnesses to the accident, much of this weather information was available and known to the pilot. Although no official weather reports were available from Fort Franklin, weather information was provided to the pilot from several sources. With this information, the pilot continued the flight to a point where the aircraft was less than 200 feet above the ground when it struck the tower.

2.3 Flight Reconstruction

Consideration was given to the possibility that the pilot was unaware that the aircraft was at this altitude. Had the pilot been conducting the company instrument approach procedure using his notebook sketch, the aircraft could conceivably have been less than 200 feet above ground when the pilot assumed he was well above the tower. If he mistakenly utilised the 850 figure for the minimum descent altitude (MDA), he could have unknowingly descended dangerously close to the ground. Although this is a possibility that cannot be entirely discounted, other evidence strongly suggests that this was not the case.

The position of the moveable alert pointer of the radar altimeter is strong evidence that the pilot had intentionally descended to about 200 feet agl. The selection of full flap also discounts the theory that the pilot was in the process of conducting the instrument approach and maintaining what he thought was the authorized MDA. Full flap is normally a configuration only used when the decision to land has been made. Further evidence that refutes this theory is the pilot's local knowledge of the area which would make it difficult for the pilot to accept 850 feet as a proper MDA for the approach. The settings on the subscales of both pressure altimeters were consistent with the barometric pressure at the time of departure from Fort Norman. Pressure differences between Fort Norman and Fort Franklin could not account for such a large deviation between the indicated altitude for the MDA and the altitude at which the aircraft struck the tower.

Given the weather report passed to the pilot during the station stop at Fort Norman, his own report passed to the Fort Norman CARS on departure, and the prevailing weather at the accident site, it is unlikely that the pilot was able to maintain VFR flight en-route to Fort Franklin. It is probable that he climbed above the surface-based layer and proceeded to Fort Franklin using the NDB as a navigational aid. Such flight was not authorized in the company's operating certificate as it did not permit IFR flight between Fort Norman and Fort Franklin.

The flight path heard and described by witnesses on the ground suggests that the aircraft arrived overhead and then proceeded out over the lake.

The moveable radar altimeter alert pointer setting of about 200 feet is consistent with remote, Arctic approach practices. The close similarity between the alert pointer setting and the altitude at which the aircraft struck the tower is strong evidence that the pilot intentionally descended to a radar altimeter indication of about 200 feet in an attempt to acquire visual contact with the aerodrome.

This procedure would not only be one with which he was well familiar, but one which he had probably successfully completed on previous occasions during his years of remote operations in the Far North.

The flight path described by witnesses as well as the ground track of the aircraft just prior to and after impact with the tower indicates that the pilot was using the inbound track of the company instrument approach procedure as a reference to approach the aerodrome. The full flap setting at impact indicates that the pilot had reduced the aircraft's speed to make visual contact and to position the aircraft for landing.

The pilot had been made aware of the presence of the telecommunications tower. Whether he was aware of its position in relation to the final approach track of the instrument approach procedure is unknown. What consideration, if any, was given to the presence and location of the tower during this procedure is also unknown. It is possible that preoccupation with the multiple tasks associated with this procedure constituted a work overload that led him to overlook the hazard presented by the tower.

2.4 Pilot Decisions

The decision to attempt the flight was apparently made by the pilot alone. Under the dispatch system employed by the company, the pilot was effectively delegated complete authority to make the decision whether a particular flight would commence.

It is apparent that the decision to cancel the morning flight was based primarily, if not totally, on the weather conditions at Norman Wells. Although it is impossible to say with certainty to what extent the conditions at Fort Franklin influenced this decision, no improvement in the Fort Franklin weather had been reported when Flight 97 departed. It is possible that his decision was influenced by the PIREPs of good weather south of the MacKenzie River, albeit these reports concerned an area that was not on the route to Fort Norman or Fort Franklin.

The investigators were unable to determine why the pilot apparently changed his mind after initially informing the passengers that the flight would not depart. There was no evidence that company management placed any pressure on the pilot to attempt the trip, nor was there any evidence that it was management's practice to place pressure on pilots to initiate or continue flights in unsuitable weather conditions. Although the unofficial reports from Fort Franklin indicated that the visibility was limited, in the absence of an official report from an accredited observer, the pilot must have decided to go and look for himself.

After the decision to initiate the trip was made, there were at least three occasions when the flight could have been terminated due to poor weather. The weather en-route to Fort Norman required the pilot to descend very low to the ground and water to maintain visual reference. In these conditions, the flight continued and successfully arrived at Fort Norman.

At Fort Norman, the pilot of Flight 97 received additional weather information which provided another opportunity to terminate the flight. However, the fact that another pilot had very recently turned back because of the near zero visibility did not dissuade the pilot of Flight 97 from attempting the flight to Fort Franklin.

The weather report passed to the pilot on arrival at Fort Franklin via the portable VHF radio provided the final opportunity for the pilot to abandon any attempt to land at Fort Franklin. During the initial radio contact with the Fort Franklin resident, the pilot was again provided information that there was little visibility. With this information, and contrary to his statement that he did not think he would be able to land, the pilot continued until the aircraft struck the tower. Notwithstanding his familiarity and likely experience with the use of a radar altimeter to ensure terrain clearance, continuation of the flight would have been in violation of the VFR under which the flight was authorized, and beyond any normal requirement to complete the flight.

2.5 Human Factors

It is apparant that the pilot was determined to commence and complete Flight 97. However, no direct external pressures were identified which would have explained his continued attempts to complete the flight in weather conditions which can only be assessed as unsuitable. It is likely that the attitude associated with "bush pilot syndrome" identified by the NTSB special study was a factor in the pilot's decisions. As in Alaska, the existence of this attitude in Canada has not been unequivocally demonstrated by statistical data. Nonetheless, a strong case can be made for its existence in remote areas.

A review of Canadian accident cases supports the existence of the same attitude with respect to risk assessment that is cited in the NTSB report. There are numerous cases where operational decisions of a pilot significantly increased risk to the point that an accident occurred.

A not uncommon situation was initiation of or continuation of VFR flight into adverse weather conditions. The existence of this attitude is further supported by the observations made with respect to weather conditions and aircraft movements at Fort Norman.

The differences in attitude which exist between remote areas and the more populated areas of Canada are acknowledged by northern operators and are a product of the limited facilities and often hostile operating environment. The use of the radar altimeter as an approach aid to ensure terrain clearance at altitudes as low as 200 feet above ground is but one example of higher risk operational practices associated with this attitude.

Given the pilot's years of operation in extremely remote areas and the type of operation with which he was involved, his assessment of risk would have probably been influenced by this attitude. As a result, he may have had sufficient confidence in his ability to safely conduct the flight in the existing weather conditions. Previous successful experience in conducting approaches to remote aerodromes using the radar altimeter to ensure terrain clearance would have served to reinforce his confidence in his ability.

The decisions of the pilot and his assessment of risk may also have been influenced by his recent past. During the seven-month period preceding this accident, numerous significant events occurred which were all stressful to some degree. These events included three incidents, one major accident, termination of employment, and commencement of new employment. Thus, the period of March through October was a time of mounting psychological stress in the pilot's life. These life changes and the resultant stress could contribute to the creation of a state of "accident susceptibility", in which the pilot was unable to accurately assess the risks to himself and passengers in deciding to continue the flight.

Considering these events, it is understandable that he would want to perform competently in his new job. Poor risk assessment and self-induced pressure to complete the trip may well have been the result. To return to Norman Wells without completing Flight 97 could have represented failure in a job considered much less demanding than the work he had been performing successfully for many years. The decisions and actions which led to the accident could thus have been the result of the effects of stress and a greater than usual personal need to complete the flight.

In view of the pilot's flying history in the six months which had preceded his employment with Nahanni Air Services, consideration must be given to the possibility that this accident might have been predicted, and thus prevented.

Although his previous employer had arrived at the conclusion that the pilot's ability to make operation decisions was in question, Nahanni Air Services did not share that opinion. Company management was aware of the recent series of events in the pilot's flying career, but since no outward signs of stress were observed in his personal habits or work performance, no significance was attached to these events. Without the benefit of training and an awareness of human factors, they would have had difficulty in assessing the possibility that these events could have created stress and a state of "accident susceptibility".

2.6 Operational Control

Although the company operations manual and the control of company flight operations were acceptable to Transport Canada, it is evident that company management participated little in the day-to-day dispatch of scheduled flights. The dispatch and authorization of specific flights was the sole responsibility of the pilot. The location of the scheduled flight office in relation to the head office further removed company management from the operational control of scheduled flights. Although pilot self-authorization in this case effectively eliminated potential management pressure on pilots to complete flights in adverse conditions, it also had the effect of reducing management's operational control. No system of checks and balances was in place. Dispatch decisions were made by individuals without the benefit of management input or established company policy. In this case, total delegation to the pilot did not protect against possible self-induced pressure to complete the flight in unsuitable conditions.

2.7 Weather and Communications Facilities

The lack of weather observation and communications facilities in northern communities deprives pilots of valuable information which can be used for operational decision making. Without official weather observations and facilities to communicate that information, the practice of going to look for oneself is encouraged.

When weather information is available only through unofficial observations, made by persons without training, the pilot is forced to find out en-route what weather conditions exist at destination. It is apparent that this lack of official weather information was a factor in the pilot's decision to commence the flight.

The hazards and consequences of inadequate weather observation and communications facilities in remote areas were well documented in the 1980 NTSB Special Study conducted in Alaska. The conclusions reached in that study can be similarly applied to the Canadian North. The physical characteristics, weather phenomena, and heavy dependence on aviation found in Alaska closely resemble the conditions present in the Yukon and Northwest Territories. These same conditions were inherent in the development of the 1974 AAFP. Although the safety of air operations was not a specific objective of that policy, the policy addressed the problems associated with inadequate weather observation and communications facilities. Less than complete implementation of the policy has maintained the inadequacy of weather observation and communications facilities at some locations.

2.8 Aeronautical Information

The lack of definitive standards and their application has resulted in inconsistencies in aeronautical information published by Transport Canada. Although these inconsistencies are not considered causal in the circumstances of this accident, they do represent potential safety deficiencies.

2.8.1 Canada Flight Supplement

The use of the term "significant" as the criterion for depicting obstructions in aerodrome diagrams requires a large measure of individual interpretation. Without the application of more specific criteria on a national basis, considerable variation exists in the depiction of obstructions on aerodrome diagrams in the CFS. In the absence of specified criteria, examination of aerodrome diagrams where obstructions are depicted can lead to the assumption that on other aerodrome diagrams, where no obstructions are depicted, none exist.

Although the obstacle clearance circle does provide some information regarding obstructions, it does not allow the pilot to determine the specific location of the obstruction. When descent below the obstacle clearance height is required, information that is only accurate to within five nautical miles is of little use in marginal VFR conditions.

2.8.2 Company Instrument Approaches

The standards used in the depiction of company instrument approach procedures have apparently not been officially adopted; nonetheless, they do represent the only guidance available. However, it is evident that this guidance is not being consistently applied in the preparation and publication of Transport Canada Route Manuals. As a result, there is considerable variation in the quantity of information provided and the format of the presentation. A need for better quality control during the approval process is indicated by the errors contained in the Fort Franklin approach procedure.

The incorporation and consolidation of company instrument approach procedures into regional route manuals was a positive step. However, without the application of standards and adequate quality control procedures, the resulting inconsistencies and errors can easily lead to mistaken assumptions and confusion among pilots conducting instrument approaches. An unwillingness on the part of pilots to rely upon these procedures may also result.

3.0 CONCLUSIONS

3.1 Cause-Related Findings:

1. The weather at Fort Franklin was unsuitable for the flight.

2. The flight was continued into weather below that which is required for VFR flight.

3. An approach to the aerodrome was attempted using the radar altimeter to provide terrain clearance.

4. The pilot descended to an altitude below the height of the telecommunications tower.

5. A lack of official weather observations and of communications facilities at Fort Franklin deprived the pilot of reliable local weather information on which to base his decisions.

6. There exists in the more remote areas of Canada a different attitude with regard to the assessment of risk in flight operations; it is likely that this attitude influenced the decisions and actions of the pilot.

7. The operational decisions of the pilot may have been influenced by the effects of stress and a greater than usual personal need to complete the flight.

8. Company management may have had a better appreciation of the risk potential associated with the recent events in the pilot's life, if they had more awareness of the effects of stress on performance.

3.2 Other Findings:

1. The regulatory authority was satisfied the carrier had a management structure that would ensure safe operations before issuing an operating certificate; but total delegation of flight authorization to the pilot eliminated the involvement of flight operations management in determining whether it was safe to conduct the flight.

2. As there are no definite criteria for the depiction of obstructions on aerodrome diagrams contained in the Canada Flight Supplement, examination of aerodrome diagrams does not provide adequate guidance regarding the presence of obstructions in proximity to aerodromes.

3. A lack of standards and quality control has resulted in inconsistencies in the depiction of Transport Canada approved company instrument approach procedures.

4. The pilot was certified and qualified for the flight in accordance with existing regulations.

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

6. The weight and centre of gravity were within the prescribed limits.

7. There was no known in-flight airframe failure or systems malfunction prior to or during the collision with the telecommunications tower.

RECOMMENDATIONS

Actions Taken

As a consequence of this accident and the subsequent investigation, two Aviation Safety Advisories were forwarded to the Canadian Air Transportation Administration (CATA) of the Department of Transport by the Canadian Aviation Safety Board (CASB) concerning:

a) the advisability of improving the format and presentation of information in the Canada Flight Supplement (CFS); and
b) the approval process for company instrument approach procedures.

The CASB notes the actions already taken by CATA with respect to the CFS to:

a) publish bearing and distance information on all navaids more than 0.2 nm from the aerodrome in the NAV Section;
b) amend the Fort Franklin aerodrome diagram to include the 200-foot obstruction; and
c) include aerodrome elevation on aerodrome diagrams.

Further Actions Required

85-07 Operational Control - The CASB questions the effectiveness of current regulatory requirements for operational control over the flight crews by air carriers using small aeroplanes in air transport operations. In particular, current practices for flight authorization and pilot dispatch are not conducive to effective operational control by management. Therefore the CASB recommends that:

> The Department of Transport amend Air Navigation Order Series VII Number 3 to include:
>
> a) a definition of flight authorization;
> b) the minimum administrative requirements for the operations manager, dispatcher or chief pilot to effect flight authorization;
> c) those conditions where flight authorization and dispatch can be delegated by the operations manager, dispatcher or chief pilot to the pilot-in-command;
> d) minimum flight watch procedures for day Visual Flight Rule (VFR) flights;
> e) the minimum qualifications required of an operations manager; and
> f) the minimum qualifications required of a dispatcher.

85-08 Human Factors - The CASB is concerned that the impact of human factors on pilot performance is generally not well understood, either by flight crews or flight management. Consequently, the CASB recommends that:

The Department of Transport develop a training program in Human Factors for flight operations supervisors. This program should be made available to Regional Aviation Safety Officers of the Department of Transport for use in company safety officer courses and should consider among other things:

a) the effects of personal stress upon individual judgement and performance; and
b) recognition of the symptoms of personal stress by pilots and management.

85-09 Canada Flight Supplement - In order to facilitate safe flight in the vicinity of an airport under VFR conditions, the CASB recommends that:

The Department of Transport publish criteria for and standardize the presentation of information for aerodromes in the Canada Flight Supplement.

85-10 Company Instrument Approach Charts - While recognizing the operational requirement for instrument approach procedures for companies operating out of remote aerodromes, the CASB believes that more rigorous standards for information presentation and procedure validation would reduce the risks in using these restricted procedures. Therefore, the CASB recommends that:

The Department of Transport amend Division 8 of Inspection Instructions TP 584E to ensure that Department of Transport approved company instrument approach charts:

a) adhere to the format established for instrument approach charts published in Canada Air Pilot;
b) indicate a fixed period of validity; and
c) are periodically validated through Department of Transport flight checks.

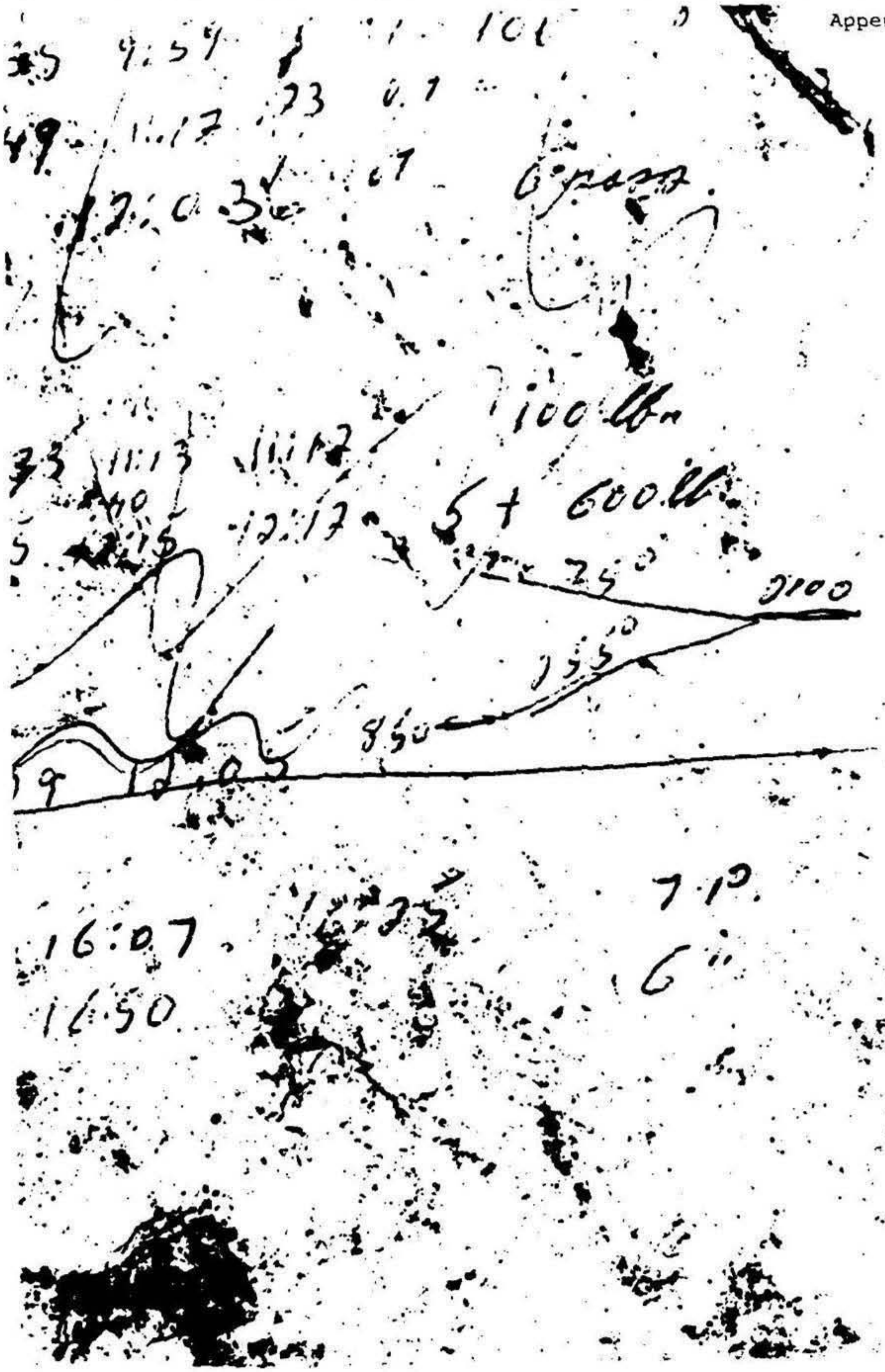
85-11 Weather and Communications Facilities - The CASB acknowledges that limitations in resource availability will perpetuate conditions of austere airport facilities throughout much of Canada's hinterland. Nevertheless, the CASB recommends that:

The Department of Transport review conditions at those Arctic C (Community) aerodromes included for development under the 1974 Arctic Air Facilities Policy, but for which the upgrade was not completed, with a view to meeting the minimum essential requirements for air-ground-air communications and the recording and the passing of meteorological observations.

ICAO Note: Appendices A, E, F and G were not reproduced.

ICAO Ref.: 2067/84

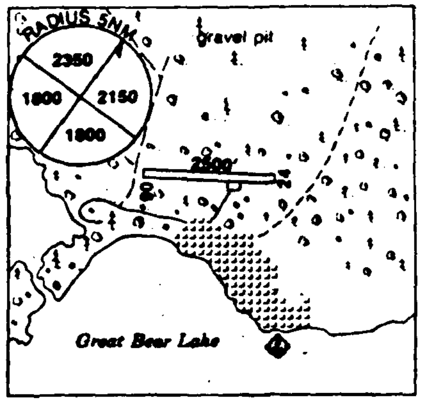
Appendix B



Appendix C

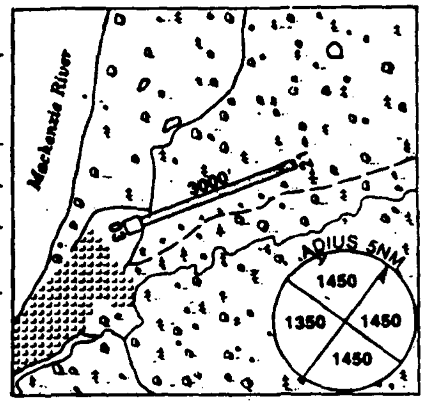
FORT FRANKLIN NWT — YWJ

REF	65 11N 123 25W 36°E GMT-7 Elev 576′ 96S½ C-10 LE2 LE3
OPR	Govt of NWT 403-589-3201 Unl
FLT PLN	
FSS	Norman Wells 403-587-2555
RWY DATA	Rwy 06/24 2500x80 gravel
RCR	opr, Ltd win maint
NAV	
NDB	WJ 287 (L) 65 11 13N 123 25 01W at A/D Pvt Unmonitored



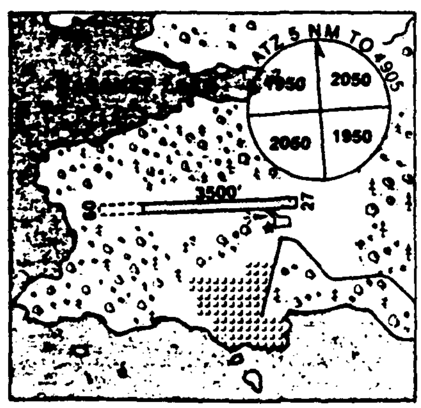
FORT GOOD HOPE NWT — YGH

REF	66 16N 128 37W 37°E GMT-7(6) Elev 215′ 106N½ C-10 LE3 HE2 CAP
OPR	Govt of NWT 403-598-2241 Unl
PF	C-1 E-3,5,6
FLT PLN	
FSS	Norman Wells 403-587-2555
RWY DATA	Rwy 03(031°)/21(211°) 3000x100 sand/gravel/snow
RCR	opr, May be clsd dur spring break-up
LIGHTING	03-(LO), 21-(LO)
COMM	
RADIO	Norman Wells 126.7
MF	122.1 within 20NM
APRT RDO	122.1 (V) Ltd hrs; ctc FSS
NAV	
NDB	GH 266 (M) 66 15 45N 128 37 10W at A/D
VOR/DME	YGH 112.3 Ch 70 66 14 10N 128 37 15W 248° 1.7NM to A/D

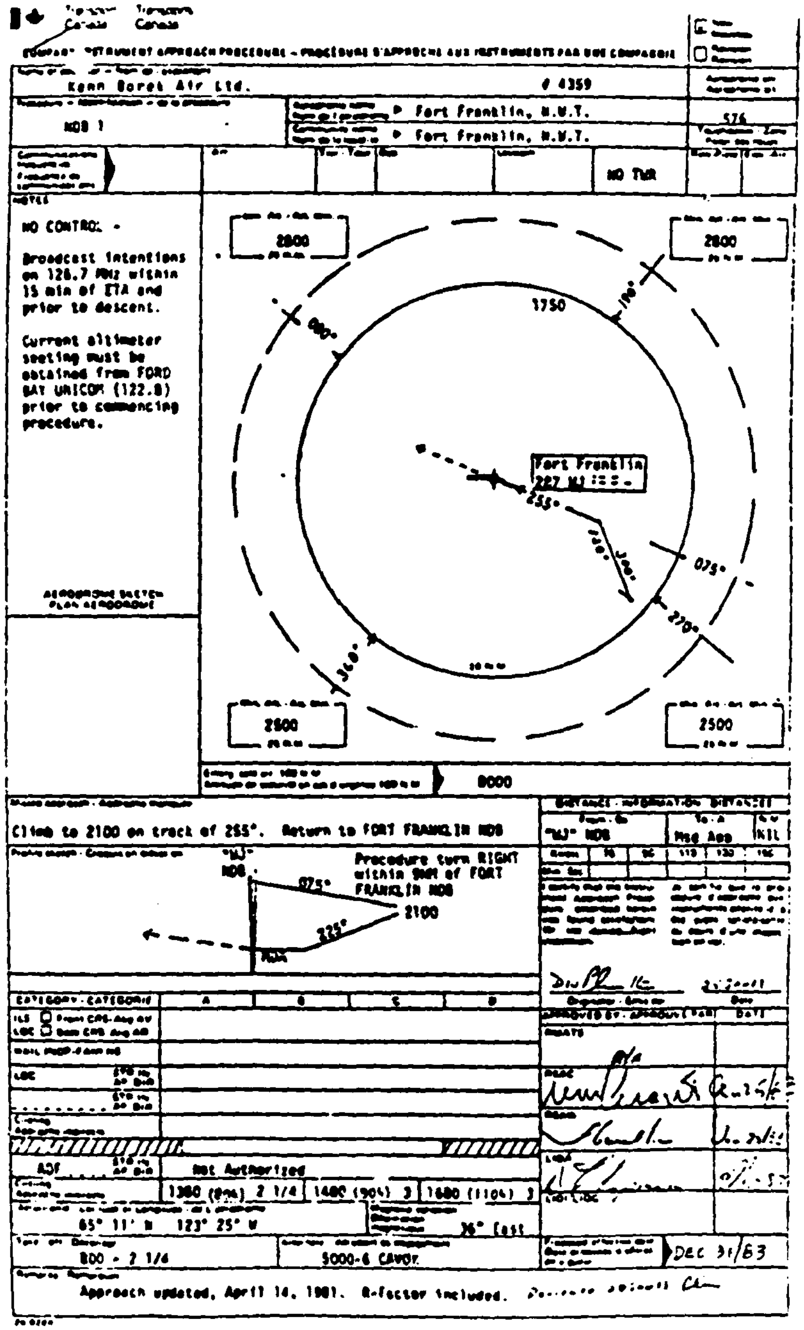


FORT HOPE ONT — YFH

REF	51 34N 87 54W Adj N 4°W GMT-5(4) Elev 905′ 42NW E-17 LE6
OPR	Ontario Ministry of Transportation & Comm 807-577-6451 or 705-242-8151 Pub Lic 14-23Z Mon-Fri exc hols
PF	C-1 E-3,5,6
FLT PLN	
FSS	Sioux Lookout 800-465-3627
RWY DATA	Rwy 09/27 3500x200 gravel
RCR	opr, Rwy brg capacity varies seasonally



Appendix D



Transport Canada Transports Canada

COMPANY INSTRUMENT APPROACH PROCEDURE – PROCÉDURE D'APPROCHE AUX INSTRUMENTS PAR UNE COMPAGNIE

Kenn Borek Air Ltd. # 4359

NDB 1

Fort Franklin, N.W.T.

Fort Franklin, N.W.T.

576

NO TWR

NOTES

NO CONTROL -

Broadcast intentions on 126.7 MHz within 15 min of ETA and prior to descent.

Current altimeter setting must be obtained from FORD BAY UNICOM (122.8) prior to commencing procedure.

AERODROME SKETCH
PLAN AERODROME

2800

2800

1750

180°

080°

Fort Franklin
227 MJ

255°

075°

270°

360°

2500

2500

8000

Climb to 2100 on track of 255°. Return to FORT FRANKLIN NDB

DISTANCE INFORMATION DISTANCES

"MJ" NDB

Msg App

NIL

"MJ"
NDB

075°

Procedure turn RIGHT within 9NM of FORT FRANKLIN NDB

2100

225°

CATEGORY · CATÉGORIE

A

B

C

D

ADF

Not Authorized

1380 (896) 2 1/4

1400 (904) 3

1600 (1104) 3

65° 11' N 123° 25' W

36° East

800 - 2 1/4

5000-6 CAVOK

DEC 31/83

Approach updated, April 14, 1981. R-factor included.

No. 7

McDonnell Douglas DC-8-55F, HC-BKN at Quito, Ecuador on 18 September 1984. Accident report released by the Accident Investigation Board, Ecuador

SYNOPSIS

On take-off, the aircraft used the whole length of the runway but failed to climb and collided with the ILS antenna at the end of the runway. The aircraft then struck several houses, which were destroyed. Before take-off the crew were involved in an industrial dispute and left in haste. The crew apparently did not notice that the horizontal stabilizer was set at 0.5 degrees nose up rather than 8 degrees nose up. This increased the time, speed and distance required for take-off and made it impossible to lift the aircraft off the runway.

1. History of the flight

The Douglas DC-8-55F aircraft bearing registration No. HC-BKN, operated by Compañía AECA airlines, was performing unscheduled cargo flight No.767-103 on the Miami-Quito-Guayaquil route. It took off from Miami at 0830 hours Z (0330 hours local time) carrying four crew members and 75 603 pounds of freight.

The Miami-Quito leg took place without incident and the aircraft landed at Mariscal Sucre Airport at 1152 hours Z (0652 hours local time).

The Quito-bound freight was unloaded at the latter airport. For this purpose all pallets on board the aircraft were moved with the exception of those in positions 1 and 13, and a new flight clearance was therefore required for the Quito-Guayaquil leg.

After these tasks had been concluded and the aircraft refuelled with 2 100 gallons of fuel, the aircraft dispatcher presented an instrument flight plan for the Quito-Guayaquil leg, which had to be altered since the aircraft's departure was delayed from 1400 hours Z (0900 hours local time) to 1600 hours Z (1100 hours local time) while the crew engaged in a labour-related discussion with members of the Ecuadorian Federation of Air Crew Members, and subsequently consulted with airline officials concerning continuation of the flight to Guayaquil.

At 16 h 04'38" Z (11 hours 4 minutes 38 seconds local time), aircraft HC-BKN initiated the take-off run on runway 35. The run was extended to 48 metres beyond the runway end.

The aircraft started to climb at this point but the angle of climb was not sufficient to prevent the main landing gear and the trailing edge of the horizontal stabilizer from colliding with the wooden structure supporting the ILS antennas, located 83 metres from the end of runway 35.

2. Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	4	-	49
Non-fatal	-	-	30
Light/none	-	-	-

3. Damage to aircraft

The aircraft was totally destroyed by the impact and subsequent fire.

4. Other damage

During take-off the aircraft caused the following damage:

- Destruction of the ILS support structure and antennas.
- Destruction of several lamp posts.
- Total destruction of a vehicle.
- Total destruction of 25 houses.
- Partial destruction of 4 houses.
- Partial destruction of 3 vehicles.

5. Personnel information

The crew assigned to Compañía AECA flight 767-103 was as follows:

a) Pilot-in-command of the aircraft: Of Ecuadorian nationality and 54 years of age.

According to his personal file, he was the holder of Airline Transport Pilot Licence No. 220 ATR supplemented by Medical Certificate No. 043 valid until 22 September 1984, stating that he must use corrective lenses when performing the duties of a pilot.

He held pilot ratings for the following aircraft:

PT-19; T6-G; T-28/33/41; PVY; CHI-C; Twin Otter DHC-6; Caribou-DHC-4; T6-D; Canadair CL-44/44-DA and Douglas DC-8. He also possessed a Flight Instructor rating.

His pilot rating for the Douglas DC-8 was issued on 17 October 1977 and continued in effect up until the time of the accident.

His last proficiency check was carried out at the United Airlines Training Centre in the United States, on 6 March 1984, at which time he passed satisfactorily in all areas.

Up to the day of the accident he had flown the following hours:

Over-all total	16 541:48 hours
Last ninety days	226:40 hours
Last sixty days	166:35 hours
Last thirty days	79:00 hours
Last seven days	07:45 hours
Total on Douglas DC-8	2 373:25 hours
Total on aircraft involved in accident	597:45 hours

b) Co-pilot: Of Ecuadorian nationality (naturalized) and 57 years of age.

According to his personal file, he was the holder of Airline Tranport Pilot Licence No. 019-ATR supplemented by Medical Certificate No. 250-84 Class "A" valid until 13 March 1985, stating that he must use corrective lenses while performing the duties of a pilot.

He held pilot ratings for the following aircraft:

Taylorcraft; PT-19; Norseman; Cessna 140/170/180; Piper PA-22; Twin Otter DHC-6; Britten Norman 2A; Pilatus Porter PC-6; Caribou DHC-4; Fairchild F-27F; Douglas DC-6.

Co-pilot ratings for:

Curtis C-46; Electra L-188; Canadair CL-44/44-DA and Douglas DC-8.

The co-pilot rating for the Douglas DC-8 was issued on 24 October 1977 and continued in effect up until the time of the accident.

His last proficiency check was carried out at the United Airlines Training Centre in the United States, on 6 March 1984, at which time he passed satisfactorily in all areas.

Up to the day of the accident he had flown the following hours:

Over-all total:	26 614:35 hours
Last ninety days	272:00 hours
Last sixty days	187:55 hours
Last thirty days	86:25 hours
Last seven days	17:15 hours
Total on Douglas DC-8	1 121:28 hours
Total on aircraft involved in accident	649:58 hours

c) Flight engineer: Of Ecuadorian nationality and 45 years of age.

According to his personal file he was holder of Flight Engineer Licence No. 129, supplemented by Medical Certificate No. 220 Class "B" valid until 14 April 1985, stating that he must use corrective lenses while performing the duties of a flight engineer.

He held ratings for the Douglas DC-8, DC-6B and CL-44; his rating for the DC-8 was issued on 17 October 1977 and continued in effect.

His last proficiency check was carried out at the United Airlines Training Centre on 6 March 1984 at which time he passed satisfactorily in all areas.

Up to the day of the accident he had flown the following hours:

Last ninety days	203:00 hours
Last sixty days	118:55 hours
Last thirty days	22:55 hours
Last seven days	17:15 hours
Total on Douglas DC-8	2 001:55 hours
Total on aircraft involved in accident	647:55 hours

d) Freight handler: Due to the nature of his duties, he did not require any licence.

6. Dispatcher information

The dispatcher of flight 767-103 on 18 September 1984, holder of Flight Operations Officer Licence No. 134, held Dispatcher ratings for the Douglas DC 3/6, Caravelle 210, Avro 748, Canadair CL-44 and DC-8-55F, valid till 26 July 1985.

The rating for the DC-8-55F was issued on 1 September 1983 and he had performed the duties of Dispatcher on this type of aircraft up to the date of the accident.

He began to work as a Dispatcher for Compañía AECA on 17 July 1979, the date on which he was granted the corresponding licence.

7. Aircraft information

Record of the Douglas DC-8-55F aircraft: The Douglas DC-8-55F aircraft registered as HC-BKN commenced flight operations for Compañía AECA on 12 August 1983, being operated by that airline under a temporary registration number on a lease-purchase or conditional purchase basis.

The Certificate of Airworthiness issued by the Directorate of Civil Aviation was valid until 26 August 1985, the aircraft having undergone a scheduled inspection on 27 August 1984 as a mandatory requirement for renewal of the above document.

Its chief characteristics were as follows:

MODEL	DC-8-55F
SERIAL NUMBER	45754
POWERPLANT	Pratt and Whitney Engines JT3D-38
MAXIMUM TAKE-OFF WEIGHT AT SEA LEVEL UNDER STANDARD CONDITIONS	325 000 pounds
WEIGHT EMPTY	131 436 pounds
MAXIMUM LANDING WEIGHT	240 000 pounds
NUMBER OF AVAILABLE SEATS INCLUDING CREW	6
SERVICE CEILING WITH 4 ENGINES	42 000 feet
ENDURANCE	10:00 hours

The aircraft was equipped for instrument flight by night.

Hours and last checks carried out on the aircraft

Up to 17 September 1984 the aircraft had totalled 60 070:17 running hours and 17 003 service cycles since leaving the factory.

According to the airline maintenance programme, the following checks were applicable:

Check "A"	Every 100 hours
Check "B"	Every 500 hours
Check "C"	Every 2 500 hours
Check "D"	Every 16 000 hours (overhaul)

The aircraft's maintenance records show that the last checks were carried out at the following dates and times:

Check "A" 07 September 1984. There were 61:50 hours remaining before the next such inspection.

Check "B" 01 August 1984, with 249:30 hours remaining before another inspection of this class was required.

Check "C" 12 August 1983, with 723:43 hours remaining before the next inspection, as of 17 September 1984.

Check "D" (Overhaul). The aircraft had arrived in the country with 5 503 hours remaining before the next check "D"; it had flown 1 276:17 hours for the airline, and therefore had 4 226:43 hours remaining before its next overhaul.

Final inspection

On 17 September 1984, at the Airline International Inc. maintenance shops, Miami, USA, the aircraft and its engines underwent the following maintenance work, consisting of adjustment and testing:

a) Engines:
- Run-up test
- Trimmed
- Lubrication and repairs to the reverse thruster of Turbine No. 2.

b) Aircraft and systems:
- Replacement of the right wing tip assembly.
- Inspection and replacement of the freon seal, right side.
- Repair of the trailing edge of the right wing.

Engine record:

Position No. 1 Serial No. P642912

Date of manufacture:	19 October 1961
Total hours of service up to date of accident:	42 140:30 hours

Hours of service on this aircraft:	1 169:30 hours
Total number of cycles on this aircraft:	418 cycles
Hours of service remaining on date of accident:	1 610:30 hours
Cycles remaining on date of accident:	392 cycles

Position No. 2 Serial No. 644219

Date of manufacture:	18 November 1963
Total hours of service on date of accident:	41 237:30 hours
Hours of service on this aircraft:	1 169:30 hours
Total number of cycles on this aircraft:	418 cycles
Hours of service remaining on date of accident:	1 731:30 hours
Cycles remaining on disc No. 2 (T2) on date of accident:	268 cycles

Position No. 3 Serial No. 645061

Date of manufacture:	22 July 1965
Total hours of service on date of accident:	34 467:17 hours
Total service cycles remaining on date of accident:	11 686 cycles
Hours of service since arrival in Ecuador:	1 266:17 hours
Total cycles since arrived in Ecuador:	456 cycles
Service cycles remaining on disc T2:	72 cycles
Hours of service remaining on date of accident:	The French authorities allowed a 7% increase in hours of service, i.e. 1 498 hours, under which conditions 54:30 hours were used.

Position No. 4 Serial No. 644899

Date of manufacture:	31 March 1965
Total hours of service of date of accident:	43 402:17 hours

Total number of cycles on date of accident:	14 614 cycles
Hours of service on this aircraft since arrival in Ecuador:	1 276:17 hours
Total cycles since arrived in Ecuador:	456 cycles
Hours of service remaining on date of accident:	471:43 hours
Cycles remaining on date of accident:	900 cycles

Last periodic checks performed on engines:

Check "A": Was carried out on 7 September 1984, with 61:50 hours remaining until the next check of this type.

Check "B": Was carried out on 1 August 1984, 257:15 hours remaining until the next check.

8. Aids to navigation

These played no part in the accident; at the time of the occurrence all the navigation aids installed at Mariscal Sucre Airport were operating normally.

9. Meteorological information

Meteorological conditions had no influence on the accident. According to the meteorological bulletin issued by the Analysis and Forecast Centre of Mariscal Sucre Airport, the meteorological conditions on the day of the accident were as follows:

Time:	1605 h Z (1105 h local time)
Wind:	070° with velocity of 05 kt
Visibility:	40 km
Cloud conditions:	4/8 cumulus at 1 200 m 3/8 altocumulus at 2 700 m
Temperature:	18°C

10. Aerodrome information

Name:	Mariscal Sucre
Coordinates:	00° 08'20"S; 78°29'06"W
Elevation:	2 812 m (9 226 ft)
Facilities:	The aerodrome has an asphalt runway 3 120 m in length and 46 m in width, with an orientation of 353/172 degrees. There is an ILS for runway 35. (The antenna for this system is located 83 metres from runway 17).

11. Communications

Communications between the aircraft and the Air Traffic Control Services functioned normally, as shown by the ATC tapes.

12. Fire

According to eyewitnesses, the aircraft showed no signs of fire during the take-off run. The fire which destroyed most of the aircraft, at the site of the principal impact broke out when the wing and left side of the fuselage collided with one of the houses in the area, and spread because the fuel on board the aircraft spilled out of the ruptured tanks and came in contact with heated engine parts.

The proximity of the accident site to Mariscal Sucre Airport facilitated the immediate intervention of the airport's fire fighting service, and minutes later, of several municipal fire fighting units.

13. Survival aspects

The nature of the accident offered the crew members no chance of survival. Forty-nine persons perished and 30 more were injured due to the destruction of several houses in the area of impact.

Victims were rescued by personnel of the Mariscal Sucre Airport fire fighting services and of several Quito emergency services.

14. Flight recorders

a) Flight data recorder (FDR)

The Douglas DC-8-55F registered as HC-BKN was equipped with a flight data recorder (FDR) having the following characteristics:

- Model: Sundstrand FA-542, S/N UNK
- Serial number: DCA-84-R-A036

When recovered, the recorder showed signs of having been exposed to fire and severe impact. It was sent for analysis to the National Transportation Safety Board (NTSB) laboratories in Washington, D.C.

It was impossible to obtain any information since the recorder in question was not operating at the time of the crash.

An inquiry by the Accident Investigation Board into the cause of the non-operation of this apparatus, indicated that it was not being properly maintained. The same side of the tape had been used three times because the tape had not been reversed after 200 hours according to manufacturer's specifications.

As regards operation of the system, it was shown that this type of recorder must be turned on and off manually, and it was assumed that flight crews were not in the habit of turning it on.

b) Cockpit voice recorder

The cockpit voice recorder was a Sundstrand /557. It was recovered on the accident site severely damaged by the initial impact and by fire. It was sent for analysis to the National Transportation Safety Board laboratories in Washington, D.C., but no information could be obtained because the tape was completely destroyed. The impact-resistant case was damaged in the accident. The cover became detached from the rest of the case leaving the fire-resistant covering directly exposed to high temperatures and leading to incineration of the tape.

The NTSB report shows that the tape appears to have been correctly loaded into the voice recorder, but no conclusions could be reached regarding its operational condition prior to the accident.

15. Wreckage information

Impact with the structure supporting the ILS antenna caused the right main landing gear to become detached, breaking off at the level of the piston damper and striking a house located 35 metres to the right of the extended runway centre line and 460 metres from runway 35.

Small fragments from the main landing gear tire treads and from the trailing edge of the horizontal stabilizer were found at the antenna site.

The aircraft broke into pieces as a result of subsequent impacts with lamp posts and houses in the area. Major wreckage was distributed as follows:

- Engines from positions No. 1 and No. 2 - 7 metres to the right of the extended runway centre line and 490 metres from the end of runway 35.

- Part of the cockpit, broken into several pieces on the left side, and part of the fuselage (left side) - 10 metres to the right of the extended runway centre line and 500 metres from the end of runway 35.

- Leg of the right main landing gear, the nose gear from which the left wheel was detached, the left main landing gear minus back right wheel - 20 metres to the right of the extended runway centre line and 510 metres from the end of runway 35.

- The detached wheel from the left main landing gear and a wheel for the nose gear which was being carried on board as a spare part, in addition to various fragments of the aircraft fuselage and left wing, were scattered between 510 and 580 metres from the end of runway 35.

- Part of the left side of the fuselage, from station 1471 to station 1004, tail section with the horizontal stabilizer complete but the vertical stabilizer detached, central section of the fuselage with the right wing partially destroyed by fire - 40 metres to the right of the extended runway centre line and 580 metres from the end of runway 35.

- Engine from position No. 4 broken into pieces, remains of equipment, fuselage and wings - 40 metres to the right of the extended runway centre line and 600 metres from the end of runway 35.

- Engine from position No. 3 - 30 metres to the right of the extended runway centre line and 690 metres from the end of runway 35.

- Wheel from nose landing gear - 180 metres to the right of the extended runway centre line and 900 metres from the end of runway 35.

- The cockpit section was completely destroyed and was scattered over a 100-metre area at the site of final impact.

16. Medical and pathological information

All the aircraft's occupants died from multiple traumas and fractures. The flight crew's medical history did not indicate any existing physical problems which might have affected their mental faculties. The autopsies and toxicological investigations showed no abnormalities in any member of the flight crew.

17. Tests and research

a) Fuel: The fuel with which the aircraft was supplied at Quito Airport was tested at the Ecuadorian State Petroleum Corporation (CEPE) laboratories and showed no signs of contamination.

b) Powerplant: All four engines were recovered from the occurrence site showing different types of damage resulting from it.

The condition in which the engine which had been installed in position No. 4 was recovered, made possible a complete examination by members of the AIB and of the Pratt and Whitney local advisory team, leading to the conclusion that it had been operating normally at the time of the accident.

The engines from positions 1, 2 and 3 were sent for analysis to Pratt and Whitney in Connecticut, USA, since the condition in which they were recovered did not permit a thorough local investigation.

Following analysis and assessment of the reports from Pratt and Whitney, the AIB concluded that the power units were operating normally at the moment of impact.

c) Clearance of the flight from Quito

The AIB received the following documents relating to the flight clearance:

- Load and Trim Sheet No. 0466 signed by the dispatcher.

- Form AGO-4260 (completed in pencil by the dispatcher and unsigned).

- Written reports submitted by the dispatcher dated 19 and 20 September 1984.

These documents were studied by the AIB and the following errors and discrepancies were found:

Load and Trim Sheet No. 0466 shows the take-off weight of the aircraft as 207 066 pounds, including a useful load of 43 630 pounds, while Form AGO-4260 shows the take-off weight as 211 397 pounds and the useful load as 48 960 pounds, without specifying the centre of gravity.

In the report dated 20 September 1984, the flight dispatcher states that he had to issue a new clearance because he was informed at the last minute that the useful load weighed 48 961 pounds rather than 43 630 pounds just as the load was being distributed in the aircraft interior.

In this report, the aircraft's take-off weight is given as 211 397 pounds and the centre of gravity is located at 28.5% of the mean aerodynamic chord (MAC).

The position of the pallets in the aircraft as shown on Form AGO-4260 does not correspond to that described by the ASA personnel who took part in their lading.

The AIB learned that the flight dispatcher, after the accident, suggested to the lading supervisor that his report be amended so as to coincide with the information given by the dispatcher in his report to the AIB.

In the course of the AIB's investigations it was discovered that the flight clearance procedure followed was incorrect, since the actual take-off weight for flight 767-103 from Quito Airport was 213 596 pounds, rather than 207 066 pounds as shown on Load and Trim Sheet No. 0466 or 211 397 pounds as appears on Form AGO-4260 and on the dispatcher's report of 20 September 1984.

The 213 596 pound take-off weight was obtained based on the following information:

- Operating dry weight	131 438.8 lb
- Supernumerary crew	200.0 lb
- Freight	50 960.0 lb
- Fuel	31 000.0 lb
TAKE-OFF WEIGHT	213 596.8 lb

This weight (213 596 pounds) does not exceed the maximum weight value allowed in the aeroplane flight manual, taking into account the runway, wind and temperature conditions prevailing at the time of take-off.

According to the aeroplane flight manual, the maximum permissible weight was limited by the runway length, and was equal to 225 000 pounds.

The conditions taken into account were:

- Available runway length:	10 236 ft
- Pressure altitude	9 000 ft
- Gradient	1% negative
- Ambient temperature	18°C
- Wind	70° at 5 kt
- Runway	dry
- Flaps	15°

The true position of the centre of gravity for the Quito-Guayaquil leg, calculated on the basis of the weights specified on the Miami clearance and consistent with testimony received from those who took part in the freight lading, was 17.3% of the mean aerodynamic chord.

d) Position of the horizontal stabilizer at the time of take-off

Considering stabilizer position to be a determinant aspect of aircraft performance, particularly during the take-off phase, the AIB recovered from the wreckage the screws which actuated this component in order to determine the position of the horizontal stabilizer via analysis of their degree of displacement. The results obtained by the AIB, like those stemming from studies carried out in the Douglas laboratories, indicate that it was set at one half degree nose up (0.5° nose up).

e) Psychological and emotional state of the crew of flight 767-103

According to information received from persons who took part in the clearance of the flight from Quito Airport, while the crew were commencing engine ignition procedures (1415 hours Z, 0915 hours local time) members of the Ecuadorian Federation of Air Crews (FEDTA) requested and were granted by the aircraft captain permission to board the aircraft and discuss subjects relating to the air crews' strike called by the above Organization, to which AECA crews did not adhere.

Statements made by witnesses who participated in or were present at these conversations, establish that the language used and the attitudes displayed were reasonable.

The FEDTA members asked the crew of flight 767-103 to support the strike and not to continue their flight to Guayaquil. In response to this request, the aircraft commander decided to consult with airline management on this matter with a view to co-ordinating the measures to be taken, and decided to continue the flight to Guayaquil.

According to the information obtained, at approximately 1557 hours Z (1057 hours local time) approximately, the crew - perhaps in order to hasten departure from Quito - ordered that the aircraft be towed to the taxiway immediately following ignition of engine No. 4 on the apron. The remaining engines were started during the towing operation.

In the light of the foregoing facts, and considering that the engine ignition procedure described is not the one normally followed and was presumably carried out in an effort by the crew to avoid any further labour-related contacts and terminate the flight in Guayaquil as originally scheduled, the AIB felt that a psychological analysis was required to determine whether the above-mentioned circumstances had a negative effect on the psychological/emotional behaviour of the crew, and to what extent they might have contributed to the occurrence.

The study, which was carried out by professionals in the fields of neuro-psychiatry and psychology, determined that the factors prevailing that day sharply diminished the crew's psychological fitness, both individually and as a group, probably to the extent that they lacked the necessary attentiveness and concentration which are essential to carrying out all the normal procedures for take-off.

18. *Analysis of the accident*

The flight crew had all licences and ratings in order. Their proficiency checks were carried out satisfactorily within the context of programmes set up for the purpose.

Studies showed that the weight of the aircraft at take-off was below the maximum take-off weight established in the aeroplane flight manual for the conditions prevailing at the time.

According to the aeroplane flight manual (page 12, Section 1, Appendix VIII), for a centre of gravity located at 17.3% of the mean aerodynamic chord (MAC) and a take-off weight of 213 596 lb, the stabilizer should be set at 8° (eight degrees) nose up.

Examination of the actuating screws showed that the aircraft stabilizer was set at only one half degree (0.5°) nose up.

Although the reason for this horizontal stabilizer setting could not be definitely determined, the most acceptable hypothesis is that due to haste as a result of the events that had taken place moments before take-off, the crew failed to make use of the airborne computer installed for the purpose to check the position of the aircraft's centre of gravity and the necessary adjustment of the horizontal stabilizer. It should also be noted that the dispatcher did not provide this information to the crew either.

This stabilizer position (0.5° nose up) significantly increased the distances and times required to reach rotation speed (V_R) and lift-off speed (V_{LOF}).

The AIB has observed that aircraft of similar characteristics require approximately 60 metres (196 feet) of usable runway for the take-off run. This would reduce the actual length to 3 600 metres (10 040 feet).

TABLE ILLUSTRATING THE INCREASES IN SPEED AND DISTANCE REQUIRED FOR TAKE-OFF

a) Conditions required for normal take-off

Stabilizer set at eight degrees nose up, flaps 15°

- Available runway distance	10 040 ft
- Decision speed (V_1)	114 kt
- Rotation speed (V_R)	127 kt
- Climb speed (V_2)	139 kt
- Runway distance to reach rotation speed	5 906 ft
- Runway distance to reach lift-off speed	6 833 ft
- Take-off distance to reach an altitude of 35 ft	8 034 ft

b) Conditions at time of accident

Stabilizer set at one half degree nose up, flaps 15°

- Available runway distance	10 040 ft
- Decision speed (V_1)	144 kt
- Rotation speed (V_R)	157 kt
- Climb speed (V_2)	169 kt
- Runway distance to reach rotation speed	9 052 ft
- Runway distance to reach lift-off speed	10 187 ft
- Take-off distance to reach an altitude of 35 ft	11 644 ft

Taking into consideration the above parameters and the tracks left by the main landing gear in the area between the end of runway 35 and the ILS antenna, we can conclude that the aircraft did in fact cover the distance established for 15° flaps and horizontal stabilizer set at 0.5° (one half degree) nose up. It can be determined that rotation started on reaching this area, as evidenced by the presence of tracks from the main landing gear only, not from the nose landing gear; the main landing gear tracks ceased 48 metres beyond the end of runway 35.

From the foregoing evidence it may be concluded that the aircraft reached lift-off speed (V_{LOF}) at 10 197 feet of its take-off run, and as this point is only 114.8 feet (35 metres) away from the ILS, it was impossible for the aircraft to clear this obstacle which would have required a 35° climb angle.

The effective angle of climb, judging by the point at which the tracks ceased and by the impact with the antenna, was only 17°.

The ILS antennas are situated 83 metres from the end of runway 35 and are in compliance with all the Standards established by the International Civil Aviation Organization (ICAO).

The aircraft, failing to initiate take-off from the usable runway, descended 1.30 metres below the elevation of the antenna mast and struck the wooden antenna supports. This situation is not envisaged in the design and installation of the system.

The impact with the structure supporting the ILS antenna not only broke the right leg of the landing gear but also led to a significant reduction in speed, making it impossible for the aircraft to continue climbing and causing it to descend 13 metres while covering a distance of 360 metres on the horizontal plane up to the point of second impact.

19. CONCLUSIONS

The aircraft was certificated and was maintained in accordance with procedures established by the manufacturer.

The AIB research established that the aircraft, engines and other components were functioning normally.

The fuel analysis showed that the fuel was not contaminated nor did not contain impurities which might have affected engine performance.

A study of meteorological conditions prevailing at the time of the accident determined that they were not a contributing factor.

The flight crew held all the necessary licences and ratings required to operate the aircraft involved in the accident.

The aircraft's take-off weight from Quito Airport did not exceed the maximum weight established by the aeroplane flight manual for the existing conditions.

The flight dispatcher in Quito did not make the calculations which would have provided him with the position of the centre of gravity and therefore did not furnish any information in this regard to the flight crew.

The redistribution of the load on board the aircraft, which was carried out in Quito, established the centre of gravity for the Quito-Guayaquil leg at 17.3% of the mean aerodynamic chord; it was therefore within the limits permitted by the manufacturer, close to the foreward limit.

The location of the centre of gravity (17.3%) and the take-off weight (213 596 pounds) required that the horizontal stabilizer be set by the crew at 8° (eight degrees) nose up, for take-off conditions.

The aircraft's horizontal stabilizer was set at one half degree (0.5°) nose up at the time of take-off.

The flight crew, probably affected by the events which had taken place moments before take-off from Quito and the resulting haste, did not request load and trim from the dispatcher and also failed to check the position of the centre of gravity on the airborne computer so as to adopt an appropriate take-off configuration.

The incorrect position of the horizontal stabilizer produced an increase in the time and distance required by the aircraft to attain the values of rotation speed and lift-off speed; in consequence, the length of available runway was insufficient. This caused the aircraft to extend its take-off run onto the area between the end of runway 35 and the ILS antenna.

The aircraft reached lift-off speed (V_{LOF}) when only a few metres away from the ILS antenna, which it was unable to clear, leading to the first impact.

20. Probable cause*

The Accident Investigation Board is of the opinion that the probable cause of the accident was the incorrect position of the horizontal stabilizer in relation to the aircraft's centre of gravity, which prevented the aircraft from reaching rotation and lift-off speed within the runway distance available.

21. Contributing factors

1. Clearance of the aircraft from Quito was done incorrectly, since the maximum take-off weight permissible for the existing runway, wind and temperature conditions, the real take-off weight, the useful load distribution and the position of the aircraft's centre of gravity were not determined.

*ICAO Note: The term "pnobable cause" is not envisaged in Annex 13, nor in the Manual of Aircraft Accident Investigation (Doc 6920).

2. The crew's state of mind may have been a contributing factor in the accident. It is assumed that it prevented the crew from concentrating on all aspects of the operation they were performing.

22. Recommendations

1. That the Directorate General of Civil Aviation reiterate to airlines the importance of requiring that their dispatchers prepare flight clearances in a diligent and appropriate manner, particularly with regard to the aircraft's load and trim, in order to provide flight crews with correct technical information.

2. That the Directorate General of Civil Aviation reiterate to airlines the importance of the crew requesting the necessary technical information from the flight operations personnel prior to commencing the flight, and that this information be duly analysed, checked and accepted, and signed by a member of the flight crew in each case.

3. That the Directorate General of Civil Aviation take steps to intensify the periodic inspections, by operations inspectors, of technical-operational units of airlines, in order to ensure that clearance procedures are carried out correctly.

4. That the Directorate General of Civil Aviation reiterate to airlines the obligation on crews to make proper use of the checklist and that this procedure be carried out with the attention and diligence necessary to make the various checks.

5. That the Directorate General of Civil Aviation reiterate to airlines the obligation to maintain voice and flight data recorders in good operating condition; and that monitoring of these devices by Directorate airworthiness inspectors be intensified.

6. That the Directorate General of Civil Aviation take steps to ensure that airport authorities continue to improve their emergency plans and co-ordination agreements with all bodies which lend assistance on such occasions.

7. That the Directorate General of Civil Aviation take steps to ensure that airport authorities do not permit activities to take place in the movement area of aerodromes which might disrupt the execution of normal aeronautical operations.

8. That the Directorate General of Civil Aviation intensify flight safety programmes aimed at making aeronautical personnel conscious of the need to comply with the standards and procedures established by the aeronautical authorities for the safe conduct of aeronautical operations.

ICAO Note: Names of personnel were deleted. Synopsis added.

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