

NATIONAL
TRANSPORTATION
SAFETY
BOARD

AIRCRAFT ACCIDENT REPORT

COMPANIA ECUATORIANA DE AVIACION

DOUGLAS C-54D,

REPUBLIC OF ECUADOR, HC-ADN

MIAMI INTERNATIONAL AIRPORT

MIAMI, FLORIDA

APRIL 14, 1970



NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D. C. 20591

REPORT NUMBER: NTSB AAR-71-2

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.-20591



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Office of the Chairman

The National Transportation Safety Board today released its report on the cause of a fatal accident involving a Compania Ecuatoriana De Aviacion C-54D cargo aircraft during an instrument takeoff from the Miami International Airport on April 14, 1970. The two pilots, the only occupants, were killed and the aircraft demolished.

The Safety Board learned that the crew first requested a takeoff clearance at 0621 but because fog reduced visibility to one-eighth mile, the tower controller delayed clearance until 0722 when the visibility was reported to be one-quarter mile, which was the minimum the pilot stated he needed for takeoff.

Following lift-off, the C-54 was observed flying in a level flight attitude, with the landing gear retracted, about 50 feet above the western end of Runway 27R which is 10,500 feet long. At this time the aircraft nosed lower, lost some height, checked momentarily, and then continued losing altitude until it contacted the ground some 230 feet beyond the western end of the runway. It continued on about 900 feet before it crashed against a concrete abutment. The landing flaps were retracted at impact although the Operations Manual prescribed that the flaps should not be retracted until the aircraft was 300 feet above the ground.

The Safety Board determined that the probable cause of this accident was . . .

" . . . improper monitoring of the flight instruments during a takeoff in instrument meteorological conditions. Additional pertinent factors were the use of improper procedures after take-off and the reduced visibility due to fog."

(over)

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The Safety Board said that no evidence was found that indicated a powerplant malfunction or any failure or malfunction of any structural components or flight controls of the aircraft. Furthermore, there was no evidence of a stall, loss of control, or flightcrew incapacitation. The Board noted, however, that the dispatching of this flight was not in accordance with the existing rules and procedures although the carrier's Operations Manual prescribed such rules for the pilot and dispatcher: the center of gravity was not computed and recorded and the cargo and weight distribution was not recorded on a form applicable to the C-54. Also, the captain filed his own flight plan rather than following the procedures outlined in the manual which required the dispatcher to plan and file the flight plan with the captain's concurrence. Finally, the Board noted that while Ecuatoriana's operations specifications authorized the use of three cargo-carrying C-54's, the Operations Manual did not contain specific operating instructions for the C-54 but was devoted to DC-6 and L-188 aircraft.

The Board pointed out that "there are two problems associated with instrument takeoffs in a condition of low visibility and no horizon, that appear to be pertinent to this accident. These problems are (1) acceleration-induced errors in the attitude indicator and (2) acceleration-induced false recovery perceptions by the pilot."

In the case of the first problem, the Board explained, research indicates that as the aircraft accelerates, the vertical reference force applied to the gyro shifts, resulting in an error in the presentation of the attitude indicator, which in transport aircraft, has been calculated to be from 3 to 5 degrees. The effect of this error is to cause the appearance of a higher-than-actual pitch attitude on the attitude indicator. The remedy is to cross-check all flight instruments and if the altimeter and vertical speed indicator do not indicate a climb the pitch attitude should be increased -- while keeping proper airspeed -- until positive climb indications appear on these instruments.

The Safety Board said the second problem -- induced perception error on the part of the pilot -- is also caused by the acceleration force imposed on the pilot, combined with the vertical force of gravity, and the resultant force vector causes the pilot to feel that he has tipped back and is climbing when in fact the aircraft may be level or even descending. This phenomenon is particularly effective when there is no visible horizon due to weather or darkness. If the pilot should consciously or unconsciously correct for this feeling after takeoff, he could fly the aircraft level or into descending flight, rather than in a

climb, the Board said and added that it "believes that one or both of these conditions existed in this case." Again, the remedy is proper cross-checking of all the flight instruments to assure that the aircraft is performing the maneuver desired by the pilot.

The flightpath described by the witnesses indicates that the aircraft climbed to an altitude of approximately 40 to 50 feet above the ground and leveled off. As soon as the landing gear was retracted, the acceleration initiated at takeoff would have increased and this could have induced or aggravated the errors in the attitude indicator and the pilot's perception. If the pilot reacted to these errors and his instrument cross-check was faulty, interrupted, or disturbed by after-takeoff cockpit activities, the resulting flightpath would have been very much like the one described by the witnesses, the Board concluded.

As the result of its investigation of this accident the Board believes that there is a need for standardization and improved supervision of Ecuatoriana's operation and dispatch procedures. The Board recommends, therefore, that appropriate action be taken to ensure that all Ecuatoriana flights operating into or out of United States' territory are conducted in strict compliance with existing regulations and approved procedures and agreements.

The Board has been advised by the Director General of Civil Aviation of Ecuador that action to correct the discrepancies discovered during this investigation has been initiated.

The Board pointed out that last December, as the result of another fatal accident involving a foreign air carrier, it had recommended that a study be initiated by the Federal Aviation Administration, with the assistance of the Civil Aeronautics Board and the Department of State, to determine the feasibility of formulating a policy whereby parties to a bilateral air route agreement would have the right to inspect, on a continuing basis, the facilities, services, and procedures of all air carriers subject to that agreement.

As a result, the Board said, the FAA proposed amending the Standard Bilateral Air Transport Agreement, which it will coordinate with the CAB and the State Department, to provide for consultation between government technical authorities to assure that adequate safety standards exist and that they are being administered properly.

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SA-None

File No. A-0001

AIRCRAFT ACCIDENT REPORT

**COMPANIA ECUATORIANA DE AVIACION
DOUGLAS C-54-D, REPUBLIC OF ECUADOR, HC-AON
MIAMI INTERNATIONAL AIRPORT
MIAMI, FLORIDA
APRIL 14, 1970**

Adopted: DECEMBER 16, 1970

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D. C. 20591

REPORT NUMBER: NTSB-AAR-71-2

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SYNOPSIS

A Douglas C-54D, HC-AON, of Ecuadorian registration, crashed at Miami International Airport, Miami, Florida, at approximately 0724 e.s.t., April 14, 1970. The aircraft was being operated as an international cargo flight by Compania Ecuatoriana de Aviacion. The accident occurred during the initial climb, following an instrument takeoff on Runway 27 Right at Miami International Airport. The flight was en route from Miami to Panama City, Panama, the first leg of a flight which was to terminate at Quito, Ecuador. The two pilots, the only occupants of the aircraft, were killed, and the aircraft was demolished by impact and postimpact ground fire.

The crew first requested a takeoff clearance at 0621 but because fog reduced visibility to one-eighth mile, the tower controller delayed issuance of the clearance until 0722 when the visibility was reported to be one-quarter mile, the visibility minimum the pilot had stated he needed for takeoff. The crew's acknowledgment of this clearance was the last recorded transmission from the flight.

Following lift-off, the aircraft was observed flying in a level flight attitude at an altitude of approximately 50 feet near the western end of Runway 27R, which was 10,500 feet long. The landing gear was retracted. As the observers watched the aircraft, they saw the nose drop slightly, check, and then the aircraft descended to earth. Impact occurred 279 feet north and 230 feet beyond the western end of the takeoff runway. The aircraft continued 890 feet beyond the initial impact point, struck a concrete abutment and burned.

The Board determines that the probable cause of this accident was improper monitoring of the flight instruments during a takeoff in instrument meteorological conditions. Additional pertinent factors were the use of improper procedures after takeoff and the reduced visibility due to fog.

The Board believes that there is a need for standardization and improved supervision of Compania Ecuatoriana de Aviacion's operation and dispatch procedures. Further, the Board recommends that appropriate action be taken to ensure that all flights operating into or from United States' territory are conducted in strict compliance with existing regulations, approved procedures, and agreements pertaining thereto.

The Board has been advised that the Direccion General de Aviacion Civil of Ecuador has initiated action to correct the discrepancies discovered during this investigation.

The Board also takes this opportunity to reiterate its recommendation that a study be initiated by the FAA, with the assistance of the Civil Aeronautics Board and the Department of State, to determine the feasibility of formulating a policy whereby parties to a bilateral air route agreement would have the right to inspect, on a continuing basis, the facilities, services, and procedures of all air carriers subject to that agreement.

1. INVESTIGATION

1.1 History of Flight

At 0559, 1/ April 14, 1970, the crew of HC-AON, a Douglas C-54D of Ecuadorian Registration, being operated by Compania Ecuatoriana de Aviacion as Ecuatoriana Flight 461, contacted Miami Clearance Delivery by radio and requested an Instrument Flight Rules (IFR) clearance to the Tocumen International Airport, Panama City, Panama. Miami Clearance Delivery advised the crew that Flight 461 could expect a departure on Runway 27R and that the current visibility was 1 mile. At 0603, Flight 461 received an IFR clearance, "as filed," to maintain 3,000 feet after departure, turn left to heading 245° for vectors to Blue eight (airway), departure control frequency 119.7 MHz.

At 0609, the first officer 2/ called the Miami ground controller and requested taxi instructions. The flight was cleared to Runway 27R and the controller advised the crew that the wind was from 300° at 5 knots. At 0621, the crew requested takeoff clearance and the Miami tower controller advised the crew that the visibility was now one-eight mile and asked the pilot what visibility minimum he needed for departure. The captain replied that he needed one-quarter mile visibility for take-off and was told to continue holding short of the runway.

At 0722, the tower cleared Flight 461 into the takeoff position on Runway 27R and advised the crew, "prevailing visibility now 1/4 mile." The flight was then cleared for takeoff and the acknowledgment by the crew at 0723 was the last transmission received from the aircraft. Tower personnel did not observe the takeoff or crash because of the restricted visibility. However, three ground witnesses were located who had observed the aircraft in flight.

One witness, north of the Runway 27R, 6,500 feet from the takeoff threshold, saw the aircraft in level flight 40 to 50 feet above the runway. He reported that the landing gear appeared to be retracted and the engines sounded normal, with no backfiring or malfunctioning.

1/ All times used herein are eastern standard based on the 24-hour clock.

2/ All transmissions emanating from the aircraft were made by the first officer unless otherwise indicated.

Two Venezuelan Airline captains, north of the initial impact point, saw the aircraft flying in a westerly direction about 50 feet above the terrain. They reported that the wings were level and that the aircraft suddenly lowered its nose, lost some height, leveled off again, but continued losing altitude until it struck the ground. They did not notice any variance in the sound of the engines or did they observe any fire, smoke, or other evidence of aircraft malfunction prior to the crash.

The accident occurred at approximately latitude 25° 48' N., longitude 80° 17' W., at an elevation of approximately 9 feet m.s.l.

1.2 Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Others</u>
Fatal	2	0	0
Nonfatal	0	0	0
None	0	0	

Post-mortem and toxicological examinations of the pilots did not reveal any evidence of pre-existing disease or physical impairment that would have adversely affected the performance of their duties.

1.3 Damage to Aircraft

The aircraft was destroyed by ground impact and the ensuing ground fire.

1.4 Other Damage

A section of the airport boundary fence was destroyed and the concrete abutment was struck by the aircraft.

1.5 Crew Information

The crew was properly certificated in accordance with the requirements of the Republic of Ecuador. Ecuatoriana's Chief Pilot said that higher takeoff weather minimums of 300 feet ceiling and 1 mile visibility or 400 feet ceiling and three-fourths mile visibility applied to newly designated captains until they had satisfactorily completed a check flight after 100 hours of pilot-in-command time. No reference to this requirement was found in the company's operations manual and it could not be determined whether the captain of HC-AON was aware of this restriction. The captain of Flight 461 had not completed the required hours of pilot-in-command time nor had he been given the check flight prior to the accident. Therefore, the higher minimums cited above applied to this flight.

Captain Jaime Casares, a 39-year-old native of Ecuador with prior flying experience in the Ecuadorian Air Force, was employed by Compania Ecuatoriana de Aviacion in June 1969. He held an Ecuadorian Airline Transport Rating (ATR) with type ratings in the DC-3, DC-4, DC-6 and B-23 aircraft and a copilot rating in the Lockheed L-188. He also possessed United States ATR Certificate No. 1981452, which was issued on December 19, 1969, for airplanes, multiengine land. His United States certificate showed no aircraft type ratings. Ecuadorian Government records indicated that he had 3,053 hours total flying time, including 318 hours in the DC-4. He had flown 95 hours as captain in the DC-4 since being rated in the aircraft in January 1970. The captain's log-book indicated that he had 253 hours instrument time and 112 hours night flying time. This included 6.25 hours instrument time in the previous 90 days in the DC-4. His first flight to Miami as a captain for Ecuatoriana was made on April 11, 1970, and the accident occurred after takeoff for the return flight to Ecuador.

Captain Casares' first-class medical certificate was issued at Miami Springs, Florida, on April 13, 1970, and contained no limitations or waivers. The captain had received flight training in the Douglas DC-6 at the Miami International Airport during the period January 16 to 22, 1970. Records showed that the captain had completed the following training since June 1969.

Ground Training - 331 hours including 20 hours recurrent training in the Douglas DC-4.

Electronic Trainer - 51 hours including 16 hours in instrument procedures trainers and 35 hours in the DC-6 and L-188 flight simulators.

Flight Training - 70 hours including 2 hours in the DC-4 and the rest in the DC-6, L-188, B-23 and Piper Aztec models. A review of the captain's training records indicated that all his grades were average or above.

A letter from the company, dated January 27, 1970, to Ecuador's Director of Civil Aviation, recommended that Captain Casares be licensed as pilot in the DC-4. The letter stated that he had been duly qualified to serve as pilot-in-command and had completed 60 hours' ground school and "30 hours instruction en route, emergencies, maneuvers, etc."

Copilot Marcelo Crosby, a 33-year-old native of Ecuador with prior flying experience in the Ecuadorian Air Force, was employed by Compania Ecuatoriana de Aviacion in January 1970. He possessed an Ecuadorian ATR pilot certificate with copilot ratings in the DC-3, DC-4, DC-7 and

Comet 4. He had 3,251 hours' total flying time, including 120 hours' copilot time in the DC-4 and 483 hours' copilot time in the DC-7. He had flown 190 hours' copilot time since his initial flight for Ecuatoriana on January 16, 1970, including the 120 hours in the DC-4.

A letter from the company, dated January 27, 1970, to Ecuador's Director of Civil Aviation, recommended that Mr. Crosby be licensed as copilot on the DC-4. The letter stated that he had been duly qualified, having completed ground school, flight instruction en route, and had made at least three takeoffs and landings.

1.6 Aircraft Information

The aircraft, a Douglas C-54D, manufacturer's serial No. 10608, had United States Registration No. N-860F, assigned prior to removal from United States Registry on May 17, 1968. A Certificate of Registration for the aircraft, dated October 29, 1968, was issued to Compania Ecuatoriana de Aviacion by the Republic of Ecuador and the identification HC-AON was assigned. Ecuador's Airworthiness Certificates were valid for 1 year and the certificate for HC-AON would have expired on July 1, 1970.

The aircraft was equipped with Pratt & Whitney R-2000 engines and Hamilton Standard 2E50 propellers. The fuel system was a six wing-tank configuration consisting of four main and two auxiliary tanks, with no provisions for fuel dumping. The cabin was arranged for cargo hauling, and the forward and aft belly compartments were used for cargo space.

The aircraft arrived in Miami on April 11, 1970, after a flight from Quito, Ecuador. It was scheduled for the return flight on the morning of April 13, but the departure was delayed for a main landing gear tire change. A further delay occurred when a crack was found in a wheel rim. The departure was rescheduled for April 14 to avoid a night flight in an aircraft without radar. Other maintenance performed in Miami, prior to the departure on April 14, included repair of an oil leak on the No. 1 engine, repair of a broken wire on the No. 2 generator, repair of the wheel brake system, and repair or replacement of the Very High Frequency (VHF) communications equipment.

The authorized maximum gross takeoff weight for the aircraft shown on the FAA Aircraft Specifications was 73,000 pounds and the maximum landing weight was 63,500 pounds. The calculated maximum permissible gross takeoff weight for Flight 461 was 72,060 pounds at Miami due to the landing weight limitation. Records showed that 2,000 gallons of fuel and 18,359 pounds of general cargo were on board the aircraft at Miami and that the gross weight for takeoff was 71,989 pounds. There was no record that the center of gravity of the aircraft was computed prior to the take-off.

The aircraft records showed a total airframe time of 20,413 hours at the time of takeoff. The last major airframe inspection (500-hour) was performed on February 13, 1970, at 20,266 hours. Except for subsequent engine changes, the records showed that only routine maintenance had been performed since the last 500-hour inspection. The records showed that the aircraft had been maintained in accordance with the company's maintenance program. Engine installation dates, times since overhaul, and latest inspections were as follows:

<u>Engine No.</u>	<u>Installed</u>	<u>Time Since Overhaul</u>	<u>Type/Date Last Inspection</u>
1	12-30-69	228	150-hour, 3-23-70
2	4-2-70	28	Not Applicable
3	4-2-70	471	Not Applicable
4	11-11-69	320	150-hour, 4-8-70

According to the maintenance records, the aircraft was in an airworthy condition at the time of the takeoff. The aircraft was refueled with grade 100/130 aviation fuel and 120 aviation oil prior to the flight.

An error in posting on the flight logsheet, dated June 14, 1968, showed a total aircraft time of 19,784 hours which was carried forward to the next logsheet, dated June 24, 1968, as 18,829 hours. This 955-hour error in the total aircraft time was carried forward in the logsheets after June 14, 1968.

1.7 Meteorological Information

Fog was prevalent at Miami International Airport at the time of the accident. It began as ground fog at 0530, became fog at 0557, and continued until after the accident.

The visibility was reduced to one-eighth mile at 0626 and increased to one-quarter mile at 0721. Weather Bureau observations completed at 0628 and 0723 showed the surface visibility as one-eighth mile and one-quarter mile, respectively.

The ceiling was a "measured 200 feet broken from 0559 to 0621," an "indefinite 200 feet obscuration from 0621 to 0653," an "indefinite zero obscuration from 0653 to 0723," and an "indefinite 100 feet obscuration from 0723 to 0830."

The 0723 weather observation was the controlling observation at the time of the takeoff and accident. It was as follows: "Indefinite 100 feet obscuration, visibility 1/4 mile, fog, wind 300° 5 knots, altimeter setting 29.95 inches, Runway 27L visual range 600 variable to 1,200 feet." ^{3/}

The Miami 0715 winds aloft observations for 1,000 and 2,000 feet m.s.l. were 290° true 5 knots and 280° true 7 knots, respectively.

The Miami 0715 radiosonde ascent (below 4,000 feet m.s.l.) showed stable air below approximately 1,100 feet with conditionally unstable air above 1,100 feet, a 3° C. inversion from approximately 400 to 1,100 feet, moist air below approximately 400 feet, and dry air above 400 feet. The freezing level was near 13,800 feet m.s.l.

Pertinent aviation terminal forecasts issued by the Weather Bureau Forecast Office at Miami were in part as follows for Miami:

Issued at 0545, valid 0600 to 1800. 0600 to 0900, clear visibility 7 miles. Issued at 0600, valid 0600 to 1800. 0600 to 0800, clear, visibility 1 mile, ground fog, brief ceiling 200 feet obscuration, visibility 1/2 mile, fog.

Issued at 0720, valid 0720 to 1800. 0720 to 0930, ceiling zero obscuration, visibility 1/4 mile, fog.

An Inflight Weather Advisory issued by the Weather Bureau Forecast Office at Miami at 0630 to 1100, was as follows:

"AIRMET Alfa 4. Cancel AIRMET Alfa 3. Over the Florida mainland and adjacent coastal waters extensive ceilings and/or visibilities below 1,000 feet and 2 miles in stratus and fog, locally ceilings and visibilities near zero. Cancel advisory at 1100."

1.8 Aids to Navigation

Runway 9L, the reciprocal of the runway which was used for the takeoff, was equipped with an instrument landing system (ILS). It could not be determined whether the pilot of Flight 461 used this system for azimuth information during the takeoff. The flight did not progress to

^{3/} Runway Visual Range equipment was installed only on the approach ends of Runway 9L and 27L.

a point where any other navigational aids would have been involved. No irregularities of the ILS or other available aids to navigation are reported. A flight check on April 14, 1970, reported that the ILS was operating normally.

1.9 Communication

No communications difficulties were noted or reported. The copilot's voice was identified as the one making most of the radio transmissions from Flight 461.

1.10 Aerodrome and Ground Facilities

Runway 27R was asphalt surfaced, 10,500 feet long and 150 feet wide. It was equipped with high-intensity runway lights and runway centerline marking. The high-intensity runway lights were set at either the brightest or next brightest setting at the time of the takeoff of Flight 461. The approach lights at the departure end of Runway 27R were on but were shielded and were not visible to crews departing over them.

1.11 Flight Recorders

No flight or voice recorders were installed aboard the aircraft or required by regulation.

1.12 Wreckage

The aircraft initially struck the ground in a near-level attitude at a point 279 feet north and 230 feet west of the end of Runway 27R. The aircraft continued 890 feet across airport property on a 274° magnetic heading and collided with a concrete abutment at the north-south perimeter road, just west of the airport boundary, where it burst into flames. A number of separated aircraft components, flight control surfaces, and fragments of structure were found in the aircraft's ground contact path. After the impact, the fuselage and empennage came to rest in a canal west of the perimeter road. Some cargo and wreckage were found on the west bank of the canal, 1,110 feet from the initial impact point. (See Attachment No. 1.)

The four engines separated from their wing attachments and the four propellers detached from their respective engines. Both wings separated between the inboard nacelles and the fuselage. The cockpit and a cabin, forward of the wing leading edges, were destroyed and there was no assemblage of the various components in the area. The fuselage, wings, and empennage were damaged by fire. No evidence of preimpact failure or malfunction of any aircraft structural member, system, or component was found.

The engines did not show evidence of any preimpact failure or malfunction. The carburetor air screens, fuel screens, and main oil screens were free of contamination. The spark plugs did not show evidence of deterioration of the leads, arcing, metal deposits, copper runout, erosion of the center electrodes, or fouling. Cylinders were removed from each engine, and the integrity of the internal components of each engine was confirmed. Examination of the propeller blade spider shim plates showed that all of the blades from the No. 1 propeller were at 28° and two blades from the No. 4 were at 25° . The remaining shim plates were damaged and a determination of the blade angles could not be made. Propeller dome markings indicated that the propeller angles at impact were: No. 1, 28° ; No. 2, 31° ; No. 3, 31° ; No. 4, 41° . All four of the propeller dome low pitch stops were positioned at 24° .

Eleven propeller blades were bent aft and the remaining blade was bent forward. The blades of all four propellers made distinct slash marks in the terrain at the initial impact point. The distances from the first to the fourth slash mark, which comprises the one propeller revolution, were as follows: No. 1, 10 feet 5 inches; No. 2, 10 feet 8 inches; No. 3, 10 feet 8 inches; No. 4, 11 feet.

The engine r.p.m. should have been 2,700 at the takeoff power setting and 2,550 at the maximum except takeoff (METO) power setting. The engine r.p.m. at the time of the crash is unknown. The Nos. 2 and 3 propellers contacted the ground first, and computations using the above data show that the groundspeed would have been approximately 142 knots with takeoff r.p.m. and 134 knots with METO r.p.m.

The pilot's instrument panel and the center instrument panel separated from the aircraft and were found on the perimeter road. Portions of the co-pilot's panel, the overhead panel, center console, and other cockpit devices were recovered from the canal west of the perimeter road. Pertinent control valve settings and instrument readings were as follows:

- a. The control column gust lock was found in the "OFF" (down) and latched position.
- b. The landing gear lever was in the retracted position.
- c. The flap lever was in the neutral position.
- d. All four main fuel tank selector valves were "ON".
- e. The six fuel boost pump switches, four mains and two auxiliaries, were in the "LOW" boost positions.

- f. The Nos. 3 and 4 mixture control levers were in the full rich detent. The Nos. 1 and 2 mixture control levers were near the rich position but not in the full rich detent.
- g. The master ignition switch was "ON"; the Nos. 1, 3, and 4 magneto switches were on "BOTH", and the No. 2 magneto switch was in the "RIGHT" magneto position.
- h. The elevator trim tab indicator was found on a 4° nosedown setting. The normal tab setting for takeoff was approximately 0°. The aileron and rudder trim tab indicators were not found.
- i. Selected instruments were examined by technicians at FAA-certified instrument repair station under the supervision of NTSB personnel.

The results of these examinations were as follows:

- (1) Pilot's directional gyroscope (gyro) - The rear cover case was removed and distinct and shiny directional scoring marks were observed on the rotor.
- (2) Pilot's gyro horizon - Rotation of the gyro rotor was observed when the unit was connected to test equipment. The caging knob was damaged but frozen in the "UNCAGED" position.
- (3) Flap position indicator - The indicator needle was impinged at an 8° flap setting. The broken cover glass was removed and the unit was found intact and operated satisfactorily when connected to test equipment. The indicator needle on a serviceable instrument oscillated when the unit was disconnected from the test equipment and shaken or moved abruptly.
- (4) The flap position transmitter was removed from the left wing. The unit was damaged to an extent that precluded a determination of the setting at the time of the crash.

The attitude indicators on this aircraft contained suction-driven gyroscopes, universally mounted, so that their spin axes could assume any position in space. The vacuum pumps that provided suction for these instruments were

mounted on both inboard engines and either pump could be selected to provide the vacuum supply to the instruments. Approximately 5 minutes of operation would be required to bring the gyros up to speed to provide normal attitude indications. This type of attitude indicator was limited to 60° of pitch, up or down, and 100° roll, right or left.

There were certain inherent errors in this type of indicator, but they were generally errors of not more than 3°. One of these errors was a pitch error in the indicated attitude that could be caused by acceleration such as that which occurs during takeoff. This error would appear as an indication of climb. The size of the instrument presentation was such that very small movements of the indicator represented most normal climb and descent pitch attitudes.

The following trim tab measurements were made with the control surfaces in the streamline positions.

- a. Right aileron tab - 1/2 inch down.
- b. Rudder tab - 1 3/4 inches left.
- c. Left elevator tab - 7 1/2° down.
- d. Right elevator tab - 20° down.

A piece of the right wing flap, extending from 24 inches inboard of the No. 3 nacelle to the No. 4 nacelle, was found attached to a section of the right wing. Two sections of the left wing flap, 2 feet and 5 feet long, were found in the wreckage path on the airport. There was no evidence of ground contact in the form of dents or abrasions along the bottom trailing edges of any of the flap sections that were recovered.

The wing flap control valve, the pressure-operated check valve, and the temperature relief valve were not recovered. The four flap actuating cylinders, two mounted in each wing, were attached to sections of the wings. One inch of the actuating rods were exposed on the right wing cylinders and the left wing outboard cylinder. The left wing inboard actuating rod was in the full up position. The hydraulic lines to the actuating cylinders had separated leaving the pistons free to float. The flap actuating rods were not bent nor were there any marks on the actuators that might indicate the wing flap position on initial ground contact. No gouge marks or impressions were found in the terrain along the ground skid path that could be related to wing flap extension below the fuselage. No witness was found who had observed the position of the wing flaps while the aircraft was parked on the runway adjacent to the runway, during the takeoff ground roll, or when the aircraft was airborne.

1.13 Fire

The wreckage sustained extensive fire damage when the aircraft burst into flames after colliding with the concrete abutment at the airport boundary. A passerby took a picture of the scene immediately after the crash that showed flames billowing from the width of the canal west of the airport perimeter road.

The fire station at Miami International Airport was located between the runways, approximately 2,000 yards from the site of the accident. Crash alarms could be passed to the fire department by an alarm system activated by tower personnel or by telephone from any location.

Tower personnel did not observe the crash because of the restricted visibility; however, the alarm was given to the fire department by telephone by an unidentified male. The alarm was received at 0731, and the five assigned firefighting vehicles and 17 firefighters were dispatched to the location given by the informant. No evidence of an accident or fire was seen at the designated location but the firemen noted people staring and running toward the runway, and followed them. When the firemen were approximately 500 feet from the crash, the fog became blacker and as they continued, they saw aircraft components and fire. Foam and water were used to extinguish the fire, and the equipment was released at approximately 0930.

1.14 Survival Aspects

This was a nonsurvivable accident. The bodies of both crewmembers were recovered from the canal west of the airport perimeter road in the late afternoon of the accident date. The autopsy reports indicated that one pilot died of injuries and the other of trauma and drowning. The cockpit area was completely disrupted by the impact.

1.15 Tests and Research

Aircraft performance data - The performance data listed below were obtained from a U.S. Air Force C-54 Flight Manual (for a gross weight of 72,000 pounds):

- a. Takeoff ground run, 4 knot headwind component at sea level - 3,050 feet.
- b. Power off stalling speed, (15° wing flap setting) - 88 knots.

- c. Power off stalling speed, (0° wing flap setting) - 102 knots.
- d. Takeoff speed (115 percent of power off stalling speed for 15° wing flap setting) - 101 knots.
- e. Flap retraction speed (120 percent of power off stalling speed for 0° flap setting) - 123 knots.
- f. Altitude at end of a 10,500 foot runway - in excess of 300 feet (goes off the chart due to runway length).

Normal takeoff procedures outlined in the flight manual were as follows:

- a. After landing gear retraction and attaining the minimum flap retraction speed of the 120 percent of the power off stalling speed (123 knots), the flaps could be retracted and the aircraft accelerated to the recommended climb speed.
- b. If the wing flaps were retracted during a period of normal acceleration, no change in aircraft attitude would be required to maintain a relatively constant flightpath slope; however, if wing flap retraction was delayed until a constant airspeed or slower rate of acceleration was attained, it would be necessary to increase the angle of attack as the wing flaps retracted. If the angle of attack was not increased, settling would occur.

The wing flaps extended 12 inches below the fuselage of another DC-4 aircraft when set at 15° , the takeoff setting.

The company's Chief Pilot flight-tested the effect of wing flap retraction immediately after takeoff with the landing gear extended. The test was conducted at Guayaquil, Ecuador (elevation 13 feet m.s.l.), in a C-54 equipped with R-2600 engines. An attempt was made to simulate a fully loaded C-54 model equipped with R-2000 engines, but the validity of the simulation was not ascertained. He reported that when the wing flaps retracted, an abrupt increase in the angle of attack was required to avoid settling back onto the runway.

1.16 Other Information

Ecuadoriana's Operations Manual related to the L-188 and DC-6 aircraft models and did not make specific reference to the DC-4 model. The company maintained an Operations base at the Miami International Airport, employed a United States certificated dispatcher and did not utilize the services of any contract agency in the dispatching of their flights. The manual stated that the dispatcher would file a flight plan, complete a weight and balance form, and present them to the captain for approval.

The captain of Flight 461 telephoned his flight plan to the Miami International Flight Service Station. A carbon copy of a DC-6/L-188 cargo weight and distribution form prepared for Flight 461 was on file in the Operations office. The form showed 18,359 pounds of cargo aboard the aircraft including 16,859 pounds in the cabin, 1,000 pounds in the forward belly compartment, and 500 pounds in the aft belly compartment. The cargo was general in nature and loaded so that it could be removed without rearranging any other. This copy was signed by the captain but did not bear the dispatcher's signature. The dispatcher said that he had signed the original. No record was found to indicate that the aircraft's center of gravity had been computed for the flight. The dispatcher produced a blank load distribution chart for a DC-4 aircraft model similar to the one he said had been completed for the flight and given to the captain. The completed form was not on file in the Operations office. The dispatcher stated that: "This was Captain Casares' first flight to Miami and I didn't know how he wanted things done."

Authorization for dispatch of flights from Miami was normally transmitted by teletype message from the company's headquarters in Quito, Ecuador. The dispatch message relating to Flight 461 was not received by the Miami base. The flight had been delayed due to maintenance and copies of messages relating to the flight between Quito and Miami were on file. The Miami base transmitted a departure message for Flight 461 on April 14, 1970, before becoming aware of the accident.

The company's Chief Pilot stated that the following takeoff procedures were utilized as a standing operating procedure:

- a. After takeoff and upon attaining a position indication on both the vertical velocity indicator and altimeter, the captain would call "Gear Up." The copilot would respond "Gear Up" and move the landing gear lever to the retracted position.
- b. The copilot would call "No Lights" when the landing gear lights went out.

- c. Power could be reduced to the METO setting after the gear lights went out but takeoff power was to be maintained to an altitude of 200 feet above the terrain, when the takeoff was made in instrument meteorological conditions.
- d. At no less than 300 feet above the terrain and after attaining the minimum flap retraction speed, the captain was to call "Flaps Up." The copilot would respond "Flaps Up" and move the wing flap lever to the up position.
- e. METO power was to be maintained to no less than 500 feet above the terrain.

A normal climb speed of 126 knots was recommended by the carrier. The company's Operations Manual and the Operations Specifications listed takeoff minima of 100 feet ceiling and one-fourth mile visibility for four-engine aircraft from runways equipped with high-intensity lights or runway centerline marking. These criteria were met by the weather and runway at the time the takeoff clearance was issued to Flight 461.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The flightcrew were properly certificated and had received the required training for the duties they were performing.

The aircraft was properly certificated and the airworthiness certificate was current. The record indicates that the aircraft was in an airworthy condition at the time of takeoff.

The flight was conducted in weather conditions which met the criteria established by the carrier's Operations Specifications. The carrier's spokesman has stated that higher minimums than those established by the Operations Specifications applied to the captain of this flight. However, these higher minimums were not contained in the carrier's Operations Manual and there is some doubt that the captain of Flight 461 was aware of them.

No evidence was found to indicate that a powerplant malfunction played any part in the cause of this accident. The propeller settings, calculated from the evidence collected during the investigation, were approximately in the range they should have been for that stage of the flight. The calculated airspeed at impact, between 134 and 142 knots, was well above the stalling speed of the aircraft in the cruise configuration.

This airspeed, considered in conjunction with the flight profile described by the witness and the physical evidence observed at the accident site, indicates that the aircraft struck the ground in controlled flight.

No evidence was found that indicated a failure or malfunction of any structural components or flight controls of the aircraft. There was no visible or audible malfunction of the aircraft or the powerplants, and there was no evidence of in-flight fire, aircraft component separation, or incapacitation of either pilot.

The aircraft trim tab settings could not be determined by examination. However, there was nothing in the described flight profile that suggested either a grossly out-of-trim condition or an out-of-balance condition insofar as the aircraft center of gravity (c.g.) was concerned.

If a C-54 were loaded so as to exceed the aft c.g. limit, the aircraft would be very difficult to taxi because the download on the nose landing gear would be relieved and this would allow the centering cam device to activate. With the centering cam device activated, the nose gear steering would be deactivated. There is nothing in the record to indicate that this condition existed.

The Board's examination of the weight and balance calculation indicates that the forward c.g. limit was not exceeded. The type, weight, and general location of the cargo indicated that the c.g. was within limits at the time of the takeoff.

The Board notes that the dispatching of this flight was not accomplished in accordance with the existing rules and procedures although the carrier's Operations Manual prescribed such rules for the pilot and the dispatcher. The center of gravity was not computed and recorded prior to takeoff. The cargo and weight distribution was not recorded on a form applicable to the DC-4. The form used was applicable to the DC-6 and the L-188. Finally, the captain filed his own flight plan rather than following the procedures outlined in the manual which required the dispatcher to plan and file the flight plan with the captain's concurrence.

The Board also notes that while the carrier's operations specifications authorized the use of the three cargo-carrying C-54's, the Operations Manual did not contain specific operating instructions for the C-54 but was devoted to the DC-6 and the L-188.

The Board's review of the weather forecasting and reporting indicates that the forecasts were timely and that the reporting was conducted in accordance with the existing rules and regulations. The official prevailing visibility at the time of takeoff was one-fourth mile. This value was observed by personnel in the tower and by the Weather Bureau personnel at ground level. The aeronautically qualified witnesses in the vicinity of the runway indicated that visibility was between one-eighth and one-fourth mile. The Runway Visibility Range (RVR) at the departure end of Runway 27F was approximately 1,000 feet or less at takeoff. There was no RVR available on the approach end of Runway 27R. The prevailing visibility thus became the controlling visibility for operations from this runway.

After reviewing the flight profile described by the ground witnesses, the Board calculated a normal takeoff profile to compare with the one described.

Normally, the aircraft would have had 15° of landing flaps extended at takeoff. The takeoff roll should have been approximately 3,050 feet. As soon as the aircraft instruments showed a positive indication of a climb, the landing gear should have been retracted. After landing gear retraction, the aircraft should have been accelerated in a climbing attitude and climb should have been maintained at takeoff power, until the aircraft was 200 feet above the ground, at which time the power should have been reduced to METO. The climb should have been continued

to 300 feet above the ground, at which point the landing flaps should have been retracted. As the landing flaps were retracted, the aircraft should have been accelerated to the recommended climbing airspeed while maintaining a positive rate of climb.

Had the takeoff been performed in this manner, the aircraft would have been approximately 200 feet above the ground at the point where it was first observed, approximately 6,500 feet from the beginning of the takeoff roll. By the time the aircraft reached the departure end of the runway, it should have been more than 300 feet above the ground with the flaps retracted, landing gear up, and climbing at METO power at an indicated airspeed of 126 knots.

The observed flightpath indicated that the aircraft leveled off at 40 to 50 feet above the ground and that the landing gear was retracted. The aircraft passed the point 6,500 feet from takeoff at approximately that altitude and continued to fly in a level attitude until it approached the departure end of the runway, approximately 10,500 feet from the initiation of the takeoff. At that point, the nose dropped slightly, checked, and then the aircraft descended to the ground.

In view of the fact that there was no evidence of malfunction of the flight controls or the powerplants, the Board examined the possibility that some malfunction of the flight instruments or the use and interpretation of these instruments caused this accident.

A review of the maintenance records covering a 12-month period prior to the accident revealed only one writeup regarding these instruments. The captain's attitude gyro vacuum lines were drained March 24, 1970. There were no uncleared writeups of this system. Our examination of the captain's suction instruments indicated that they were powered and uncaged at the time of impact. The Board therefore believes that these instruments were operating normally at the time of takeoff.

There are two problems associated with instrument takeoffs in a condition of low visibility and no horizon that appear to be pertinent to this accident. These problems are acceleration-induced errors in the attitude indicator and acceleration-induced false sensory perceptions by the pilot.

Research into the effects of acceleration forces on gyroscopic instruments has been conducted over the years. This research has indicated as the aircraft accelerates, the vertical reference force applied to the gyro shifts, resulting in an error in the presentation on the attitude indicator. The magnitude of this error is a function of the acceleration and, in the case of transport aircraft, has been calculated to be from 3° to 5°. The effect of this error is to cause the appearance of a higher-than-actual pitch attitude on the attitude indicator.

The remedy for this problem is to cross-check all of the flight instruments and if it is discovered that the altimeter and vertical speed indicators do not indicate a climb, while proper airspeed is maintained the pitch attitude should be increased until positive climb indications appear on these instruments.

The second problem, induced perception error on the part of the pilot, is also caused by acceleration of the aircraft. ^{4/} The acceleration force imposed on the pilot, combined with the vertical force of gravity and the resultant force vector, causes the pilot to feel that he has tipped back and is climbing when in fact the aircraft may be level or even descending. This phenomenon is particularly effective when there is no visible horizon due to weather or darkness. Again, the remedy is proper cross-checking of all the flight instruments to assure that the aircraft is performing the maneuver desired by the pilot. If the pilot should consciously or unconsciously correct for this feeling after take-off, he could fly the aircraft level or into descending flight, rather than in a climb.

The Board believes that one or both of these conditions existed in this case. The flightpath described by the witnesses indicates that the aircraft climbed to an altitude of approximately 40 to 50 feet above the ground and leveled off. As soon as the landing gear was retracted, the acceleration initiated at takeoff would have increased and this could have induced or aggravated the errors in the attitude indicator and the pilot's perception. If the pilot reacted to these errors and his instrument cross-check was faulty, interrupted, or disturbed by after-takeoff cockpit activities, the resulting flightpath would have been very much like the one described by the witnesses.

The landing flaps were found retracted. The retraction of the flaps would have increased the acceleration as well as causing a nosedown pitching motion which would require back pressure on the elevator control to counteract. This condition probably occurred during the latter portion of the flight over the runway when the witnesses observed the nose of the aircraft descend, check slightly, and then the aircraft descended to the ground. The acceleration caused by the nosedown attitude of the aircraft at this point in the flight would have been added to any pre-existing acceleration errors in the attitude indicator and/or the pilot's perception of his attitude.

^{4/} Army Flight Surgeon's Manual, Vol. I, P. 13-37, 1970.

After due consideration, the Board believes that a finding of flight instrument malfunction cannot be sustained and that incorrect use or interpretation of the flight instruments led to this accident.

2.2 Conclusions

(a) Findings

1. The flightcrew was properly certificated and had been trained to perform their duties.
2. The aircraft was airworthy and properly certificated at the time of takeoff.
3. The flight was conducted in weather conditions that were reported to have met the minimums specified in the carrier's Operation Specifications.
4. The carrier indicated that higher-than-standard minima applied to the captain of this flight. These higher minima were not published in the Operations Manual and there is some doubt that the captain of Flight 461 was aware of them.
5. There was no evidence found that indicated any malfunction of the powerplants. They were operating in the power range appropriate for the stage of the flight existing prior to impact.
6. The calculated airspeed at impact was between 134 and 142 knots.
7. There was no evidence of a stall, loss of control, or flightcrew incapacitation.
8. There was no evidence of a significant out-of-trim condition at impact.
9. The weight and balance was not properly computed or recorded prior to takeoff. However, the Board believes that the center of gravity was within the established limits. The weight was lower than the prescribed maximum.

10. The flight was not dispatched in accordance with the existing company rules and regulations.
11. The carrier's Operations Manual did not contain operating instructions for the C-54 aircraft although they were authorized to use three C-54's in this service.
12. The weather forecasting was timely, and the weather reporting was conducted in accordance with the existing rules and regulations.
13. The official prevailing visibility was one-quarter mile, but pilots in the vicinity of the runway reported visibilities of between one-eighth and one-quarter mile. The Runway Visual Range in the accident area was 1,000 feet or less. In these circumstances, the prevailing visibility was the controlling visibility for the takeoff.
14. The takeoff profile of this flight did not conform to that prescribed by the carrier.
15. The aircraft was observed by aeronautically qualified witnesses at two points, 6,500 and 10,500 feet from the initiation of the takeoff. In both cases, the landing gear was up and the aircraft's altitude was approximately 40 to 50 feet above the ground. Witnesses did not observe the position of the landing flaps.
16. During the second observation, the aircraft's nose was lowered, leveled off slightly, and then the aircraft descended into the ground.
17. There was no significant flight instrument problems recorded in the maintenance records.
18. The attitude indicator installed in this aircraft was subject to acceleration errors which could have been as much as 30° to 50°.
19. These same acceleration forces can cause a pilot to feel as though he is climbing when the aircraft is level or descending.
20. A continuous comprehensive cross-check of all the flight instruments would give the pilot the true attitude of his aircraft and overcome the problems generated by these acceleration forces.

21. The landing flaps were retracted at impact, indicating that the crew retracted them before they reached a point 300 feet above the ground as prescribed by the Operations Manual.
22. The Board is unable to determine whether this retraction of flaps was intentional or inadvertent.
23. The attitude of the aircraft at impact indicates that the aircraft was under control.
24. The airspeed at impact was higher than that which should have been used for a normal climb.

(b) Probable Cause

The Board determines that the probable cause of this accident was improper monitoring of the flight instruments during a takeoff in instrument meteorological conditions. Additional pertinent factors were the use of improper procedures after takeoff and the reduced visibility due to fog.

3. RECOMMENDATIONS

The investigation of this accident has produced evidence indicating that the flight preparations and conduct were not in accordance with the existing rules and regulations governing this operation.

The Board believes that there is a need for standardization and improved supervision of Compania Ecuatoriana de Aviacion's operational and dispatch procedures for their flights into and out of the United States.

Therefore, the Board recommends that appropriate action be taken to ensure that all Compania Ecuatoriana de Aviacion flights operating into or out of the United States be conducted in strict compliance with existing regulations, approved procedures, and agreements pertaining to such flights. In this connection, the Board has been advised that the Direccion General de Aviacion Civil of Ecuador has initiated action to correct the discrepancies discovered during this investigation.

The Board also takes this opportunity to reiterate its recommendation that a study be initiated by the FAA, with the assistance of the Civil Aeronautics Board and the Department of State, to determine the feasibility of formulating a policy whereby parties to a bilateral air route agreement would have the right to inspect, on a continuing basis, the facilities, services, and procedures of all air carriers subject to that agreement.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

December 16, 1970.

NOT IDENTICAL TO THE
NORTH ATLANTIC OCEAN
ATLAS, 1964-1965

