CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: May 19, 1954 Released: May 27, 1954

NATIONAL AIRLINES, INC. - IN GULF OF MEXICO, FEBRUARY 14, 1953

The Accident

National Airlines' Flight No. 470 of February 14, 1953, a DC-6, N 90893, was lost with all 46 persons aboard off Mobile Bay, Alabama, at about 1710.1/ Seventeen bodies and light parts of the aircraft surfaced and were recovered the following day. It was not until May 20 that a part of the aircraft structure was recovered. Subsequently, approximately 75 per cent of the wreckage was located and raised.

History of the Flight

Flight 470 originated at Miami, Florida, for New Orleans, Louisiana, with one stop scheduled at Tampa, Florida. Captain Ernest Springer, First Officer C. T. Stettner, Flight Engineer Edward Campion, and Stewardesses L. Blamseuser and B. Baucom comprised the crew.

Both pilots reviewed the weather situation at the company's Miami Flight Control office.2/ This weather data consisted of U.S. Weather Bureau sequence weather reports, upper air winds and regional and terminal forecasts. The company's flight superintendent discussed the expected weather with both pilots. All available pertinent weather data were attached to the flight's clearance.

From Miami the flight was uneventful, with departure at 1415, and according to Visual Flight Rules, with the Tampa landing at 1515. Both pilots went to the company's Tampa operations office and obtained the flight's clearance to New Orleans. Additional weather information then available, the 1430 sequence report including weather at New Orleans and stations along the Gulf coast, was attached to the clearance. Fuel was added, bringing the total to 2,100 gallons. Seventeen passengers boarded at Tampa and there were 24 through passengers, making a total of 41, and five crew members. Upon departure, at 1543, the aircraft's gross weight was 78,580 pounds, or 11,320 pounds less than the maximum of 89,900, and its center of gravity was located within prescribed limits.

Another National Flight, No. 917, also a DC-6, had left Tampa for New Orleans at 1311. At 1524, 19 minutes before the departure of Flight 470,

1/ All times herein are Central Standard, and based on the 24-hour clock.

2/ National Airlines has a direct teletype service with the U. S. Weather Bureau, wherein it automatically receives the latest weather information from Miami and New Orleans and intermediate stations.

National's Flight Control at Miami sent Radio-New Orleans this message, "Ask Captain Abel to give us picture of flying conditions on hold over New Orleans. Stop. If out of ordinary give to Flight 470. Acknowledge."

There are three position reporting points over the Gulf of Mexico between Tampa and New Orleans, all determined by radio fixes. They are, from east to west, NA-3, 145 miles from Tampa; NA-2, 131 miles from NA-3; and NA-1, 115 miles from NA-2. NA-1 is 107 miles from New Orleans.

As stated, Flight 470 departed Tampa at 1543. Its flight plan, filed previously at Miami, specified a cruising altitude of 14,500 feet according to Instrument Flight Rules and an estimated elapsed time of two hours for the direct 498 statute miles to New Orleans. Included among the weather data attached to the captain's copy of the flight plan was a forecast of thunderstorms attended by moderate to severe turbulence in the vicinity of New Orleans, the destimation. The CAA Air Route Traffic Control cleared the flight at the 14,500-foot level direct to New Orleans.

Flight 470 passed over NA-3 at its cruising altitude of 14,500 feet at 1614, estimating over NA-2 at 1642, and so reported to Radio-Tampa one minute later. At that time the flight also gave the local weather: broken clouds at 6,000 feet, broken clouds at 20,000 feet and temperature 4 degrees Centigrade.

Meanwhile, Flight 917 landed at New Orleans at 1612. It reached the ramp at 1617 and at 1624, its captain sent the following message to Miami Flight Control and to all company stations between New Orleans and Jacksonville, Florida, including Pensacola, Florida: "Flight 917 advises extreme turbulence all altitudes just east of New Orleans." At 1636, the captain sent the following message to the same stations: "Reference extreme conditions stop at present time severe turbulence No. 1 check (NA-1) to New Orleans weather looks better to west of New Orleans."

At 1649, Flight 470 reported passing over NA-2 at 1645 at 14,500 feet, and estimated being over NA-1 at 1710. It also reported, "Thunderstorms all quadrants . . ." Pensacola radio received and acknowledged this message, and advised the flight of "severe turbulence" between NA-1 and New Orleans as reported by Flight 917. Flight 470 acknowledged, asked what altitude Flight 917 reported turbulence, and was informed "severe turbulence at all altitudes." Again Flight 470 acknowledged.

At 1654, the flight advised Pensacola that it was reducing power because of turbulence and five minutes later requested Air Route Traffic Control clearance to descend from 14,500 feet to 4,500 feet. This was granted within a minute or so, with the provision that descent between 10,000 feet and 8,000 feet be visual. At 1703, the Flight advised Pensacola of passing through 10,000 feet, and at 1712 (recorded), advised that it had reached 4,500 feet at 1710. Pensacola repeated this message back to the flight and gave it the 1648 New Orleans special weather. This was: measured 800, overcast, visibility 10 miles, wind north-northeast 25 m.p.h., with gusts to 34, the altimeter 29.61; barometer unsteady. The flight acknowledged and there were no further radio contacts.

An attempt by New Orleans at 1718 to contact Flight 470 was unsuccessful, as were subsequent attempts by several other stations, and at 1840 the Coast Guard's air-sea rescue service was alerted.

Low clouds and heavy seas hampered the search both by air and sea. However, on the following day (February 15) floating debris and 17 bodies were recovered from a fairly localized area in the Gulf of Mexico at about 30° 38' North Latitude and 87° 46' West Longitude. This position is approximately 38 miles to the right of the aircraft's direct course and is about 20 miles southeast of Mobile Point at the easterly mouth of Mobile Bay. Two wrist watches on bodies were impact stopped at 5:10 (1710).

Investigation - Part I - General

The floating debris that was recovered the day following the accident was carefully examined. This material consisted of hand luggage, personal belongings, and numerous diversified broken and torn fittings and furnishings from all sections of the cabin. Severe damage to many of these small articles, such as the extreme distortion of a lady's metal compact within a leather purse, indicated that the impact forces must have been of great magnitude. Early in this search there were false rumors of distress signals of a type that could have come from the aircraft's emergency transmitter (Gibson Girl). However, the emergency transmitter could not have been used except from a life raft; none had been inflated and condition of the bodies told clearly that no one had survived, even briefly. Two fully discharged CO_2 bottles of the aircraft's main fire extinguishing system were also floating among the debris. Their attached actuating cables were broken, thus indicating that they were discharged when thrown free at time of impact. None of the floating material showed any evidence of fire.

All of the seventeen recovered bodies had numerous fractures and a few bore marks of discoloration. These marks were first and second degree burns and were scattered over various parts of anatomies with no apparent pattern. The cause of these burns could not be determined with finality but competent medical opinion is that they were not electrical (lightning) but were possibly friction, or more likely, thermal as from exposure to a flash fire following impact.

When it became apparent that the actual wreckage site was not in the immediate vicinity of the recovered floating material, an intensive organized search of the surrounding area in the Gulf was instituted. Aircraft of the company, the United States Navy, the United States Coast Guard and surface craft of the Navy and Coast Guard as well as pleasure and fishing boats, participated. The Navy did considerable diving at suspected locations. This search proved futile and was discontinued officially on March 20, 1953, after it appeared improbable that the wreckage could ever be located. But a group of the passengers' relatives elected to continue an unofficial search, and on May 20 commercial fishermen in their employ located a piece of wreckage of N 90893. At the request of the Board, the Navy and the Coast Guard once more renewed their search and diving activities and in the subsequent days two separate wreckage areas were located. The main wreckage area was located at Latitude 30° 10' 25" North and Longitude 87° 57' 10" West, and contained fuselage parts, right wing parts and the Nos. 3 and 4 power plants. The second area was located 2,100 feet to the northwest of the main wreckage on a bearing of 331°, and left wing parts and the No. 1 power plant were found in this area. Water depth at both places is about 50 feet and the distance from the Gulf shore is about 3.8 miles.3/

3/ See Attachment A.

The floor of the Gulf in the vicinity of each of the wreckage areas was thoroughly explored by Navy and other divers. Several hundred dives, both by deep sea equipped divers and by shallow water equipped divers (frogmen) were made during the course of this work. It is estimated that about 75 per cent of the total structure was recovered from the two wreckage areas. Major components that were not recovered included the No. 2 power plant, the empennage, the left aileron, and a portion of the left wing from Station 60 near the fuselage outboard to about Station 130. Since it was felt that the recovery of these components would shed additional light on the probable cause of the accident, the search activities were extended to a larger area in an effort to locate these parts. Sonar sweeps and dragging operations were employed in this operation. Except for one small part of the rudder leading edge, no portion of the major missing units was found.

All of the recovered parts were transported to Brookley Air Force Base at Mobile where arrangements had been made to "reconstruct" the wreckage. The structure was carefully laid out in its relative form and the relationship of the different fractures with one another was carefully studied. The three power plants were torn down and the internal working parts were examined for evidence of failure.

Investigation - Part II - Wreckage

Early in the investigation, it was believed that the corrosion problem would be severe. For this reason, arrangements were made to wash all wreckage with fresh water as soon as it was recovered from the Gulf. In addition, all important structural parts were carefully examined by technicians soon after they were recovered. As it developed, the anticipated corrosion problem did not materialize except for the magnesium engine parts, landing gear wheels, etc.

Examination of the three recovered power plants (Nos. 1, 3 and 4) indicated that there had been no operational failure of these engines or propellers. There was no evidence of fire in, or in the general proximity of, the power plants prior or subsequent to impact. The positions of No. 1 and No. 4 propeller blades at impact were 30° and 32°, respectively, whereas the No. 3 blade position was 53°. The No. 1 and No. 4 propeller blades were damaged in a similar manner, i.e., one blade broken, one blade bent and one blade only slightly damaged. On the No. 3 propeller, two of the blades were bent forward and one was bent aft slightly. The No. 3 and No. 4 engines had sustained severe impact damage on their lower cylinders, while the No. 1 engine had sustained similar damage but on the upper cylinders.

As indicated, the right wing and fuselage parts were all found in the main wreckage area. Severe water impact forces had disintegrated the right wing and fuselage into numerous small sections. The general condition of this wreckage indicated that the right wing and fuselage unit had contacted the water in a relatively flat attitude with no appreciable forward motion. The upper portions of the nacelles and fuselage including the cockpit area all retained their general contours. In general, direct water impact damage was confined to the lower sides of these two components, and the force application appeared to be predominantly in an upward direction, with very little, if any, indication of aft force application. The right flap and aileron were recovered, and these units were similarly damaged on their under surfaces. Since the tail section was not recovered, the fuselage material in the area

of the separation of Fuselage Station 938 was carefully examined for evidence of a progressive type failure, but no such evidence was found. The fractures in this area all appeared to have resulted from the application of static type forces and no consistent directional pattern was apparent.

All of the left wing parts recovered were found in the second wreckage area located 2,100 feet from the main wreckage. A large section of the left wing panel from Station 130 to Station 558 was recovered as one unit reasonably intact. It was broken, torn and pierced in such a manner that there could not have remained any trapped air to contribute buoyancy. The center spar was in place in this section for the entire length. The front spar was in place out to approximately Station 460. The rear spar was in place from Station 280 out to Station 421. The upper surfaces of this entire wing panel unit had sustained severe hydraulic damage for its entire length, and those sections of skin panel still remaining in place were crushed downward toward the lower surfaces. The left landing gear was still attached to the spars at the inboard end. The outboard nacelle (No. 1) was still in place on the wing but its upper side had been crushed down severely by water impact forces. In general, the lower wing surface including the lower portions of both Nos. 1 and 2 nacelles was undamaged by water impact forces. Four other sections of the left wing were recovered in the same area and these parts had similar water damage on their upper surfaces. Various pieces of fabric, later identified as clothing by laboratory examination (Federal Bureau of Investigation Report dated September 17, 1953) were found entwined in several places inside the wing, on the No. 1 nacelle and on the No. 2 engine mount.

A close examination of the fractures at Station 130 on the left wing was made. Since the portions of the wing inboard from this station to the side of the fuselage were not recovered, the examination was necessarily confined to the fractures on the outboard side. This examination disclosed that the outboard portion of the wing had failed downward relative to the inboard portion. Further, no evidence of fatigue failure was found. Laboratory tests (U. S. Bureau of Standards Report, Reference No. 8.3/G-13732 of September 17, 1953) verified the preliminary findings. These tests further disclosed that the chemical composition and tensile strength of the material at the failed section met the original specifications for that metal.

A large number of instruments, switches and controls from the cockpit area were recovered. Most of these were in such a badly mutilated condition that it was not possible to make an accurate determination of their setting prior to the breakup.

Two altimeters were recovered. The barometric scale on each altimeter was set at 29.61 inches, which was the New Orleans reading given the flight during the final transmission. Both the wing flap handle and the landing gear handle were rusted in the retracted position on their sectors and these positions were consistent with the observed damage to the wing flaps and landing gear.

All recovered control system components were examined for evidence of failure or malfunctioning prior to impact but no such evidence was found.

The damage to the hydraulic system, electrical system and oil system components was so extensive that nothing significant relative to the functioning of these systems prior to impact could be learned from an examination of the

component parts. Numerous sections of cabin overhead panel, flooring, seat structure, etc., were recovered but an examination of these parts disclosed no significant evidence.

No evidence of fatigue failure was found in any of the numerous fractures examined. All of the fractures were of the general "static type" as distinct from the fatigue type.

No evidence of fire damage or combustible explosion damage was found on any of the recovered wreckage. The wreckage was examined for indications of lightning damage but none was found.

Investigation - Part III - Weather Experienced by National Flight No. 917

The captain of Flight 917 testified that when he was approaching New Orleans (between NA-1 and New Orleans) at his assigned cruising altitude of 4,500 feet, he experienced severe turbulence, coupled with heavy rain and heavy hail. He also testified that the aircraft's instrument panel intermittently shook so violently that the flight instruments were difficult to read. Another indication of the severe and abnormal weather is found in his statement that the turbulence was not of the violent updraft and downdraft type usually associated with well-developed thunderstorms. Rather, the gusts seemed to be more lateral; the captain stated, "The rudder was forced back and forth without changing direction of flight." He also stated that most of the passengers became airsick and". . . we had more of a twisting whirling motion, too, which caused the airplane to shake and shudder from one side to another which is unusual in a normal thunderstorm." There was very little lightning and altitude was controlled within 1,000 feet.

This captain also testified that shortly before he reached the worst of the weather, he discovered by radio fix that he was approximately 40 miles to the right of his course. Extreme changes in heading were necessary to get back on the course, and subsequent computation shows that the unusual and unexpected wind that he encountered must have been from a general southerly direction and in the order of 100 miles per hour. This drift occurred in the vicinity of NA-1.

Despite the highly unusual weather conditions as described by the captain of Flight 917, he reported to his company only "extreme" turbulence, and later, "severe" turbulence between NA-1 and New Orleans. The lost flight therefore received only the information that there was severe turbulence at all altitudes.

At New Orleans the captain of Flight 917 had the aircraft inspected for possible damage caused by turbulence induced stresses or hail. None was found.

Investigation - Part IV - Witnesses

Early in the investigation it was believed that Flight 470 was lost in the Gulf of Mexico not far from the mouth of Mobile Bay. Accordingly, statements were taken from a considerable number of persons in that area. There are 18 witness locations; at several of these there was more than one witness. A tanker was at anchor approximately a mile south of the mouth of Mobile Bay because of the heavy weather; statements were taken from 12 of its crew.

Of this large number of persons, 10 stated that they heard a low flying

airplane. One of the 10, a woman, testified as to actually seeing an aircraft at low altitude, but could not identify it as to type. She believed that it was traveling from the northeast toward the southwest. The majority of the 10 persons who claim to have heard an airplane believe that it was traveling from a generally northeast direction towards the southwest. The consensus of this witness evidence is that at or about 1710, the time of the accident, weather conditions were at their worst. The wind has been variously estimated as from 50 to 100 miles per hour. A lighthouse keeper at the mouth of Mobile Bay, accustomed to reporting weather conditions, stated that the wind reached "whole gale force," which by definition could mean up to 75 miles per hour. There is some diversity of testimony as to wind direction but the majority opinion is that it changed from easterly to westerly at about 1710.

There is no uniformity of opinion as to the intensity of rain in the area. Most of the witnesses state that it was "heavy," while others, a relatively short distance away, claim that there was little or no rain. None of the witnesses saw any hail.

One witness who was on the tanker thought that the wind was about 100 miles per hour, and stated that the visibility was so poor that he could barely see half of the ship's length (about 250 feet). This witness is one of the 10 who claim to have heard an airplane, and he believed it to be so low that he thought it might strike the vessel.

There is no uniformity of opinion relative to the amount of lightning and thunder. Some witnesses stated that both were heavy and frequent, while others declined knowledge of any thunder or lightning at all, and still others claimed to have heard thunder but saw no lightning. Crew members of the tanker believe that the seas were running about 25 feet high.

In reference to possible tornadoes, one witness, a commercial fisherman and therefore in all probability a fairly observant judge of weather who was at home about eight miles east-northeast of the crash site, stated that he looked out of the south window overlooking the Gulf and saw a tornado extending approximately half way down to the surface from the bottom of the cloud deck which he estimated to be 300 feet high. Another witness, a man of scientific background, believed that he heard the noise of a tornado (he had heard other tornadoes) but did not see it.

There was scattered property damage throughout this general area near the mouth of Mobile Bay. Some trees were leveled and a few structures were damaged. At nearby Fort Morgan, Alabama, a U. S. Coast Guard lighthouse keeper reported their flag pole was bent over. This flag pole was of galvanized iron pipe three inches at base, tapering off to one and one-half inches at top, 45 feet above ground, and equipped with three 1/4-inch cable guy wires. Two of these wires broke and the pole was blown nearly down, bending at the base. The time was 1700 hours. It took 15 minutes from the time he first noticed the pole bending until it reached maximum deflection. He estimated the wind velocity to be 50 to 60 m.p.h. or greater. There was a No. 10 United States flag flying at the top of the pole. However, the damage was not as extensive as generally caused by fully developed tornadoes.

In this connection it may be pertinent to point out that the development of this storm was under radar surveillance at the Keesler Air Force Base,

Mississippi, approximately 60 miles west-northwest of the recovered wreckage. The radar manifestation showed that the storm was generally southwest of Keesler Air Force Base and lay across the direct route between Tampa and New Orleans, and that it reached its peak development from 1600 to 1700. The observer on duty stated that the echo was the most intense encountered by him in nearly two years of weather observation on radar scopes at Keesler Air Force Base.

A careful investigation was conducted of the possibility that the aircraft heard by 10 people may not have been Flight 470. Accordingly, examinations were made of the movements of all aircraft, both civil and military, in the general area at the approximate time. One Navy aircraft, a RL-D6 (Super DC-3) was in the area at about 1710, the time of the accident. It was en route from Jacksonville, Florida, to Saufley Field, Pensacola, Florida, and during its instrument letdown passed over the general area of the most easterly location of ground witnesses. The Navy pilot testified that the weather was unusually bad and that he descended to an altitude of about 1,500 - 1,000 feet in the above-mentioned area. He was unable to land and subsequently proceeded to, and landed at, Shreveport, Louisiana, via Mobile, Alabama. During this flight in the Mobile area, he encountered severe turbulence at 4,000 feet.

It may be that these witnesses did hear this airplane and later, learning of an accident, associated it with that accident. It is clear that this Navy plane was never closer than several miles to the accident site. This does not refute the possibility that more distant witnesses did hear the National DC-6.

Investigation - Part V - Weather Experienced by National Airlines' Flight 470

Weather reports for the Tampa-New Orleans route are made from land based stations, all located along the Gulf shore to the north of the direct route. On the day of the accident, there was no weather information supplied by any surface craft except one so far from the storm center that its report was not significant.

The crest and center of a very energetic, open wave, extra-tropical cyclone4/ was in the general area where the flight crashed at about the time of the crash. It had moved unexpectedly fast across the Gulf of Mexico from near Brownsville, Texas. See Attachment B.

A cold air mass moved southward across the United States east of the Rocky Mountains during the period February 11-13, 1953, and as frequently happens, the cold front that preceded it became nearly stationary across the southern Gulf of Mexico and extended northwestward across Mexico and into western New Mexico. By the morning of February 13, cyclogenesis was indicated

4/ The term "extra-tropical cyclone" should not be confused with "tornado" or "hurricane." An "extra-tropical cyclone" originates in mid or northern latitudes, with an anti-clockwise circulation in the northern hemisphere. A "tornado" is a violent vortex of small diameter having a funnel-like shape. Its marine counterpart is a "waterspout," often of far less energy. A "hurricane" is a cyclonic storm of tropical origin, rotating anti-clockwise in northern latitudes.

on the surface map in extreme northern Mexico near the boundaries of Arizona and New Mexico. This low pressure deepened and moved southeastward into central Mexico on the 13th. There are indications that new cyclogenesis occurred on the cold front during the early morning of the 14th west of Brownsville, and that it moved off the coast as an open wave low center between Brownsville and Corpus Christi about 0630. This latter open wave low center became the dominant one of the system and was accompanied by moderate winds and light to moderate rains in the Brownsville-Corpus Christi area but with no severe weather reported. From that time until it reached the Mississippi Delta area, there were no weather reporting stations sufficiently close to establish accurately either its position or intensity.

The regional forecasts available to Flight 470 at time of briefing at Miami were filed at 0933 and were for the period 1000 to 2200. These indicated the low center in the northwest Gulf area moving east-northeastward about 15 miles per hour and being located about 140 miles south-southwest of New Orleans at the time of intended arrival of Flight 470. Increasing cloudiness and lowering ceiling were forecast across the northern Gulf with light rain and scattered thunderstorms. However, over the land area from Mobile to southern Louisiana, occasional moderate to heavy thunderstorms with ceilings down to 400 feet were forecast, accompanied by moderate to severe turbulence5/ in the build-ups of cumulus and cumulo-nimbus clouds with gusty surface winds to 50 miles per hour.

The latest weather reports along the coast showed light to moderate thunderstorms and rain showers from Mobile to New Orleans with ceilings mostly 300 to 600 feet. The next hourly sequence weather which was available at Tampa showed no important change in weather conditions along the coast.

At about the time of takeoff of Flight 470 from Tampa, new regional and terminal forecasts from Miami and New Orleans were available at National Airlines' offices from Miami to New Orleans. In these new forecasts Miami had a wave located 100 miles south of Pensacola moving northeastward. New Orleans' forecast had the wave low center about 100 miles southwest of Grand Isle, moving into southern Alabama by 0400 of the 15th. The Miami forecast called for moderate to briefly severe turbulence in thunderstorms and the New Orleans forecast gave moderate to severe turbulence in thunderstorms through southern Louisiana and southern Mississippi. Terminal forecasts from New Orleans to Pensacola indicated heavy thunderstorms, ceilings occasionally down to 300 feet and gusty winds to 60 miles per hour. At 1622 the Weather

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5/ For forecasting purposes the U. S. Weather Bureau defines moderate and severe turbulence in its own publication "Volume III, Service Operations, Chapter B-20. Aviation Forecasts." as follows:

Moderate — Associated with towering cumulus, average frontal conditions, and in the vicinity (but not interior) of isolated thunderstorms. General passenger discomfort.

Severe — Rare. Usually impossible to control aircraft. May cause structural damage.

(Copies of the above-mentioned Weather Bureau publications were mailed to scheduled air carriers by the Air Transport Association in January 1953.)

Bureau, Miami, issued an amendment to their forecast as follows: "Add to clouds and weather, surface winds over waters and exposed coastal areas southerly 25 to 35 miles per hour becoming northerly over western Florida behind wave. Surface winds occasionally gusty in thunderstorms to 35 to 50 miles per hour." Also at about 1615, a Severe Weather Bulletin was issued by the Weather Bureau's analysis center in Washington, D. C., after consultation with its New Orleans office. That bulletin was received by the Miami Weather Bureau at 1619 and was delivered to CAA at 1629 who transmitted it on teletype Service A Circuit 8004 for general distribution at 1650. It was at this time that the National's Operations office received the Severe Weather Bulletin which was approximately 20 minutes before the accident. This bulletin read as follows: "Low center 2200Z (1600C) just north of Burrwood (Louisiana)6/ will move to southwest Georgia by 0630Z (0030C) increasing thunderstorm activity extreme southern Alabama and Georgia and northwest Florida with locally severe thunderstorms, gusts with winds of 50-60 miles per hour, hail reaching the ground, more severe storms and severe turbulence aloft." Although these forecasts and the Severe Weather Bulletin were received by National Airlines in Miami, the evidence of record shows that no attempt was made to transmit any portion of them to Flight 470.

Between 1600 and 1630, the center of activity connected with the principal wave of the front moved close to land and crossed the southern portion of the Mississippi Delta and then continued out over Breton Sound. It was while this center was in that area that the severe weather was encountered by Flight 917 between NA-1 and New Orleans.

The most severe weather of this system occurred in the vicinity and to the north of the apex of the wave. It was traveling east-northeastward between 50 and 60 miles per hour and appears to have not only been located at about the area of the crash but to have attained its most severe development during that period. Flight 470 must have encountered unusually severe turbulence in that area. Weather conditions in general were such that waterspouts and/or tornadoes might possibly have existed.

A related subject is a matter of company frequencies on interchange equipment. In this case, Flight 470 - a National Airlines DC-6 - (the lost aircraft) approximately two and one-half hours behind Flight 917 - an American Airlines DC-6 being operated by National - which had encountered the same storm en route to New Orleans, had the same VHF company frequency but a different HF company frequency. Line of sight transmission inherent in VHF would prohibit contact between the two aircraft at 4,500 feet and two and one-half hours apart, while HF communication may have been possible enabling Flight 917 to warn Flight 470 directly of the severe conditions including heavy rain, heavy hail, and very strong southerly winds. Although some of this information was relayed to Flight 470, it could have been transmitted directly and in more detail had the two aircraft been able to communicate with each other on HF.

Investigation - Part VI - Dispatching

National Airlines does not maintain its own meteorological service; rather it depends on the U. S. Weather Bureau for weather information.7/ The National

6/ (Louisiana) supplied.

7/ Some air carriers have their own meteorological service, but are not required to do so.

dispatchers were properly certificated, and the examination for that certificate demands some knowledge of basic meteorology. None of the dispatchers on duty at Miami on the day of the accident had taken any extensive courses in meteorology. However, company records disclose that both had been serving as flight dispatchers for a number of years, including the dispatching of flights over the route involved. Airline pilots such as this crew had had long experience in practical meteorology and thus were able to evaluate weather data as it pertains to flight. It therefore appears that the dispatchers' working knowledge of meteorology, together with the crew's practical knowledge, should have insured a proper evaluation of the weather data then available.

There was testimony at the hearing as to whether the crew of Flight 470 had visited the Weather Bureau station at the Miami Airport on February 14 to be briefed on the weather en route. The three Weather Bureau meteorologists on duty at the station during the period involved stated that they did not recall briefing the crew. These meteorologists further stated that many pilots from several airlines are briefed daily and it is entirely possible that the crew of Flight 470 could have been briefed by one of them. None of the three knew Captain Springer or First Officer Stettner. However, the evidence is clear that sequence reports, upper air winds and forecasts pertinent to the flight were on file at the weather station. This material was available to the company and the sequence reports, upper air winds and forecasts pertinent to the flight were on file in the company's Operations office and available to the crew.

Weather conditions fast became worse over the western part of the route while 470 was in flight. The U. S. Weather Bureau did not anticipate the severity or the rapid development of the storm system as it moved northeastward over the Gulf. It issued amended forecasts and the Severe Weather Bulletins, at which time the flight was approaching the storm center. No Weather Bureau advisory reports were given to Air Route Traffic Control (ARTC) for forwarding to en route flights regarding the unexpected development and movement of this storm system.

The flight, however, did receive weather information supplied by Captain Abel of Flight 917 upon his arrival at New Orleans. As previously stated, Captain Abel's message stated that he had encountered severe turbulence but that it appeared to be clearing west of New Orleans. Later Captain Abel testified at the hearing that had he known the severity of the storm, he would not have ventured into it. However, at the time he did not think to pass on this information to Flight 470. Thus when Captain Springer received this message, he may well have thought that conditions would be much better by the time he arrived at New Orleans.

Captain Springer had accumulated 4,100 hours in DC-6 aircraft and had lengthy experience in flying through thunderstorm areas, and he had a qualified and experienced copilot.

Investigation - Part VII - Aircraft Maintenance

All flight forms and maintenance records of the subject aircraft for a long period prior to the accident were studied and analyzed with care. Although a number of discrepancies were noted, none of these documents contained entries or items of apparent significance in connection with this accident.

Investigation - Part VIII - Military Areas

There are several military danger areas along the Gulf coast and in the vicinity of the wreckage site. However, investigation disclosed that there was no military activity in these areas that could have endangered the flight near the time of the accident.

Analysis - Part I - Weather

The development of open wave extra-tropical cyclones on quasi-stationary cold fronts in the Gulf of Mexico area is rather a common occurrence during the winter and spring months. However, in connection with the storm of February 14, 1953, an unusual complication of meteorological factors simultaneously affected the northern Gulf area which resulted in a storm of remarkable severity including turbulence aloft.8/ The following factors at the 500-millibar level (approximately 18,000 feet) during February 11-13, 1953, were important in the development of the February 14 storm:

1. A pressure trough extended from the northern plain states southwestward over Arizona, New Mexico and northern Mexico.

2. A pressure ridge lay along the Pacific Coast.

3. Another trough lay to the west of the ridge over the Pacific.

4. A small closed low of cold air aloft moved southeastward from the Pacific northwest to over Arizona.

5. A second tongue of cold air was moving southeastward over the United States from Montana.

As the cold air aloft reached Arizona, a low pressure center formed at the surface which deepened and moved southeastward into central New Mexico. New cyclogenesis took place in eastern Mexico which became the principal low center and moved out into the Gulf north of Brownsville about 0630 of the 14th. In the meantime, the high level Pacific trough moved eastward to the coast and replaced the ridge that formerly existed there. The interior high level trough moved into Texas and was joined by the cold air low that had previously moved into Arizona. Also, as this trough moved to east Texas, it was further strengthened by the arrival of the cold air aloft from Montana. This produced a very steep temperature gradient aloft and reacted to form a jet stream of southwesterly wind with a maximum velocity of 75-100 knots through southern Texas to Georgia. This condition was apparently directly related to the speeding up of the wave cyclone over the Gulf to between 50 and 60 miles per hour. Also the interaction of the cold, dry air to the north of the center and the moist, warm air of the Gulf waters deepened the low center and increased the severity of the accompanying weather. In fact, upper air analysis indicates tongues of dry air aloft, at intermediate levels, moved into the

8/ The United States Weather Bureau made a special study of this storm. Results of that study, published by the Weather Bureau in its February 1953 issue of "Monthly Weather Review," were considered in the preparation of this report.

area just north of the wave, which together with the high moisture content of the air below, was a very conditionally unstable situation. It appears that the energy from just such a situation was released in the Delta-Mobile area by means of frontal lifting which undoubtedly contributed to the very severe turbulence in that area.

Barograph traces at stations in the Gulf area from southern Louisiana to western Florida, showed rapid and marked fluctuations indicative of the chaotic air movements aloft. Also further adding to those movements and to the complexity of the system there was indication of a pressure dropline moving northeastward about 60 miles per hour and another line of pressure jump crossing the pressure dropline and moving east-southeastward about 32 miles per hour. The significance of these is that they indicated traveling waves on the frontal surfaces.

So far in this analysis only one wave on the front has been referred to although additional minor waves seem to have occurred. However, the other waves appear to have been at low levels as only one appears at the 850-millibar level (about 5,000 feet), and the most severe conditions in the storm occurred in a semicircular area mostly northward from the main wave crest. It was in that area and apparently very near the wave crest that the accident occurred.

Instead of the large updrafts and downdrafts that are frequently associated with thunderstorms and squall lines, the turbulence in this storm seems to have been in the nature of rapid, very sharp gusts of a chaotic nature. The Navy pilot at 4,000 feet, just west of Mobile and north of the crash site, estimated the gusts at 2-½ to 3G's. There are indications that even more severe weather existed along the coast and offshore just south of Mobile.

Due to the many complex features of this February 14th storm, much study was necessary to arrive at a satisfactory analysis. Considerable information important to that analysis was not available to the forecasters at the time forecasts were made. It appears that between 1530 and 1630 errors in the movement and development of the storm were becoming apparent and that even though current forecasts included "severe turbulence," revised forecasts should have been issued by the Weather Bureau at New Orleans and Miami, particularly after the Severe Weather Bulletin had been received. Certainly the movement of the storm was not adequately covered by the current forecast at that time. A special advisory would have drawn attention to that development. Particularly, it appears that Flight Advisory Weather Service should have issued information to ARTC to be passed on to flights; on June 5, 1953, Weather Bureau offices were instructed by their Washington, D. C., headquarters to highlight such information.

In this situation pilots could have contributed much. It appears that the first pilot information that reached the Weather Bureau indicating unusually severe turbulence aloft was after Flight 470 had crashed. The captain of Flight 917 did not give a full report of his difficulties.

As the word "severe" as applied to turbulence appears not uncommonly in weather forecasting, a study was made of the frequency of its use. During the two-month period, January and February, 1953, the Weather Bureau Forecasting Service at Miami, Florida, and New Orleans, Louisiana, each prepared 236

scheduled weather regional forecasts. In the Miami series of forecasts, "severe turbulence" appeared 34 times, and in the New Orleans series of forecasts, the term appeared 18 times. Thus it appears that the word has acquired a connotation other than literal, as defined, by frequent usage. It may well be that Weather Bureau forecasters use the term when in doubt to be on the safe side. It is fully realized, of course, that any well-developed thunderstorm cell is a potential breeder of severe turbulence and also that the exact conditions within such a cell cannot be predicted with certainty. In any event, neither National's pilots nor dispatchers considered the word "severe" to mean what it was intended to mean by official definition.

Although Flight 470 was dispatched in accordance with approved company procedures, a review of the company's dispatching policy would indicate that a closer monitoring of en route flights would provide both the dispatchers and the crew with better current weather information whereby each could counsel with the other and arrive at a joint decision as to any change in plan affecting the safe conduct of flights.

Analysis - Part II - Structure

In studying the evidence, one is immediately impressed with the suddenness of the accident. It is apparent that whatever difficulty manifested itself, occurred rapidly and was of such a nature that the crew did not have an opportunity to communicate their predicament to ground personnel. Any probable cause arrived at must of necessity be consistent with this basic fact.

In arriving at the final probable cause, the Board has considered many different possibilities. There was no evidence of in-flight fire, explosion or lightning strike in the wreckage recovered. Temporary blindness caused by intense lightning flashes could have temporarily created a confused condition in the cockpit; however, airline crews are thoroughly familiar with this and normally take precautions against such occurrences. Control system failure was considered, but the examination of the recovered system components and a study of the circumstances surrounding the accident both serve to discount this possibility. Power failure would not ordinarily cause such a catastrophic accident unless an initial propeller blade failure resulted in serious structural damage and/or electrical or control system failure. Since the No. 2 engine and propeller were not recovered, this possibility was given careful consideration. The fuselage material and control system parts in the vicinity of the propeller plane on the left side were examined for propeller cutting marks, but none was found. Equipment failure must always be considered a likely possibility in an accident of this type. Had the flight experienced a total electrical power failure, radio equipment failure, or complete flight instrument failure while flying in turbulent instrument conditions, it is conceivable that a hazardous condition would result. However, no facts were developed during the investigation to indicate that equipment failure had actually occurred. The multiplicity of radio equipment, the availability of an emergency electrical source and past experience relative to the high level of reliability of the DC-6 flight instrumentation, all tend to preclude equipment failure or malfunctioning. It must be noted, however, that the crew of Flight 917 had extreme difficulty in reading instruments because of turbulence induced vibration.

In-flight structural failure was thought to be a likely possibility, and a detailed study of all available evidence was made in an attempt to substantiate or disprove its probability. While a number of puzzling, unexplainable points will probably remain, the Board is of the opinion that the preponderance of evidence indicates a structural breakup in flight prior to the initial water impact.

A number of significant factors lead to the conclusion that an in-flight structural failure occurred. First of all, it is difficult, if not impossible, to explain the relatively great distance between the two wreckage areas unless it is theorized that the aircraft broke up in flight. Initially, it was thought that the left wing may have floated away from the main wreckage, or that underwater currents had drifted the wreckage to the separate location. However, a review of the facts indicates that this could not have been the case. Early in the investigation, the separation of the two wreckage areas was explained by reasoning that the aircraft contacted the water in a flat attitude with sufficient force to fail the left wing downward, and then the remaining portions ricocheted 2,100 feet to their final resting place. This theory was proffered by competent industry persons, and accordingly, the Board has given this possibility careful consideration and study. The extremely rough seas (waves variously estimated at 12-25 feet in height), the tendency of the aircraft to "bury itself" rather than bounce when under high downward accelerations such as would be required to separate the left wing panel, and the incredibility of the right wing fuselage unit bouncing nearly a half mile -- these are some of the reasons why this theory was discounted.

The dissymmetry of water impact on the left wing parts and on the right wing fuselage parts is another important reason for believing that the aircraft was not intact when it contacted the water. Had the aircraft been flown into the water in a near-level attitude, it would be much more reasonable to expect water damage on the lower surfaces of all major components. Further, there would be evidence of the wing leading edge having crushed into the front spar, and a general rearward deformation pattern of the wing box structure. Instead, the left wing sustained water damage on its upper side, and no evidence of leading edge crushing or wing box rearward deformation was observed. It is much more probable that the falling, rotating left wing mass contacted the water in such a manner that the upper surface only sustained major water damage. In any event, the Board believes that the dissymmetry of water damage is inconsistent with the theory that the aircraft was "flown into the water."

During the course of the investigation, the possibility of a structural failure of other components was also carefully considered. Since some of these components (notably, the tail section) were not recovered, the presence or absence of a failure of these units could not be directly established. However, using the facts available as developed during the investigation, the relative merits of each possibility could be determined and their probability assessed. It was of particular interest and importance to make a determination with regard to a failure of the tail section. The results of this evaluation lead the Board to believe that the tail section did in effect separate, but that, in all probability, the tail failure followed and was the direct result of left wing failure.

A wing will fail when either its fatigue strength or its static strength is exceeded. The fatigue strength is related to repetitive gust and/or

maneuver loads over a period of time, whereas the static strength involves the strength under the application of a single large gust or abrupt maneuver or combination thereof. Fatigue was an important consideration early in the investigation, but the wreckage examination and the confirming laboratory tests clearly indicated that fatigue was not a factor in causing the separation of the left wing in flight. Accordingly, it was apparent that the left wing failure could be attributed to loads which exceeded the static strength of the wing structure.

The Board has made a detailed study of the strength characteristics of the DC-6 wing. No evidence was disclosed either during this study, the investigation or the subsequent public hearing to indicate that the DC-6 wing was deficient in static strength. On the contrary, the facts clearly indicate that adequate strength provisions had been incorporated into the design in accordance with the pertinent airworthiness portions of the Civil Air Regulations. In fact, it appears that in many instances additional strength had been provided in some parts and additional tests had been conducted above and beyond those required by the regulations. In this regard, it was developed that in addition to the normal stress analysis and proof test procedures which are generally used to substantiate a design, actual structural flight testing had been conducted to demonstrate the structural integrity of the aircraft. Six years of successful service experience is further proof that there are no significant deficiencies in the static strength of any major structural component.

At the public hearing held in connection with this accident, the Air Line Pilots Association indicated its belief that the design gust load criteria were inadequate and recommended that consideration be given to increasing the severity of the gust load conditions. In particular, it urged that the DC-6 be strengthened for higher values of gust intensity. The Board has studied this proposal and has concluded that the facts developed during the investigation do not support such drastic action. It should be realized that all aircraft design is essentially a compromise, and that the severity of the gust criteria (and all other design conditions for that matter) is adjusted to provide adequate strength provided normal airline operating procedures are followed. Additional margins of safety are incorporated for reasonable deviations from standard procedures. These design gust intensities have been determined on a statistical basis from a large number of experimental flights in turbulent conditions. They are not necessarily the highest gusts that could conceivably be encountered if the aircraft were flown into or very near, say, a tornado. Since the gust criterion has been in use, it has been monitored by the NACA with the cooperation of the airlines and CAA. Records from flight recorders installed in airline aircraft are continually being studied by the NACA to determine conformity with existing requirements and also to extend the general knowledge. These studies have indicated that the current requirements are adequate.

There is no doubt that weather was definitely a major factor in this accident. Studies made by the Weather Bureau, the NACA, and the Board's own meteorologist indicate that this particular storm was most unusual and that tornadic conditions may have been present. Reports received from the crew indicated that they were encountering severe turbulence. The testimony of the crew of National Airlines' Flight 917 verifies the unusual nature of the storm.

Captain Springer may not have realized the severity of the storm he was encountering until it was too late to take effective evasive action. Whether or not the aircraft became involved with a tornado vortex, the Board cannot say. Had this occurred, there is no doubt structural disintegration would have followed. However, the Board is inclined to believe that this did not occur. It appears more likely that the aircraft was upset by a sharp unsymmetrical gust and that in the recovery (or attempted recovery) gust loads combined with maneuvering loads exceeded the strength of the left wing and caused it to fail downward. This follows since past experience has shown that the real danger in encountering severe turbulence lies not in the possibility of structural damage from gusts alone, but, rather, the danger is associated with loss of control, gust induced maneuvers, excessive speed, stalling out and other related difficulties. In extremely turbulent conditions, the situation can rapidly get beyond the control of even the most skilled pilot. For this reason the identifiable areas of intense turbulence are generally avoided by airline crews and more circuitous paths through or around the storm are flown.

It appears that soon after arriving at the 4,500-foot altitude (the flight made a normal report of reaching this altitude) the aircraft became upset from its normal level attitude and that failure of the left wing occurred almost immediately thereafter. At the time of the left wing separation, the aircraft may have been upside down. The Board can only conjecture on the events that followed. Following the wing separation, it probably collided with the lower fuselage and/or the empennage. Either this collision and/or the abnormal maneuvers following the left wing separation could have resulted in the detachment of the empennage. Clothing found entangled in the left wing could have come from the baggage compartment when the left wing struck the fuselage. The No. 2 power plant quite probably was detached either during the initial wing failure or during the subsequent collision with the rear fuselage tail unit, and it fell free of the other components. The main portion of the aircraft without the stabilizing effect of the tail and left wing would fall with the longitudinal axis of the airplane in a relatively flat attitude, striking the water on the underside of the fuselage and the right wing at a high rate of descent. Also, the effect of the weight of Nos. 3 and 4 engines, fuel in the tanks, particularly outboard, and the existing turbulence could contribute to the right wing striking the water in a nearly horizontal attitude. The left wing then fell as a separate unit and struck the water on its upper surface predominantly. The tail unit fell separately and conceivably was broken into relatively small pieces.

The Board well realizes that the sequence of events following the left wing failure as described in the preceding paragraph is largely a matter of deduction. An examination of the missing components undoubtedly would shed additional light on the actual sequence. If at any time in the future the missing components are recovered, the Board will conduct such an examination and will make such revisions and changes to this report as may be necessary.

In conclusion the Board wishes to state that investigation of this accident has spared no known detail. It has been extraordinarily sweeping and painstaking by not only the Board but by other interests. From the record the Board can only conclude that the pilots in the case were beset by a most unusual complex of conditions beyond their control.

The principal weather factors affecting this accident may be alleviated in the future by the installation of airborne radar. Developmental equipment

shows promise of meeting the problems of weather avoidance, weather probing and weather intelligence.

Findings

On the basis of all available evidence, the Board finds that:

1. All required certificates relative to the carrier, the aircraft, and the crew were current and valid.

2. The aircraft was loaded well below its maximum allowable takeoff weight and the load was properly distributed in relation to the C. G. limits.

3. The crew was briefed in the company's Operations office on weather data available prior to departure.

4. The flight was dispatched in accordance with the approved company's standards, but an adequate exchange of en route weather information did not exist between the dispatcher and the company's flights.

5. The latest weather sequence report for stations along the Gulf coast including New Orleans was attached to the flight clearance at Tampa.

6. After passing the NA-2 check point, the flight reported thunderstorms in all quadrants.

7. The flight requested and was granted clearance to descend to 4,500 feet due to turbulence.

8. Its last message reported reaching 4,500 feet at 1710.

9. The aircraft penetrated a storm system of unusual severity.

10. Tornadic conditions including high winds, violent gusts, and possible waterspouts were occurring in the storm system.

11. The storm's movement had not been adequately anticipated in current weather forecasts.

12. Although a special Severe Weather Bulletin issued at Washington, D.C., was received by National Airlines and the Weather Bureau at Miami and New Orleans, no U. S. Weather Bureau advisory weather reports were issued to ARTC to report the unexpected development and movement of the storm to en route flights; nor did National Airlines attempt to relay this information to Flight 470.

13. Flight 470 entered the storm system without full knowledge of its severity.

14. The aircraft's structure failed at a moment when, in all probability, gusts loads combined with violent maneuvering loads were being imposed to maintain or regain control.

15. The main wreckage was located in the Gulf of Mexico 3.8 miles offshore and about 52 miles to the right of course; the left wing was found 2,100 feet from the main wreckage.

16. Examination of the recovered parts revealed no indication of malfunctioning control, fatigue failure, fire, explosion, or lightning strike while in flight.

Probable Cause

The Board determines that the probable cause of this accident was the loss of control followed by the in-flight failure and separation of portions of the airframe structure while the aircraft was traversing an intense frontal-wave type storm of extremely severe turbulence, the severity and location of which the pilot had not been fully informed.

BY THE CIVIL AERONAUTICS BOARD:

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

/s/ OSWALD RYAN

/s/ JOSH LEE

/s/ JOSEPH P. ADAMS

SUPPLEMENTAL DATA

Investigation and Hearing

The Board's Investigator-in-Charge at Atlanta, Georgia, the nearest regional office, was notified that National's Flight 470 was overdue and missing on February 14 about 1945. An investigation was immediately initiated in accordance with the provisions of Section 702 (a)(2) of the Civil Aeronautics Act of 1938, as amended. The Board ordered a public hearing which was held at the McFadden-Deauville Hotel, Miami Beach, Florida, on March 30 to April 3, 1953, inclusive, and continued at the Empress Hotel, Miami Beach, Florida, on August 26 and 27, 1953.

Air Carrier

National Airlines, Inc., is a Florida corporation with its main office at Miami, Florida. The company operates as a scheduled air carrier under a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration. These certificates authorize the transportation by air of persons, property and mail between various points in the United States including Miami, Florida; Tampa, Florida, and New Orleans, Louisiana.

Flight Personnel

Captain Ernest A. Springer, age 46, held a currently effective airline transport pilot certificate with a DC-6 type rating. He had been employed by National Airlines since November 1, 1938, and had been a captain since 1941. His total flying time on many types of aircraft was in excess of 17,000 hours, and 4,110 hours of this had been on DC-6's. Captain Springer had successfully completed his last physical examination on August 23, 1952, less than six months prior to the accident. All of a series of successive physical examinations prior to that of August 23, and at six-month intervals, also showed him to be physically sound.

First Officer Christopher Tarlton Stettner, age 38, had been employed by National Airlines since April 1945. He held a CAA airman certificate with appropriate ratings for the subject flight. Mr. Stettner had flown a total of 4,485 hours, of which 184 hours had been in DC-6 aircraft. He passed his last physical examination on October 1, 1952, less than six months prior to the subject accident.

Flight Engineer Edward B. Campion, age 38, had been employed by National Airlines since 1947. For the next several years he held various positions having to do with overhaul work and was made a flight engineer in November 1952. His total flying time was 487:09 hours, all of which had been in DC-6 aircraft. Mr. Campion held an aircraft and engine mechanic certificate and a flight engineer certificate.

Stewardess Lillian Blamseuser was employed by National Airlines as a stewardess in November 1949. Her total flying time while in the employ of National was 3,010 hours. She had successfully completed company courses on the subjects of emergency procedures, ditching, location of emergency equipment and other maters embraced in the duties and responsibilities of a stewardess.

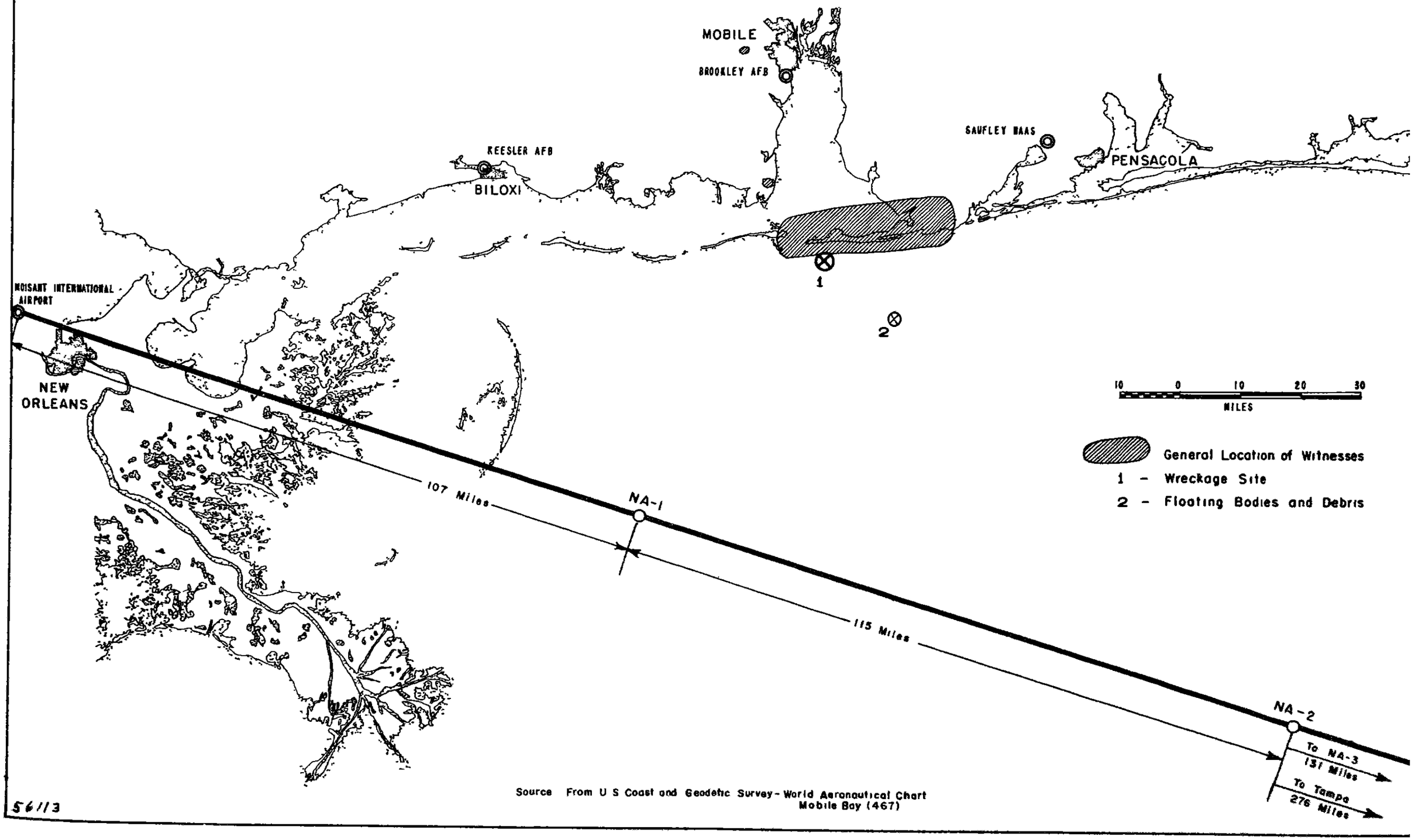
Stewardess Betty Baucom was employed by National Airlines as a stewardess in September 1950. Her total flying time since employment with National was 2,150 hours. She also had satisfactorily completed company training courses as mentioned for Stewardess Blamseuser.

The Aircraft

N 90893 was a Douglas Model DC-6 owned and operated by National Airlines. It was built in June 1947, and had accumulated a total of 15,994 operating hours. Its engines were Pratt and Whitney Model R-2800-CB16, and the propellers were Hamilton Standard. At the time of departure from Tampa, the aircraft was airworthy, properly certificated, and fully equipped with all required emergency equipment.

ATTACHMENT A

ACCIDENT TO NAL DC-6, N-90893, FEBRUARY 14, 1953 IN GULF OF MEXICO



Source From U S Coast and Geodetic Survey - World Aeronautical Chart Mobile Bay (467)

56113

ATTACHMENT B
108a

FORECASTED AND COMPUTED MOVEMENT OF SEVERE STORM INVOLVED IN THE ACCIDENT OF NAL DC-6, N-90893 ON FEBRUARY 14, 1953

MOBILE
PENSACOLA
BILOXI
PANAMA CITY
WRECKAGE SITE
NEW ORLEANS
MOISANT INTERNATIONAL AIRPORT
Normal Course Tampa to New Orleans
BURWOOD
GALVESTON
CORPUS CHRISTI
BROWNSVILLE

Interpretation of the forecasted track of the center of the low pressure which was associated with the intense frontal wave, including hourly locations, as contained in the Severe Weather Bulletin issued at 1615c by the Air Mass Analysis Center Weather Bureau, Washington, D C

Interpretation of the forecasted track of the center of the low pressure which was associated with a frontal wave including hourly locations, as issued at 1533c, Weather Bureau Miami, Fla (This forecasted wave was a minor one that preceded the intense one encountered by the [illegible] Miami forecast made no mention of the wave encountered by the flight where the accident occurred)

Interpretation of the forecasted track of the center of the low pressure which was associated with the intense frontal wave, including hourly locations, as contained in the regional forecast issued at 1535c, Weather Bureau, New Orleans, La

Computed track, obtained by analysis, of the center of the low pressure which was associated with the intense frontal wave, including hourly locations

G U L F O F M E X I C O

Details plotted from section of U.S. Coast and Geodetic Survey Route Chart 2206