SA-411 File No. 1-0001

AIRCRAFT ACCIDENT REPORT

ALLEGHENY AIRLINES, INC.
ALLISON PROP JET CONVAIR 440, N5825
NEAR BRADFORD, PENNSYLVANIA

JANUARY 6,1969

ADOPTED: MAY 27,1970

NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Aviation Safety
Washington, D. C. 20591

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SYNOPSIS

About 2035 on January 6, 1969, Allegheny Airlines Flight 737, an Allison Prop Jet Convair 440, N5825, crashed on a golf course about 4.7 nautical miles northwest of the Bradford, Pennsylvania, Regional Airport. The accident occurred while the flight was making an instrument landing approach to the airport. Of the 28 persons aboard the aircraft, 11, including the two pilots, received fatal injuries.

Investigation revealed the aircraft initially struck the top branches of a tree about 79 feet in height, at a terrain elevation of 2,175 feet m.s.l. In a descending flightpath, the aircraft cut a swath through trees bordering a fairway of the Fine Acres Golf Course. The main portion of the aircraft struck the ground along the side of the fairway about 1,000 feet beyond the tree of initial contact, and came to rest inverted about 400 feet beyond the point of initial ground impact.

At the time of the accident, weather conditions at the Bradford Regional Airport were reported as: partial obscuration, measured 800 feet, overcast; visibility 1-1/2 miles, light snow showers; temperature 20° F., dew point 17° F., wind 170° at 10 knots; altimeter setting 29.47 inches.

The Safety Board is unable to determine precisely the probable cause of this accident. Of some 13 potential causes examined by the Board, three remain after final analysis. They are: (1) misreading of the altimeter by the captain, (2) a malfunction of the captain's altimeter after completion of the instrument approach procedure turn, and (3) a misreading of the instrument approach chart. Of these three, however, no single one can be accepted or rejected to the exclusion of another based on the available evidence.

On January 17, 1969, the Safety Board sent a letter to the Administrator of the Federal Aviation Administration. In the letter, the Board expressed its concern over the high number of approach and landing type accidents and made 13 specific recommendations to improve safety relative to this type of accident. The Safety Board also held several meetings with the aviation community to stimulate additional measures to prevent this kind of accident.

1. INVESTIGATION

1.1 History of the Flight

Allegheny Airlines Flight 737, of January 6, 1969, was a scheduled passenger flight from Washington, D. C., to Detroit, Michigan, with en route stops at Harrisburg, Bradford, and Erie, Pennsylvania. The aircraft was an Allison Prop Jet Convair 440, 1/ N5825.

Flight 737 operated routinely through Harrisburg, but was 43 minutes late due to a late arrival of the aircraft at Washington caused by Air Traffic Control (ATC) weather delays. Departure from Harrisburg was at 1952 2/ on an IFR (Instrument Flight Rules) flight plan and clearance via Airway Victor 13 to the Bradford VOR at 12,000 feet. The flight was subsequently cleared to descend to 6,000 feet, and upon arrival in the Bradford area about 2022, was instructed to contact Erie Approach Control for clearance to make its instrument approach 3/ for landing at the Bradford Regional Airport.

About 2023, Erie Approach Control queried Flight 737 as follows: "Allegheny seven thirty seven, what are you showing DME 4/ from Bradford?" Upon receiving the reply, "Fifteen," Erie Approach Control instructed, ". . . descend and cruise four thousand via Victor thirty three and cleared for the VOR thirty two (Runway 32) approach to the Bradford Airport, report leaving six and Bradford's current weather sky partially obscured, measured ceiling eight hundred overcast, visibility one and one half and light snow showers, wind one seventy degrees at ten (knots) Bradford altimeter twenty nine point four nine." The flight replied immediately with, "Okay, we're out of six for four, and we're cleared for a VOR thirty two approach and twenty nine forty nine on the altimeter." Erie Approach Control responded "Seven thirty seven, that's correct and you can go to Bradford Radio for any late change there in field conditions and so forth. Give us a call when you are on the ground." Wing the subsequent contact with Bradford Radio (Bradford Flight Service Station), Flight 737 gave its position as "ten DME from the VOR." Bradford Radio acknowledged this position report and advised that the surface wind was from 190° at 10 knots, and the altimeter setting was 29.48. After this communication exchange, Flight 737 asked for clearance to make its instrument approach to Runway 14 instead of

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1/ More commonly called a Convair 580.

2/ All times herein are eastern standard, based on the 24-hour clock.

3/ The Bradford Regional Airport does not have an air traffic control tower; therefore, the responsibility for separation of IFR traffic making instrument approaches to the airport is assigned to the Erie approach control facility. The airport has a Flight Service Station located in its terminal building.

4/ Distance Measuring Equipment: An electronic method of measuring slant distance between the aircraft and the ground-based transmitter.

Runway 32. The Bradford FSS Specialist obtained approval for this change from Erie Approach Control and so advised the flight.

About 2027, the flight advised, ". . . we're four miles from the VOR level at four thousand." At 2028, it reported it was over the VOR outbound, and at 2031:45 advised, ". . . Allegheny seven thirty seven is completing procedure turn inbound." Bradford Radio answered with, "Seven thirty seven, understand procedure turn inbound, the wind's one six zero at one four." The flight acknowledged "Okay." This was the last known communication from the flight.

About 2039, an Allegheny Airlines agent asked the Bradford Flight Service Station Specialist if he were still in contact with Flight 737 because he had received a phone call that an aircraft had crashed on the Pine Acres Golf Course near Marshburg. Attempts to contact the flight were made without success.

A Pennsylvania State Police Officer, who was at the airport when the phone call came in, immediately drove to the scene and confirmed the accident. This was about 2050.

The most consistent information obtained from the survivors of the accident indicated that Flight 737 seemed quite normal from Washington to Harrisburg, and thereafter until the crash sequence began.

A majority of the survivors recalled that the flight from Harrisburg to the Bradford area was fairly smooth but the "Fasten Seat Belt" sign remained on. Several said the aircraft was above a cloud layer until it began to descend and entered the clouds a few minutes before the accident. A number said it became rougher due to turbulence as the plane descended.

The hostess visited the pilots' compartment while the flight was between Harrisburg and Bradford, and noted the pilots were normal. When the "No Smoking" sign came on, the hostess made the Bradford landing announcement and began checking passenger seat belts. Before she could take her seat at the rear of the cabin, the crash occurred. According to a passenger, the "No Smoking" sign came on about 2030.

The surviving passengers stated it was difficult to identify precisely the occurrences in the impact sequence. Nine identified the first occurrence as two or more, or a series of heavy impacts accompanied by impact sounds. Four recalled the first unusual occurrence as a downdraft action of the aircraft and then the impacts. Other observations during the impact sequence were a rolling motion of the aircraft, flashes of fire or sparks, and the sound of trees breaking.

Several passenger survivors indicated an awareness of the aircraft's striking the ground and, while it slid along the ground, rolling to an inverted position. Seven stated that after the aircraft stopped, they were held upside down in their seats by their seat belts.

Those who recalled the weather after the accident said it was very cold, snowing lightly or not at all, and the ground was heavily snow-covered. Some recalled seeing the only lights in the area which varied from 350 to 900 feet from the crash site.

There were three known eyewitnesses to a portion of the accident sequence. All were in a private residence watching television. The set was located below a picture window which faced out on the golf course, affording the witnesses a view perpendicular to the crash path of the aircraft. The crash path was between 75 and 100 yards from the residence.

The witnesses reported that the first occurrence associated with the accident was a loud noise, which they variously described as a sudden blast or roar like an explosion or a sudden roar of engine power. This was accompanied by a flash of red or reddish-orange fire and the sound of breaking trees. The flash was to the left of straight out the window and between 30 and 50 feet above the ground. They then saw a shadow-like object move across the window from left to right. This was followed by a heavy impact sound to the right of their line of sight.

The witnesses stated that it was so dark and the sequence of events took place so rapidly they could not determine the altitude of the plane, what lights might have been on, and, in fact, only from the nature of the overall circumstances, did they realize it was an aircraft crashing.

One of the eyewitnesses notified the airport and emergency agencies of the accident. The three eyewitnesses gave invaluable assistance in rescuing and assisting the survivors.

The eyewitnesses reported that the weather conditions were: light snow showers with visibility that permitted them to see all of the lights in the area.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	9	0
Nonfatal	1	16	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 impacts with trees and the ground.

1.4 Other Damage

The crash path of the aircraft was along a wooded area bordering a fairway of the Pine Acres Golf Course. A number of trees hit by the aircraft were damaged or destroyed. Areas of the fairway were also damaged.

1.5 Crew Information

The flightcrew of Flight 737 was properly certificated and qualified for the flight. (For detailed crew information see Appendix B.)

1.6 Aircraft Information

The aircraft was originally built as a Convair 440. It was modified to an Allison Prop Jet Convair 440 and reissued a Standard Airworthiness Certificate, dated July 11, 1967. (For detailed aircraft information, see Appendix C.)

The gross weight and center of gravity for the aircraft were computed and found to be within their respective limitations. (For details, see Appendix C.)

The flightcrew and a Federal Aviation Administration (FAA) Air Carrier Inspector aboard N5825, when it arrived at Washington to originate Flight 737, stated that they had experienced no difficulties with the operation of the aircraft. They all stated specifically that both the captain's and first officer's altimeters were accurate, within allowable tolerances.

1.7 Meteorological Information

The weather in the Bradford, Pennsylvania, area at the time of the accident was characterized by low overcast, cloudiness, and snow showers. The 1900 surface weather chart, prepared by the National Meteorological Center, showed a low-pressure system centered over central Lake Huron and a cold front extending from the low-pressure center to near London, Ontario, to just east of Cleveland, Ohio, to near Akron-Canton, Ohio, then continuing southwestward.

The 2200 surface weather chart showed a low-pressure system centered over central Lake Huron and a cold front extending southeastward from the low-pressure center to eastern Lake Erie, then southwestward across northwestern Pennsylvania and beyond.

The Bradford, Pennsylvania, surface weather observations for January 6, 1969, were, in part, as follows:

1858--Partial obscuration, measured 1,000 feet broken,
1,600 feet overcast, visibility 1-1/2 miles, light

snow showers, temperature 20° F., dew point 16° F., wind 170° 10 knots, gusts to 18 knots, altimeter setting 29.50 inches, 3/10 of the sky obscured by snow.

1958--Record Special, partial obscuration, measured 800 feet overcast, visibility 1-1/2 miles, light snow showers, temperature 20° F., dew point 17° F., wind 170° 10 knots, altimeter setting 29.49 inches, 3/10 of the sky obscured by snow.

2044--Special, measured 500 feet overcast, visibility 1-1/2 miles, light snow showers, temperature 22° F., dew point 20° F., wind 170° 10 knots, altimeter setting 29.47 inches.

The weather conditions reported at the Bradford Regional Airport covering the accident period were substantially as forecast. With respect to icing, the forecast called for moderate to heavy rime or mixed icing in the clouds and precipitation below about 8,000 feet m.s.l. The Weather Bureau duty forecaster stated that icing was in the forecast although temperatures were well below freezing because the air was nearly saturated from the surface to about 9,000 feet. The weather conditions which existed at the time of the accident were not unusual, but rather typical for the area during the winter months.

There was nothing in the records of the Weather Bureau and FSS offices at either Washington or Harrisburg to indicate that the pilots of Flight 737 obtained a weather briefing from any of these facilities. However, the dispatch papers given the crew for the flight contained all of the pertinent and available weather information. Also, a self-help weather briefing display was available in the Allegheny Airlines Operations Office in Washington for the pilots to obtain their own detailed weather information.

1.8 Aids to Navigation

Instrument approaches to the Bradford Regional Airport utilize the Bradford VORTAC which is a VOR (Very High Frequency Radio Range) with the capability of providing distance information to aircraft equipped with DME. This equipment was installed in N5825. The Bradford VORTAC is located .9 nautical miles 5/ from the approach end of Runway 32.

The approved instrument approach procedure to Runway 14 is identified as a VOR/DME approach, and the procedure is depicted on the Jeppesen Approach Chart 6/ which Allegheny Airlines uses. 7/

Among other things, the approach procedure provides that an aircraft, upon passing over the Bradford VORTAC, will proceed outbound on the 323°

5/ From the VORTAC, the crash site was 6.5 nautical miles.

6/ See Attachment 1.

7/ The current chart for the VOR/DME instrument approach to Runway 14 was recovered in the aircraft wreckage of N5825.

radial and execute a procedure turn not below 3,900 feet m.s.l. between the 6- and 16-mile DME fixes. The procedure provides that upon completion of the procedure turn, the aircraft may be descended to 3,300 feet m.s.l., but not below this altitude until the 6-mile DME fix is passed. The inbound heading is 143°. After passing the 6-mile DME fix, the aircraft may then be descended to the MDA (Minimum Descent Altitude) which, for the subject approach, is 2,643 feet m.s.l. or 500 feet above the elevation of the airport. Descent below the MDA may not be made until the runway or markings identifiable with the runway are clearly visible to the pilot.

The visibility minima. for the subject instrument approach are three-quarters of a mile if the runway high-intensity lights are in operation and 1 mile if they are not.

1.9 Communications

The communications between Flight 737 and the various air traffic control facilities were routine and made in accordance with standard procedures. There was no indication of communication difficulties, and there was nothing in the communications to indicate the flight was experiencing any problem of another kind. The last communications from the aircraft were routine when, about 2032, the flight advised it was completing its procedure turn inbound, and in response to a final wind advisory from the FSS answered, "okay."

Persons familiar with the voices of both the captain and the first officer agreed that the air-to-ground communications from Flight 737 were made by the first officer. This information clearly suggests the captain was flying the aircraft.

1.10 Aerodrome and Ground Facilities

Runway 14 (140° magnetic) at the Bradford Regional Airport is 6,500 feet long and 150 feet wide. It is equipped with high-intensity runway lights. At the time of the accident, none of the runways was equipped with Instrument Landing System (ILS) or an approach light system. The airport elevation is 2,143 feet m.s.l.

On the evening of January 6, 1969, Runway 14 was plowed free of snow accumulation but it was covered to a large extent by patches of hard-packed snow and rough ice.

The Bradford FSS Specialist, on duty at the time of the accident, reported that for a time period well before and after the accident, there were no alarms of the monitoring system to indicate any power interruptions, malfunctions, or failures of instrument approach facilities. After the accident, both ground and flight checks of the facilities showed they were operating within allowable tolerances.

The FSS Specialist also stated the high-intensity runway lights for Runway 14 were on at the time of the accident and set on step 5, the highest brilliancy setting. He also described the manner of determining visibility using the runway lights. He stated that from his experience, the visibility was 1-1/2 miles.

1.11 Flight Recorders

(a) Flight Data Recorder

N5825 was equipped with a United Data Control Model FA-542 flight recorder. 8/ The recorder was recovered from the wreckage and the recording medium was found undamaged. All parameters, altitude, heading, airspeed, and vertical acceleration had been functioning normally throughout the flight.

The flight recorder receives its data from the first officer's instrument Pitot-static source systems. It is independent of, and in no way connected to, the captain's Pitot-static instrument source systems.

Examination of the recording medium revealed all traces became aberrant, due to the crash, approximately 42:36 minutes after takeoff from Harrisburg.

Examination of the altitude trace revealed a correlation within 100 to 150 feet lower than clearance altitudes for the en route phase of the flight, and a close correlation for the specified procedure turn altitude for the VOR/DME instrument approach procedure and the terrain elevation at the crash site. More specifically, the altitude trace showed that the aircraft descended to an average altitude of about 3,900 feet m.s.l. about 9.0 minutes before impact and remained there for about 7.0 minutes. The trace then showed that a descent from about 3,900 feet m.s.l. began about 1:46 minutes before impact and stopped at about 2,500 feet m.s.l. for about 8 seconds. This descent of 1,350 feet took place in about 1:20 minutes. After the 8-second interval, the altitude trace showed that descent began again and continued until major impact occurred, which stopped the voice and flight recorders 18 seconds later at an altitude trace indication of 2,225 feet m.s.l. The 'terrain elevation of the crash site was 2,175 feet. The brushing tree contact was about 76 feet above the ground elevation of the tree.

The heading trace from the flight recorder revealed that during the period the aircraft was at an average of 3,850 feet m.s.l., heading changes occurred which were consistent with the instrument approach procedure turn. These heading changes started about 4 minutes before impact and ended less

8/ Allowable tolerances for this recorder are: Altitude -- plus or minus 100 feet from sea level to 2,000 feet, 125 feet from 2,000 to 3,000 feet, and 150 feet from 4,000 to 10,000 feet. Airspeed tolerances are plus or minus 10 knots and for heading plus or minus 2°.

than 30 seconds before impact. Also, before the procedure turn, headings reflected by the heading trace were consistent with headings to establish the outbound radial. For about 1.0 minutes before the heading trace became aberrant, it was unsteady while changing from about 175" to 165°. When the trace became aberrant, it showed a heading of 165°.

The airspeed trace for a period of 0:26 minutes before ending showed a gradual decrease from 145 knots to 134 knots.

The vertical acceleration trace varied from 1.00 g plus or minus 0.33 g for an approximate 4-minute period before it ended.

(b) Cockpit Voice Recorder

N5825 was equipped with a United Data Control cockpit voice recorder, Model V557. The voice recorder was undamaged and a transcription was made of the recordings starting with Flight 737's initial radio contact with Bradford FSS 9/ until the recorder was stopped by impact. Because the recording was of poor quality, the Federal Bureau of Investigation (FBI) was requested to examine the flight recorder tape and attempt to determine if more intelligence were on the tape than obtained by the Safety Board's readout. The FBI was unable to improve on the results of the readout made by specialists of the Safety Board.

1.12 Wreckage 10/

Investigation disclosed that the initial contact of the aircraft with ground environment occurred as a brushing contact with the uppermost branches of a tree. The contact was 79 feet above the base of the tree at a terrain elevation of 2,175 feet m.s.l. Following the initial contact, the aircraft hit other trees and cut a swath through them about 100 feet wide on a magnetic heading of 160". The swath sloped downward at an angle of 2.5° for an initial distance of 530 feet.

As the aircraft continued through trees, major pieces and components separated from the aircraft. Along the side of the fairway of the golf course the swath through the trees steepened to about 6" and the heading shifted from 160° to about 140°. Ground impact occurred about 1,000 feet from the tree that was initially hit, and the main portion of the aircraft stopped inverted about 1,400 feet beyond this tree.

In general, the main wreckage consisted of the major portions of the cockpit and passenger areas of the fuselage, the wing center section, and a large section of the right wing. Both engine nacelles were in the main wreckage with their respective main landing gears in an extended and locked psition. The right engine was near its nacelle; the left was about 100 feet from the main wreckage.

9/ Attachment 2, Transcript of Voice Recorder Readout.

10/ Attachment 3, Wreckage Distribution Chart.

Major portions of the right wing, empennage, and other primary structures were found back along the ground and tree swath paths for a distance of about 800 feet to a large tree which had received a major impact. Miscellaneous structure was recovered along the ground from this tree to near the tree initially contacted by the aircraft.

In the main wreckage area and back along the ground and tree swath paths, all of the airframe structure was accounted for. All structure separations were determined to have been induced by impact, and no evidence was found to indicate malfunction or failure of the primary structure or flight controls prior to impact with the trees. Impact forces on all separated structures were predominately rearward. The fuselage sections were crushed rearward and upward as viewed in their inverted positions.

Both wing panels were separated from the wing center section and both were damaged extensively by impact. All components of the ailerons and wing flaps were recovered and, from the right inboard flap which received limited damage, it was determined that at impact the wing flaps were extended 15°, which is the maneuvering flap setting. The landing lights were found retracted with their bulbs and lenses broken out.

Except for the right horizontal stabilizer and elevator, major portions of the empennage were separated from the aircraft. Most of the separated portions were recovered along the last 1,000 feet of the wreckage path. Examination indicated the separations were due to impact and no evidence was found to indicate operating distress, malfunction, or failure.

The right horizontal stabilizer, including the elevator and trim tab, was intact with light impact damage. The trim tab was deflected downward, aircraft noseup, 1-3/4 inches measured at the outboard end.

Examination of the powerplants of N5825 disclosed no evidence of operating distress, malfunction, or failure prior to impact. Disassembly of the propellers revealed existing blade angles which, for the operating conditions at the time of the accident, were equivalent to a power development of 600 shaft horsepower for the left engine and 700 for the right. Both of these power developments are in the descent range and well below that required for level flight at a constant airspeed.

Convair 580 aircraft operated by Allegheny have three normal pitot static systems. One is for the captain's static system instruments; another is for the copilot's instruments which also serves the flight data recorder; the third is for the altitude controller. Each is an independent, balanced system with two static ports, one on each side of the aircraft. The static ports for the copilot's instruments and flight data recorder are located just below the captain's. All are recessed. The static ports for the altitude controller system are located just behind those for the individual pilot's systems.

Examination of the static systems of the aircraft revealed considerable impact damage; however, all of the lines and associated components were accounted for. At the accident scene, where below freezing conditions existed, the static systems were examined for possible icing in or around the ports and at breaks in the lines. None was found. The systems were also checked for security of connections and fittings. When no discrepancies were found, the systems were then removed from the aircraft and taken to a warm hangar to check for moisture in the systems. None was found.

Following these examinations the lines and components were taken to the maintenance facilities of Allegheny where the systems were examined to verify their integrity. Special attention was directed to line conformity, proper connections and attachments, evidence of corrosion in the lines and components, chafing of lines, and obstructions of any nature within the lines and components. This work revealed no evidence of discrepancies of any kind which would affect the normal function of the systems.

The captain's and the first officer's altimeters were recovered and examined under laboratory conditions. The rocking shaft pivot of each was broken and both failures were caused by overload. When these pivots were replaced, each instrument functioned normally within allowable tolerances. The barometric setting in the captain's instrument was 29.46 and in the first officer's, 29.47. The altitude indications of both instruments were meaningless due to the broken rocking shaft pivots and impact forces.

The autopilot system from the aircraft was examined in the manufacturer's test facilities. The autopilot controller was found to be functional in all respects. The altitude hold switch was determined to be in the off position, and the mode switch was considered to be positioned to the approach mode because the captain's command bars for roll pitch indications were displayed. The autopilot power source switch was on; however, it could not be determined if the autopilot was engaged.

The altitude controllers of the autopilot system were recovered and the altitude sensors were examined for evidence of altitude information at impact. Because of the evidence of impact forces received by these components, it was indicated that such information would not be reliable. However, the internal components of the controllers showed no evidence of malfunction or failure prior to impact.

The captain's course indicator instsment was tested. It would not function because of dents in the case and a loose internal motor which had shifted due to impact. When the case was removed and the motor repositioned, the instrument operated normally. The course heading selected in the instrument was 140°.

The first officer's course indicator was tested and it functioned normally in all respects. The course heading selected for this instrument was 147°.

The Distance Measuring Equipment (DME) was examined at the scene and it read 7.5 miles. The actual readout taken from the transceiver unit was 6.7 miles. In tests, the DME functioned normally without alteration or repair.

Examination of icing protection systems indicated that the anti-icing systems of the aircraft were not being used at the time of impact, but were capable of normal operations.

The other systems of the aircraft such as electrical, hydraulic, communications, and lighting were examined and nothing was found to indicate malfunction or failure of any of them prior to impact.

1.13 Fire

Examination of the aircraft wreckage and eyewitness and survivor information indicated there was no fire in the main wreckage. Sooting on various structural fractures showed there were flash fires after separations of structural components during impacts with the trees and along the ground path. The eyewitnesses and some of the survivors also recalled seeing puddles of burning fuel at several locations from 25 to 100 feet back along the ground path from where the main wreckage stopped. Burned areas on the ground, observed later, verified these observations.

1.14 Survival Aspects

This was an accident in which 17 of the 28 persons aboard the aircraft survived. Twelve of the survivors were seated behind seat row 7. Of these, seven were seated on the left side of the cabin, four on the right side, and the hostess was standing at the rear of the cabin. The other five survivors were seated ahead of seat row 7 on the right side of the cabin. The survivors ahead of row 7 were injured more seriously than those behind seat row 7. The left side of the cabin ahead of row 7 was considered a probable nonsurvivable area. The pilots' compartment was a nonsurvivable area. The survivability of the rear portion of the cabin was because the aircraft struck the ground partially or completely inverted and, relative to the surface, in a nose-low attitude. This resulted in the greatest impact forces being sustained and absorbed by the pilots' compartment and the forward portion of the passenger cabin.

The cabin portion of the aircraft came to rest inverted. That portion ahead of seat row 7 was demolished, while the portion behind seat row 7 was relatively intact but, as viewed inverted, the top of the cabin was crushed upward to about the top of the seat backs. There was a large break across the fuselage ahead of seat row 7. Two other breaks made openings in the cabin. One was where two trees impaled the aft fuselage as it stopped and the other was just ahead of the empennage. The cabin lights went in the crash sequence and the emergency lighting was rendered inoperative.

Most of the passenger seats ahead of seat row 7 were found outside of the fuselage. Those to the rear of seat row 7 remained in place, although the seat backs of five were either broken or sprung. The safety belts of four passengers were broken in the crash sequence.

Based on the best recollections of the survivors and rescuers, and other evidence, five survivors were thrown outside the fuselage, apparently very close to the time and place where the fuselage stopped. Six crawled out through the emergency window exit at seat row 9 on the left side of the cabin, three crawled out through the rupture in the fuselage made by the two trees which impaled the aft cabin, and one was pulled out through a broken cabin window at seat row 7 on the right side of the cabin. The means of exit used by two are unknown. Some survivors were helped out of the aircraft by other survivors or by the three eyewitnesses who reached the crash site within about, 2 minutes after the accident.

A fourth person who had planned to watch television with the three eyewitnesses arrived on the scene about 10 minutes after the accident. He immediately took several of the most seriously injured survivors to the hospital in his station wagon. In the meantime, other survivors were guided, helped, or carried to the golf course "pro" shop which was heated. They were taken to the hospital from there as soon as possible thereafter when resuce vehicles arrived.

1.15 Tests and Research

Following this accident, several flight tests were conducted to explore the operating characteristics of the Convair 580 static system with respect to possibilities of errors induced into the static system instruments. The general areas covered by the tests were to determine the effects of the following:

(1) Operations of the static system with static ports partially obstructed.

(2) Operation of the static system with irregularities in the fuselage area in the vicinity of the static ports.

(3) Altimeter responses to pressure changes under very low temperature conditions.

(4) Static system water ingestion characteristics.

The test for effect with the static ports partially obstructed was conducted in two phases. In phase one; only one static port was operative while the other was taped off. In phase two, all but one hole of each "salt shaker" of both static ports were closed off. The altimeter and airspeed indications of the test system were then compared with a normal system during flight. In normal and rapid descents during each phase, the variations in readings between the instruments of the test and normal systems were insignificant. Even in abnormalmaneuvers, such as sideslipping, the variations were insignificant. Maximum variations between the readings were 7 knots in airspeed and 60 feet in altitude.

The second test, to determine the effect of fuselage surface irregularities, such as an ice buildup close to a static port, was set up by taping a 1/8-inch diameter cylindrical spoiler to the fuselage in a vertical position, one-quarter of an inch in front of one static port. The other static port was taped off. Readings of test altimeter and airspeed were again compared to those of a normal system. During climbs and descents of 1,400 to 1,500 feet per minute, variations in airspeed were from 9 to 15 knots and in altitude from 20 feet to 300 feet. The maximum variation of 300 feet occurred in climb. The maximum variation in descent was 200 feet. The conclusion drawn from this test was that the static system was significantly responsive in altitude indication to a fuselage surface irregularity in front of the static port.

To determine the effect on an altimeter by extremely low temperatures, the readings of an altimeter which was cold soaked for 21 hours in temperatures between minus 20° F. and minus 38° F. were compared with another altimeter at room temperature. In a descent from 10,000 to 4,000 feet, the cold-soaked instrument took about 3 seconds longer per 1,000 feet than the instrument did at room temperature. In continuing the descent from 4,000 feet to 1,090 feet, the cold-soaked altimeter lagged about 2 seconds per 1,000 feet behind the altimeter at room temperature. The variations found from this test were considered negligible.

The test to evaluate the water ingestion characteristics of the static system and the effect on the system was set up as follows:

1. One static port of the first officer's system was blocked leaving one operative port.

2. A plastic tube was installed to the operable static port for viewing the water accumulation, and the water was colored to make it easier to see.

3. A water discharge device was installed 1 to 1-1/2 feet ahead of the operable static port which was capable of pouring 4 to 5 gallons of water per minute over the fuselage surface about 15 inches in front of the port.

4. The static system for the captain's instruments was not affected for the test and, as in the other tests, readings from the test system were compared to the normal systems.

To test the self-purging characteristics of the system, the stand pan area adjacent to the static port was filled with water while the aircraft was on the ground. This resulted in an altimeter indication error of 200 feet. Wing the takeoff roll or just after lift-off, the water ran out of the test system, and the altimeter gave accurate indications during climb.

At 15,000 feet, the water was turned on, and the aircraft was descended at a rate of 1,500 feet per minute and an airspeed of 125 knots. Water became visible in the plastic tube at 13,500 feet and filled it 8 to 10 inches at 8,500 feet. At this point, the water was turned off and the descent was continued to about 3,000 feet, where the aircraft was leveled off. Wing the descent, a maximum variation of 36 hots in airspeed and 600 feet in altitude occurred between the test system instruments and the normal ones. Both readings of the test instruments were higher than actual. When the aircraft was leveled, the water ran out of the test system and the instruments presented accurate readings. This test was cited as again demonstrating the self-purging capability of the static system.

Another descent was made from 15,000 feet, this time using 1,500 feet per minute rate of descent and 250 knots airspeed. With the water discharge on during the descent, no water was ingested in the test system and the instruments of the test system gave accurate indications.

From the foregoing tests, it was concluded that the static system can be made to ingest water under certain specific conditions, which are:

1. The aircraft must be descending.

2. Airspeed is critical with water ingestion occurring only at slower speeds.

3. All holes in the "salt shaker" portion of the static port must be covered simultaneously with water for a sustained period. It was estimated that in the tests, a flood of water equivalent to the quantity being felt by the entire fuselage during a rainstorm was concentrated in a mall area.

4. Airflow through the operable static port must be accelerated by removing the function of the other static port from the system.

During the investigation, the possibility of moisture freezing in the static system lines and "T" fittings was considered. This was considered possible because some of these lines are routed along the inside of the aircraft close to the outside skin under the pilot compartment and cabin areas. Also, if such freezing were to occur and restrict the static system to a high degree, erroneous altimeter and airspeed indications would occur.

In view of the foregoing, on December 18-19, 1969, a flight test was conducted using an Allegheny Convair 580 to resolve the possibility. To effect the test, thermocouples were attached to the lines and fittings of the captain's static system where they were supported by a bracket attached to the inside of the outer skin of the aircraft. The aircraft was then flown in outside air temperatures ranging from minus 4° F. to minus 22° F. for more than an hour. Results of this test revealed that at no time did temperatures of the static system components approach freezing. The lowest temperature recorded was plus 45° F.

Another part of the test just described revealed that when the static system was restricted to the extent that it caused the altimeter to indicate 3,200 feet when the actual altitude was 2,200 feet, the airspeed indication increased from an actual airspeed indication of 150 knots to a false indication of 205 knots.

1.16 Other Information

The Allegheny Airlines Operations Manual, as it existed at the time of this accident, provided that the duties of the pilot not flying the aircraft during descent and approach included the following callout procedures: 11/

> "Call out approaching 18,000 feet as a reminder to reset altimeters. Call out 15,000 feet, 10,000 feet, 5,000 feet, and 1,000 feet above initial approach altitude or 1,000 feet above field elevation in the case of VFR approaches.
>
> "On final approach, upon reaching 500 feet above field elevation, the pilot not flying shall call out altitude, airspeed and rate of descent. Thereafter, he shall call out specific deviations from programmed airspeed and desired rates (this is especially important in turbojet aircraft)."

The duties of the pilot not flying also require him to observe outside conditions to the degree possible throughout the approach, and no later than 100 feet above the minimum altitude, to be alert to spot and call out approach lights, runway in sight, or other pertinent information.

With respect to the callout procedures stated above as they were appropriate to this flight, a review of the voice recorder readout indicates that none of these callouts was made.

11/ See Section 3, Recommendations and Corrective Measures for changes in callout procedures following the accident.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

Based on all the available evidence obtained from the investigation of this accident, it is apparent that Flight 737 was operationally routine as it progressed over its route of flight into the Bradford area to make an instrument approach and land at the Bradford Regional Airport. Readouts of the voice and flight data recorders, study of air-to-ground communications, examination, tests, and functional checks of ground and airborne navigational equipment, and examination of the aircraft wreckage failed to disclose evidence that any operational or mechanical difficulties were experienced by the flight. The voice recorder readout and air-to-ground communications make it evident that the captain was flying the aircraft prior to and during the instrument approach, and at the time the accident occurred.

Approaching the Bradford area, the pilots of Flight 737 requested a VOR/DME approach to Runway 14 instead of Runway 32. Because of the patches of snow on the runway, and the downwind component which would have resulted during an approach and landing on Runway 32, the request was probably based on the above factors. The approach plate for the approach to Runway 14, having been found in the cockpit area, suggests the crew was prepared for this approach.

The information provided by the flight data recorder, together with pertinent factors affecting flightpath such as wind and aircraft performance, showed that prior to the initiation of the instrument approach, the flightpath was in close conformity to clearance altitudes and positions reported by the crew. The recorder data showed that after the approach was initiated, the flightpath remained good with respect to the procedures prescribed by the instrument approach until just after the flight completed the procedure turn. The outbound radial appeared to be well established, the procedure turn was made within the proper DME fixes, and the inbound radial was well established. According to the flight recorder information, the procedure turn was flown at approximately 3,900 feet m.s.l.

The flight recorder data revealed that just after the completion of the procedure turn, the aircraft entered a descent of approximately 1,200 feet per minute. It descended at a steady rate until it was about 2,500 feet m.s.l. At this point the aircraft leveled for a brief interval of about 8 seconds. The data showed that after this brief period, a descent of about 750 feet per minute was commenced which continued unabated until the aircraft struck trees and crashed about 18 seconds later. At impact, the aircraft was still descending and the engine power development was consistent with an intentional descent.

At the point of the initial tree contact, the flight recorder altitude trace showed an indication of about 2,265 feet m.s.l. At this point the terrain elevation, including the height of the tree, was about 2,255 feet m.s.l. Based on the flight recorder information and the elevation of the initial tree contact, the aircraft at this point was approximately 1,050 feet below the altitude of 3,300 feet m.s.l. specified in the approach procedure prior to reaching the 6-mile DME fix. It was also about 380 feet below the specified MDA and only about 120 feet above the published airport elevation.

In view of the foregoing, it is evident that the sole factor producing this accident was the radical departure from the altitude requirements specified for the instrument approach procedure. It is further evident that this critical deviation took place in its entirety after the procedure turn was completed. The descent also occurred after close adherence to clearance and specified altitudes before the instrument approach was initiated and during that portion of the instrument approach preceding the completion of the procedure turn. Accordingly, the investigation was centered on efforts to determine what may have been the reason or reasons for this excessive deviation in altitude.

In its attempt to find the reason for the excessive descent, the Safety Board has considered and ruled out several possible mechanisms of failure based on the known facts derived from the accident investigation. Examination of the aircraft wreckage indicated convincingly that prior to impact there was no structural failure of the aircraft, no malfunction or failure of its controls or systems, and that both engines and propellers were capable of normal operation. The voice recorder and air-to-ground communications reflected no evidence of the existence of any kind of an emergency or of any interference or distraction of the pilots by an unauthorized person in the cockpit. Pilot fatigue is highly unlikely because the pilots were off duty 24 hours before the flight, and on duty only a little over 3 hours while preparing for and conducting the flight. Based on the voice recorder information and post-mortem examinations of the pilots, inflight pilot incapacitation has been eliminated.

From the evidence, it is reasonable to conclude that the crew asked for clearance to land on Runway 14 instead of Runway 32 was reasonable because of wind and runway conditions. Both the captain's and the first officer's altimeters were found set within 00.02 inches Hg of the latest barometric setting furnished the flight. This difference amounts to only 20 feet which is insignificant to the accident.

As a more probable reason for excessive descent, the Safety Board explored the factors relating to a possible intentional departure from the prescribed altitude requirements of the approach. It also explored the mechanical and operational factors under which the descent might have occurred while the pilot believed they were complying with the instrument approach altitude requirements.

The hypothesis of an intentional departure from the prescribed procedures breaks down for several reasons. First, there would be no advantage to the pilot in making a premature descent to or below the in an attempt to make a visual approach. With the exception of the few lights on the golf course where the aircraft crashed, the entire area under the instrument approach path to Runway 14 was very dark and sparsely lighted, with some of the area being the Allegheny National Forest. A pilot familiar with the area would know that an attempt to conduct a visual approach over this area at night in reduced visibility would be extremely difficult. The captain involved in this accident had made approaches to the Bradford Airport and was familiar with the area. Secondly, any conceivable descent below the MDA for the purpose of avoiding a high rate of descent during the final descent to land would be associated with weather conditions at or near minima for the instrument approach. However, in this instance the ceiling was reported as 300 feet above the MDA and the visibility was 1-1/2 miles, or twice the required minimum. Under these conditions there would be little or no benefit to be gained by a descent below the MDA at a distance of some 5 miles from the airport. Thirdly, if the pilot flying the aircraft purposely intended to descend below the preecribed approach altitude minima, there should have been some conversational exchange with the other pilot on the voice recorder about such an intent; however, there was none. Even if the descent were made intentionally and knowingly by the pilot, it would be most difficult to explain why there were no altitude warning calls when the altitude was becoming so dangerously low, as it did particularly during the final 18 seconds before impact. Finally, the overall hypothesis becomes wen harder to rationalize in light of the accident involving a compeny aircraft at the same airport less than 2 weeks earlier, a fact which the Safety Board believes would have made the pilots of Flight 737 more attentive to altitude requirements.

As stated earlier, a second reason for the excessive descent may have been that it occurred unknowingly and/or unrecognized by the pilots. In evaluating this reason, the Safety Board considered the factors relative to several possible mechanical and operational ways that this might have occurred.

One of the first considerations was that erroneous information was presented to the-pilots due to a malfunction of the ground-based or airborne navigational equipment, and that such malfunction led the pilots to believe they were much closer to the runway than the actual distance. This possibility would have to assume the descent was made before the runway was sighted, but with the expectation that visual contact with the mway was imminent.

The Safety Board concludes that this possibility is remote based on the factual and circumstantial evidence. First, on the factual side, a readout of the DME of the aircraft showed the actual distance from the crash site to the VORTAC, and, in tests after the accident, the airborne DME functioned normally without alteration or repair. These factors cause the DME readout to be considered highly accurate and reliable evidence. In addition, the Bradford VORTAC was both ground and flight checked after the accident and found to be operating normally. Secondly, there were no malfunction warning alarms with respect to the facilities during a period well before and after the accident.

There are also three circumstantial reasons to believe that the ground and airborne navigational equipment was functioning normally and the pilots were aware of their position over the ground. The first is the accuracy with which the instment approach was flown in all respects except altitude. Had the pilots not been receiving accurate navigational information, it would be most difficult to understand how such accuracy could have been accomplished. Secondly, when the "No Smoking" sign came on, the hostess was unable to finish her cabin duties before the crash occurred, although she would have been able to do so in the time it would have taken the aircraft to reach the runway from the crash location. Conversely, had the pilots believed the aircraft was much closer to the airport than it actually was, the "No Smoking" sign should have been turned on much sooner than it was. Finally, had the pilots believed they were much closer to the runway, the landing gear should have been extended sooner, and pre-final-landing-approach-flap position should have been selected instead of the maneuvering setting which existed as determined by wreckage examination.

Another possibility considered was that the altitude hold feature was engaged to hold the MDA, and in some manner it became disconnected, which lead to an undetected descent below obstructing terrain.

The evenness of the altitude trace and the steady rate of turn during the procedure turn, as reflected by the flight data recorder, muld be very difficult to achieve by flying the aircraft manually, and are indicative of the use of the altitude hold and the autopilot at this time. Subsequent to the procedure turn, however, a descent was made which would require the altitude hold to be turned off. If the pilot thereafter wished to use the altitude hold to maintain level flight after descent to a desired altitude, it could account for the 8-second period of level flight shown by the flight recorder data. An inadvertent disconnect of the altitude hold for some reason at that time could result in an undetected reentry into a descent.

The most convincing factor indicating that the descent following the 8-second interval was intentional and was not related to an autopilot malfunction was the engine power development. For the aircraft to have maintained a constant altitude at the MDA under any condition, related or unrelated to the use of the autopilot and altitude hold, approximately 1,200 shaft horsepower was required from each engine. In this instance, the left and right engines at impact were developing 600 and 700 shaft horsepower, respectively. Not only were these power developments inadequate to maintain level flight, they were also consistent with a descent of about 750 feet per minute as reflected by the flight recorder.

As another reason for the excessive descent, the Safety Board considered misreading of the instrument approach chart. Descent well below the MDA could occur if the pilot misread the altitude restriction prior to the 6-mile DME fix as 2,300 feet instead of 3,300 feet. The profile for the descent indicated by flight data recorder would be consistent with such an error, assuming the reinitiated descent after the 8-second interval of level flight was to continue to the MDA.

While the pilot might make the error described above in order for the accident to have occurred the way it did, the error should have been compounded by another error of the same kind. This is because, before starting the descent, it would be normal for the pilot to determine the MDA, which in this instance was 2,643 feet m.s.l. Accordingly, if the pilot were to misread the 6-mile DME fix altitude as described, he would also have to misread the MDA or be faced with the unique situation of seeing an MDA higher than the 6-mile DME final approach fix altitude.

It is conceivable that the pilot misread the 6-mile DME fix altitude but at that time did not determine the MDA, intending to do this after the initial descent. In this situation and with the altitude displacement reflected before the instrument approach,, it could be reasoned that the aircraft struck the trees without the compounding second error. This reasoning, however, breaks down because there would be no rational reason for the break in the descent close to the MDA, the reinitiation of the descent after the 8-second interval of level flight, and the continuing descent of the aircraft which existed at impact.

During the investigation, considerable attention was centered on the examination and testing of the static systems of the aircraft. It was reasoned that ice, water, or deicing fluid in the lines and fittings of the system, or ice around the static ports disrupting airflow, might create such an effect on the static system that it would cause erroneous readings of the pilots' static instruments. More specifically, if a restriction occurred, the altimeter could lag behind the actual altitude of the aircraft during descent. At the same time, the rate of descent displayed to the pilot would decrease along with the altimeter lag. Obviously, in such a situation it would be possible for the pilot to have flown the aircraft to an altitude below obstructing terrain while believing he was conforming to the specified instrument approach altitudes.

For a number of reasons, the Safety Board concludes that restriction of the static systems of the aircraft was probably not the cause of the excessive descent. Cont'd

The first of these reasons rests with the physical examination of the system at the accident scene and thereafter. During the wreckage examination, no evidence of ice Water was found on or around the static ports. In fact there was no evidence of airframe icing. Had such ice existed, the below freezing temperatures which prevailed at the crash would have prevented such ice from melting. In addition, breaks in the lines of the static system and areas adjacent to the breaks were examined for moisture or ice formation if moisture had run out of the lines; none was found. Later when the components of the system were taken to a heated area, they were examined for moisture which muld indicate icing within the components and none was found. Still later the system components were examined for any evidence of restriction of the system or any other discrepancies which could effect n o d operation. No such evidence was found.

In addition to the foregoing evidence, flight tests were conducted by Allegheny Airlines to determine the response of the static system flight instruments to static system restrictions and environmental influences. The tests were also made to determine to what degree the system could tolerate these influences and finally whether or not ice would form if water were present in the system.

From the flight tests, it was learned that complete blockage of one of the two static ports of a static system had no significant effect on the static instruments served by the affected system. It was learned that all but one hole of the "salt shaker" static port inlet could be blocked on both ports of the same system without significant effect on the static instruments served by the system. Furthermore, it was demonstrated that the blockage of a large cross section of a static line could be tolerated without affecting the instruments served by the line. When the restriction progressed to the point where complete blockage existed, the altimeter stopped on the altitude indication existing at the time of total blockage and remained at that indication, notwithstanding the fact that the aircraft was descending. At the same time, the vertical speed indicator ceased to function. The airspeed indicator, however, responded by showing an airspeed of 205 knots at an actual airspeed indication of 150 knots.

With respect to water being ingested into the static system and the effect on static system instrument readings, flight tests revealed the system could be made to ingest water and it would affect the static instrument readings but only under certain conditions, extremely artificial. to n o d operations. These were: the aircraft must be descending at a slow airspeed; all holes in the "salt shaker" portion of the static ports must be covered simultaneously with water for a sustained period and in an amount estimated as equivalent to the quantity being felt by the entire aircraft fuselage during a rainstorm concentrated on a small area; and airflow through an operable static port must be accelerated by removing the function of the other static port from the system. The tests also demonstrated that ingestion of water could not be made to occur during level or climbing flight and the system was self-purging immediately when level or climbing flight was achieved.

With respect to the possibility of water freezing in the static system, the flight tests showed that freezing temperatures would not occur in the system even in areas where it was most subject to the outside air temperature.

As previously stated, the flight data recorder and the first officer's instruments are served by the same static system, while the captain's are served by an entirely separate system. Also, as described earlier, the flight data recorder showed that the aircraft was flown about 100 to 150 feet lower than assigned en route altitudes which, in consideration of recorder and instrument tolerances, was in close conformityto clearance altitudes. The recorder also showed the instrument approach, until completion of the procedure turn, was flown with precision. From the completion of the procedure turn, the flight recorder altitude trace continued to depict the descent as it occurred because, at the point of impact where the recorder was stopped, it reflected the impact elevation within 10 to 20 feet of the actual elevation.

From all of the foregoing eyidence, it is probable that the captain's and the first officer's static systemswere functioning normally. Also, because the captain was flying the aircraft, he would be positioning it in all respects, including altitudes by reference to his own instruments. Thus, the flight recorder served by the first officer's static system was reflecting indirectly the instrument information displayed to the captain by his instruments, served by his separate static system. It is therefore evident that at least until the completion of the procedure turn, the flight recorder was recording what the captain was seeing on his instruments and the information was accurate.

From the foregoing information, the Safety Board may draw several inferences. First, the captain's and the first officer's static systems were probably operating normally until impact. Second, the captain and the first officer were receiving accurate altitude information up to at least the completion of the instrument approach procedure turn. Finally, if the reason that the excessive descent went undetected were due to a mechanical fault, it would have to rest with the captain's altimeter instrument itself. Conversely, if the altimeter were displaying accurate information, the descent below prescribed altitudes must have been due to human factors.

The Safety Board cannot rule out the possibility that some altimeter fault occurred after the procedure turn, causing the captain to receive erroneous altimeter information which made him believe he was flying the aircraft in accordance with the specified altitudes of the approach procedure. However, if such fault did occur, the reason for it was not evident from examination of the altimeters. In fact, when the impact-broken rocking shaft pivot of each instrument was replaced, both instruments functioned normally. In addition, it would be most unusual for an altimeter to develop suddenly a major fault, coincident with the completion of the procedure turn, after continuous normal operation before and throughout the flight. It would also seem unusual for an altimeter to stick or lag to such an extent that it registered less than 600 feet of descent during the descent of some 1,650 feet, which took place between completion of the procedure turn and impact, and show no evidence of a reason for such a fault. It might also be difficult to understand why such a great disparity of indicated and actual descent would not be detected by cross check with other instruments reflecting descent, such as the flight director altitude presentation, the vertical rate indication, and even the engine power settings.

On the basis of the overall evidence, the Safety Board does not consider it reasonable that a simultaneous fault occurred to both the captain's and first officer's altimeters. Therefore, it is faced with the perplexing question of why the excessive descent was not detected by the first officer. One possible explanation is that a fault developed with respect to the captain's altimeter. While this was occurring, the first officer was watching the DME readout, which is only displayed on the captain's instrument panel, to call out the 6-mile DME fix. If this were the case, the first officer could have been checking the captain's altimeter for altitude information instead of cross checking against his own instrument. If this occurred, it could explain the total void, reflected by the voice recorder, in crew coordination with regard to altitude awareness. However, this premise would also have to include the presumption that the first officer's attention was away from his own instruments for the entire period from completion of the procedure turn until the aircraft crashed.

The remaining possibility which could explain the excessive descent is a misreading of the altimeter by the captain. In considering this possibility, it should be noted that the aircraft involved was equipped with the three-pointer type altimeter and studies have concluded that of the various types of altimeters, the three-pointer type is the most difficult to read with speed and accuracy. In a pilot interview study 12/ conducted by the Psychology Branch, Aero Medical Laboratory, Engineering Division of the U. S. Air Force Material Command in 1947, it was stated: "Errors in interpreting multi-revolution instrument indications accounted for 18 percent of the total errors. The most common specific error was misreading the altimeter by 1,000 feet. This 1,000-foot error accounted for 13 percent of the total incidents collected." This report notes that only detailed factual information furnished by an eyewitness or the pilot who made the error was accepted for the study.

A more recent study 13/ states that a 30-percent chance of initial reading error is possible with the three-pointer altimeter. This study

12/ Psychological Aspects of Instrument Display: Analysis of 270 "Pilot Error" Experiences in Reading and Interpreting Aircraft Instruments, 1 October 1947.

13/ Howard Garfield Heininger, Jr. - A Systematic Method for Determining the Best Altimeter Display for High Performance Aircraft, February 22, 1966.

3. NTSB Crew functions not directly related to the approach and landing should be reduced or eliminated, especially during the last 1,000 feet of descent.

FAA Although it is believed the airlines require all cockpit check procedures, particularly the in-range checklist, to be completed well before the final 1,000 feet of descent, inspectors will be requested to doublecheck and take action where warranted.

4. NTSB During the final approach, one pilot should maintain continuous vigilance of flight instruments inside the cockpit until positive visual reference is established.

FAA Inspectors have been instructed to assure that cockpit check procedures are arranged so that the pilot flying devotes full attention to flight instruments. 14/

5. NTSB Wing approaches where less than full precision facilities exist, there should be a requirement that during the last 1,000 feet of final approach, the pilot not flying call out altitude in 100-foot increments above airport elevation.

FAA Instructions have been issued to inspectors to assure airlines emphasize in training, and include in training manuals, altitude awareness procedures to be used during climbs, descents, and instrument approaches. The FAA-recommended procedures require callouts at 500 feet above field elevations, 100 feet above minimums, and minimums. Such a procedure keeps cockpit conversation at a minimum and reduces pilot workload, while at the same time assuring pilot altitude awareness.

6. NTSB There should be a requirement to report indicated altitudes to Air Traffic Control at various points in the approach procedure, such as the outbound procedure turn and at the outer marker position.

FAA Such a requirement would significantly increase frequency congestion and increase crew and controller workload. Efforts in the areas of pilot training and education will prove to be the most beneficial course of action.

7. NTSB The aviation community should consider expediting development and installation of audible and visible altitude warning devices and the implementation of procedures for their use.

14/ Crew vigilance and cockpit discipline was one of the areas stressed in a telegram sent by the FAA Administrator to all airline presidents on December 30, 1968, expressing concern with the rash of accidents.

FAA A rule became effective on September 28, 1968, which will require by February 28, 1971, both visual and aural altitude alerting signals to warn pilots of jet aircraft when approaching selected altitudes during climb, descents, and instrument approaches.

8. NTSB Altimetry systems should be reassessed with particular regard to their susceptibility to insidious interference by forms of precipitation.

FAA FAA plans to participate with NASA and the aviation industry in an assessment of possible failure modes of altimeter static systems. At this time, FAA is unaware of any practical replacement for the barometric altimeter.

9. NTSB The possibility of development of additional altitude warning systems, external to the aircraft, should be explored. One possibility is a high-intensity visual warning red light beam, projected up along and slightly below the desired approach glide slope, to warn of flight below the desired path.

FAA The suggested device would not provide complete information concerning the optimum glidepath as does the Visual Approach Slope Indicator (VASI) systems, which are or will be installed at many runways throughout the country.

10. NTSB Development is needed in the fields of radio/radar, and inertial altimetry and CRT/microwave pictorial display approach aids as possible improved replacements for the barometric altimetry system in the near future.

FAA The use of inertial altimetry must be considered as a long-range research and development program. CRT/microwave pictorial display has been evaluated by the military, and the FAA will look into this matter further when it gets additional information.

11. NTSB Modified use of existing approach radar should be further studied with regard to its adaptability as a surveillance (accident prevention) tool for nonprecision instrument approaches (i.e., to monitor automatically and warn against the descent below desired glidepath of any aircraft in the final descent mode).

FAA A more effective and less expensive alternative to the use of radar as a monitor for nonprecision approaches in the installation of Instrument Landing Systems. 15/

12. NTSB There should be increased surveillance and more frequent and more rigorous inspection and maintenance of altimetry systems by both the air carriers and the FAA.

FAA FAA has met with the Air Transport Association (AW) to review and discuss altimetry problems. Although few altimetry troubles are being experienced by flightcrews, ATA has agreed to further explore this area.

13. NTSB Certification requirements and procedures should be reexamined to determine if there is a possibility of a single failure mode of nominally dual systems which, when combined with an already existent passive failure or inadequate cockpit procedures, can invalidate dual failure protection features.

FAA A Notice of Proposed Rule Making was issued on August 16, 1968, proposing to require in systems design means to assure continued safe operation following any single failure or combination of failures not shown to be extremely improbable. Industry comments are now being reviewed and analyzed. 16/

The FAA has also reported that an Instrument Landing System (ILS) was installed at the Bradford Regional Airport in the fall of 1969. Bradford Airport met the criteria necessary to qualify for the installation of such a system for several years prior to its installation. However, budgetary restrictions have limited the rate of which ILS's can be installed even at those airports which qualify therefor.

ILS is a precision instment approach and landing system which allows aircraft to operate into airports under weather conditions which are more adverse than the minimums established for nonprecision approaches. In other words, since the ILS provides a greater degree of precision, a lower obstruction clearance and visibility are approved than those associated with nonprecision approaches, such as a VOR.

15/ The Safety Board's recommendation on this matter, and the Administrator's response thereto, are more fully set forth in letters dated June 19, 1969, (NTSB) and July 28, 1969, (FAA).

16/ Copies of the letters summarized above are contained in the Public Docket of Recommendations, which is maintained in the Safety Board's office in Washington, D. C.

It can thus be seen that one of the intents of requiring different sets of minimums for precision and nonprecision approaches is to afford equivalent levels of safety. Accordingly, it might be said that the installation of an ILS is not a "corrective measure" in terms of safety. Nevertheless, the Board believes that a precision approach system, such as an ILS, provides a significant addition to safety by affording the pilots of an aircraft making an approach not only vertical guidance, but also a valuable and reliable cross-check of the aircraft altimetry down to an altitude close to the ground. Accordingly, the Board urged that the FAA expedite, to the extent possible within the limits of available resources, the installation of ILS at qualified fields currently equipped only with nonprecision approaches.

It is the understanding of the Safety Board that approach light systems are usually installed only in conjunction with an ILS. We believe, however, that approach light systems provide a significant safety feature, even apart from an ILS, by increasing the conspicuity of the mway environment during low visibility conditions. We are also informed that new approach light systems are becoming available, including systems 1,500 feet in length, which might be appropriate for use without an ILS. In view of the foregoing, the Board recommends that the FAA consider again, within the limits of the available resources and equipment, the installation of approach lights to improve the safety of nonprecision instrument approaches at those airports where the installation of a full ILS is not feasible.

Finally, with respect to landing and approach accidents in general, the Board wishes to reiterate its concern with the problem and to reemphasize our interest in the progress of the various remedial measures that are currently underway. To this end, the Board held a series of meetings with other segments of the aviation community early in 1969 in which particular attention was devoted to the subject of altimetry. Measures initiated by these meetings included the collection and assimilation of statistical information necessary to provide a sound basis for corrective action. We will continue to work in close cooperation with these groups in order to explore to the fullest extent all appropriate steps which might prove useful in reducing the rate of this type of accident. At the present time the National Aeronautics and Space Administration (NASA) is considering undertaking a project to study possible problems with altimetry.

In addition' to the above, Allegheny Airlines revised its callout procedures relative to approach and landing as follows:

"Duties of the pilot not flying the aircraft during the descent and approach: Call out approaching 18,000 feet as a reminder to reset altimeters. Call out 15,000 feet, 10,000 feet, and 5,000 feet. At 1,000 feet above airport elevation call out '1,000 feet.'

"<u>VFR</u>

"At 500 feet above airport elevation call out '500 feet', then call out airspeed and rate of descent.

"<u>IFR</u>

"500 feet should be called out as in VFR. In addition --- 100 feet above minimums call out '100 feet above minimums', then call out airspeed and rate of descent.

"At minimums call out the words 'AT MINIMUMS' then call out airspeed and rate of descent.

"Thereafter, call out any deviations of altitudes, airspeed and rate of descent from normal programmed rates.

"During circling approaches call out any altitude, airspeed or descent deviations from normal or as specified by the captain. Deviations defined as:

"Altitude - whenever indicated altitude varies from minus 50 feet to plus 100 feet from required altitude for that portion of approach being made, i.e., altitude prior to final fix, MDA, circling, etc.

"Glide Slope and Localizer needle - when one dot or more deviation exists after leaving outer marker or final fix inbound, call 'glide slope' or 'localizer', whichever applies.

"Airspeed - whenever airspeed varies plus or minus 10 knots from programmed speed. Minus airspeed never to be less than 1.3 V_s (V ref).

"Sink Rate - whenever descent rate exceeds 750 feet per minute on final."

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

Adopted May 27, 1970

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board received notification of the accident about 2200, on January 6, 1969. Because of the weather conditions, an investigation team could not be flown to Bradford that night but one was dispatched early the next morning. Working groups were established for operations, witnesses, structures, aircraft and maintenance records, human factors, powerplants, weather, air traffic control, flight and voice recorders, and aircraf't systems. Parties to the Investigation were Allegheny Airlines, the Federal Aviation Administration, the Air Line Pilots Association, Allison Division of General Motors, the Weather Bureau, and Collins Radio Company.

The on-scene phase of the accident investigation lasted approximately 10 days.

2. Hearing

A public hearing was convened June 3, 1969, at Bradford, Pennsylvania, and lasted 2-1/2 days. The hearing encompassed both this accident and the Allegheny Airlines accident which also occurred at Bradford on December 24, 1968.

3. Preliminary Reports

A preliminary factual report on the accident was issued on May 26, 1969. A summary of the testimony taken at the public hearing was issued by the Safety Board on June 24, 1969.

Crew Information

Captain William I. Blanton, Jr., aged 33, was employed by Allegheny Airlines, Inc., in May 1962. He was upgraded to captain status on April 27, 1967. He held Airline Transport Pilot Certificate No. 1423562, with type ratings in the Allison Prop Jet Convair 340/440 and the Fairchild Hiller F27/227 aircraft, and commercial privileges in single-engine land aircraft. He satisfactorily passed his last examination for a Federal Aviation Administration (FAR) First-class Medical Certificate on September 6, 1968, without limitations.

According to Allegheny Airlines, Inc., records, he had accumulated a total of 5,761 flying hours. Pilot time in the Allison Convair 340/440 aircraft was 499:50 hours, of which 175:16 hours was acquired in the 90 days preceding the accident, and 76:27 hours was acquired in the last 30 days.

He was qualified into the Bradford Regional Airport on May 15, 1967. On April 16, 1968, he satisfactorily accomplished a proficiency check in the Allison Convair 340/440 aircraft. The report of this check flight contains the FAA Inspector's comment "very nice professional job." His most recent proficiency check was accomplished in the Fairchild Hiller F-27 aircraft on October 4, 1968. Line checks in the Allison Convair aircraft were satisfactorily accomplished on' May 27, 1968, and November 27, 1968.

First Officer Ronald Lesiak, aged 31, was employed by Allegheny Airlines, Inc., on February 1, 1967. He held Commercial Pilot Certificate No. 1512950 with aircraft single- and multiengine land, Douglas DC-3 and instrument ratings. He satisfactorily passed an examination for an FAA First-class Medical Certificate on February 19, 1968, without limitations. According to Allegheny Airlines, Inc., records, First Officer Lesiak had accumulated 8,220 flight-hours. His total pilot time in the Allison Convair 340/440 aircraft was 738:32 hours, of which 159:25 hours was acquired in the 90 days preceding the accident, and 62:29 hours in the last 30 days.

Both pilot crewmembers had a rest period of 24 hours prior to Flight 737 and their duty time during the period was 3:15 hours, of which about 1:30 hours were flight time.

Flight Attendant Marjorie Hatfield was employed by Allegheny Airlines, Inc., on July 27, 1965. Her last recurrent training was completed on May 15, 1968.

Aircraft Information

N5825 was originally certificated as a Convair 440, manufacturer's serial No. 386. The aircraft was subsequently modified to permit the installation of Allison 501-D13 engines, and Aeroproducts A6441FN606A propellers. A Standard Airworthiness Certificate for N5825, identifying the manufacturer and model as Allison Prop Jet Convair 440 was reissued on July 11, 1967, following the modification.

The total time on the aircraft was 27,285:56 hours.

The elapsed time since conversion and the 4,600-hour overhaul was 3531:10 hours. A balance check (No. 3) and midperiod check was performed on December 18, 1968, at a total aircraft time of 27,172:10 hours.

An examination of the maintenance records for N5825 disclosed that the aircraft had been maintained in accordance with Allegheny Airlines, Inc., and Federal Aviation Administration procedures. There were no discrepancies noted that would have adversely affected the mechanical or structural airworthiness of the aircraft. Required inspections had been accomplished and nonroutine items had received corrective action.

The maximum certificated takeoff weight for N5825 was 54,600 pounds. The maximum landing weight at the Bradford Regional Airport was 52,000 pounds. The estimated fuel burn-off between Harrisburg and Bradford, Pennsylvania, of 1,792 pounds established the maximum allowable takeoff weight at Harrisburg, Pennsylvania, as 53,808 pounds. The actual takeoff weight shown on the Allegheny Airlines, Inc., Load Manifest Form OF-11 was 51,714 pounds.

The following computations relating to the weight and balance of N5825 on departure from Harrisburg were made using the actual aircraft basic weight rather than the permissible fleet standard weight used for dispatch purposes. This results in the apparent difference of 110.8 pounds between the takeoff weight shown on the Load Manifest Form OF-11 and this computation.

Aircraft Basic Weight	33,881.8	pounds
Standard Operations Equipment	979.0	"
Fuel Load	10,720.0	"
Passenger Weight 1/	4,250.0	"

1/ Using the approved average passenger weight of 170 pounds.

Forward Cargo Compartment Load	1,046.0	Pounds
Rear Cargo Compartment Load	948.0	"
Total Weight at Takeoff	51,824.8	"
Estimated Fuel Burn-Off to Bradford	1,792.0	"
Estimated Aircraft Weight at Time of Crash	50,032.8	pounds

Allegheny Airlines, Inc.., procedures for the Allison Convair 340/440 aircraft provide for seat blocking for balance purposes depending on the number of passengers on board and the actual cargo weight in compartment D (cargo compartment). There are minimum and maximum loads for compartment D which vary as the passenger and cargo load varies. As long as the loading in this compartment is between the minimum and maximum limitations, the aircraft will be in balance. With 25 passengers aboard, the minimum and maximum weights in compartment D for Flight 737 were 600 pounds and 1,420 pounds, respectively. The actual weight in compartment D was 948 pounds and seat blocking was not necessary.

With the assumption that random seating of the passengers existed to provide a passenger centroid 351.39 inches aft of datum, the computed center of gravity was 27.4 percent MAC. On the basis of these computations, N5825 was within the center of gravity limits, and 1,856 pounds less than the permissible takeoff weight on departure from Harrisburg, Pennsylvania.

The aircraft was powered by two Allison 501-D13 engines equipped with Aeroproducts A6441FN-606A propellers.

The left, No. 1, engine had accumulated 15,483 hours, 2/ of which 1,430 were since overhaul. The right engine, No. 2, had accumulated 4,001 hours, of which 350 were since overhaul.

The No. 1 propeller had accumulated 3,047 hours since overhaul and the No. 2, 4,097 since overhaul.

2/ To the nearest full hour.

ATTACHMENT 1

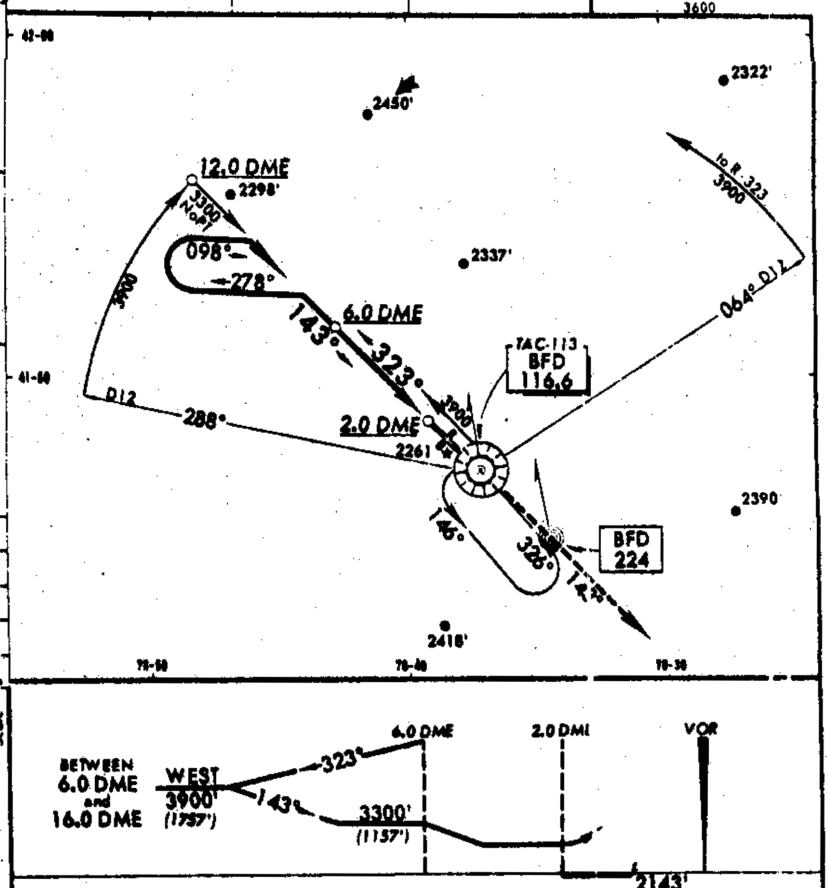
Jeppesen Approach Chart DEC 13-68 (13-1)

BRADFORD, PA.
BRADFORD REGIONAL
VOR DME Rwy 14
VOR 116.6 BFD

Apt. Elev 2143'
Var 07°W
Class BVORTAC

ERIE Approach	Departure	Ground
118.4	118.4	

MSA 3600



PULL UP to 4000 feet outbound on BFD VOR R-143 within 10 NM, return to BFD VOR and hold SOUTHEAST, LEFT turns.

STRAIGHT-IN LANDING RWY 14		
	MDA 2643'(500')	
		HIRL out
A B C	3/4	1
D	1	
All Non Std	MDA 2643'(500') 1	

CIRCLE-TO-LAND	
	MDA
A B	2643'(500')-1
C	2643'(500')-1½
D & 3 Eng Jet	2743'(600')-2
	Non-Std 2843'(700')-2

Gnd speed-Kts	60	80	100	120	140	160
2.0 DME to MAP 0.0						

CHANGES: St-in minima.

TRANSCRIPT OF VOICE RECORDER READOUT
ALLEGHENY AIRLINES FLIGHT 737, January 6, 1969

This transcription reads as follows:

LEGEND

CAM	-	Cockpit Area Microphone source
RDO	-	Radio transmission from N5825
INT	-	Aircraft public address system source
BFD	-	Bradford Flight Service Station
-1	-	Voice identified as Captain
-2	-	Voice identified as First Officer
-3	-	Voice identified as Stewardess
-?	-	Voice unidentified
*	-	Unintelligible word
CC-R	-	Bradford Company Radio Operator

CONTENT

SOURCE & TIME	
RDO	And Bradford Radio, Allegheny, ah, seven three seven's on your frequency descending to, ah, four thousand
CO-R	Seven thirty seven do you read Bradford?
CAM-?	*
BFD	Allegheny seven thirty seven, Bradford, ah, say again your position
RDO-2	Okay, we're ten DME from the, ah, VOR and we've been cleared for a VOR thirty-two approach and, ah, descending to, ah, four thousand

CO-R Seven thirty seven do you read Bradford?

BFD Ah, roger, ah, surface winds are showing one nine zero degrees at 1-ten knots, and the altimeter, two niner four eight, twenty-nine forty-eight

RE-2 Two nine four zero?

BFD Negative, two nine four eight

RDO-? Two nine four eight

CAM-? *

CAM-? * he's already cleared us

CAM You want to request a VOR fourteen approach?

CAM-? Yeah **

CO-R Seven thirty seven you read Bradford?

RE-2 And Bradford Radio, Allegheny seven thirty seven, wonder if we could request that VOR number, ah, fourteen approach?

BFD Allegheny seven thirty seven, roger, stand by, I'll check for you

BFD Seven thirty seven, ah, fourteen approach is approved

8:19

RE-2 Okay, thank you, and, ah, we're about four miles from the vla-- we're four miles from the VOR level at four thousand

BFD Okay, understand

CAM-? *

CAM-? That's all right

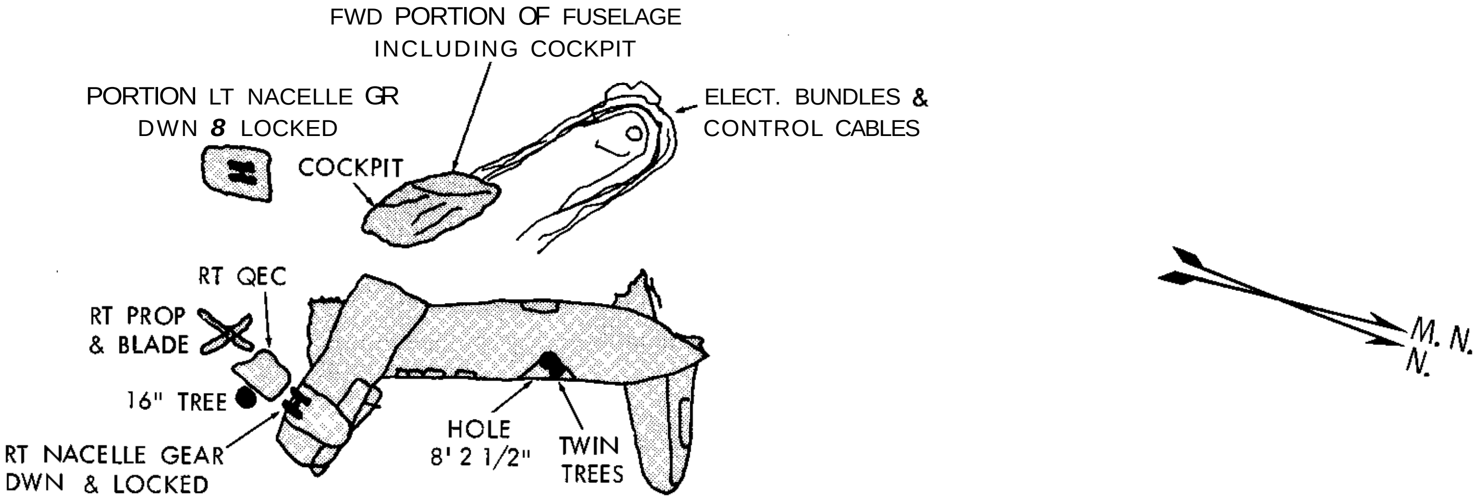
CAM-? *

CAM-? Wait a few minutes * * * *

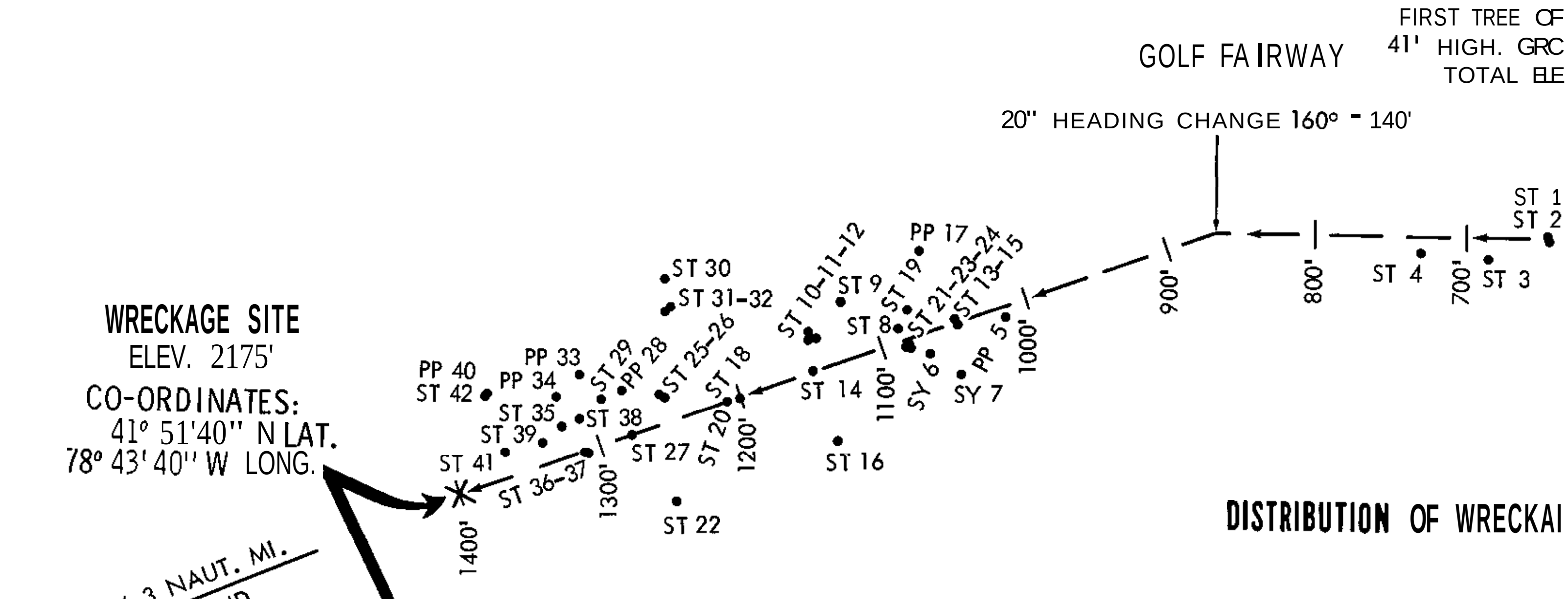
CO-R Seven thirty seven do you read Bradford?

6:59

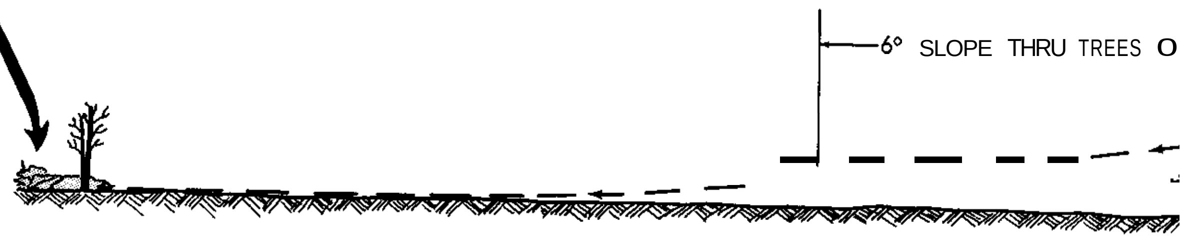
RW-2	And Allegheny, ah, seven thirty seven is, ah, VOR outbound
BFD	Seven thirty seven, roger, VOR outbound
CO-R	Seven thirty seven do you read Bradford?
CAM-2	We'll be around, ah, forty-eight thousand five hundred, should be around ninety-nine, one oh five at the boundary
CAM-1	Okay
CAM-?	Take 'em all
CO-R	Seven thirty-seven do you read Bradford?
3:15.6	
RDO-2	And Allegheny seven thirty-seven is completing procedure turn inbound
BFD	Seven thirty-seven, understand procedure turn inbound, the wind's one six zero degrees at one four
RW-2	Okay
CAM-1	Down fifteen
CO-R	Seven thirty-seven from Bradford
0:42.1	
CAM-1	Drop that gear
0:40.5	
INT-3	In preparation for landing please extinguish all cigarettes, recheck your seatbelts to see that they are securely fastened, and place your seat in a full upright position. Thank you
0:05.1	
CAM	Sound of impact begins
0:00	End of recording



ENLARGED DRAWING OF WECKAGE

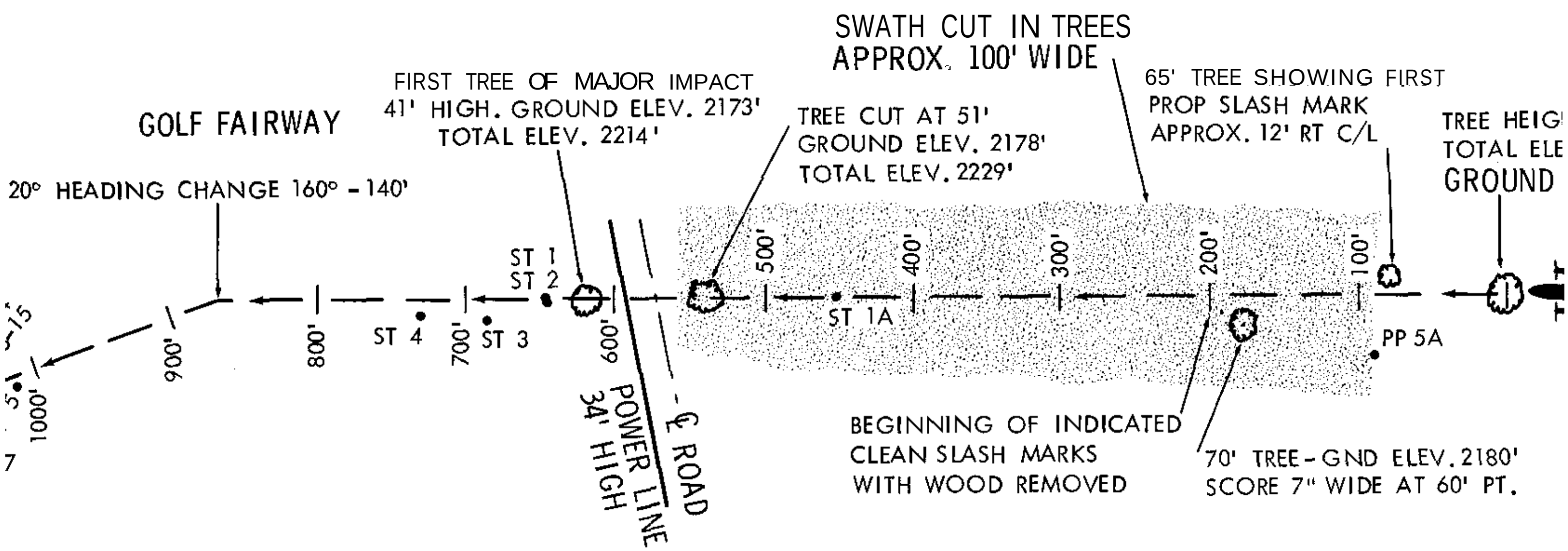


DISTRIBUTION OF WRECKAI

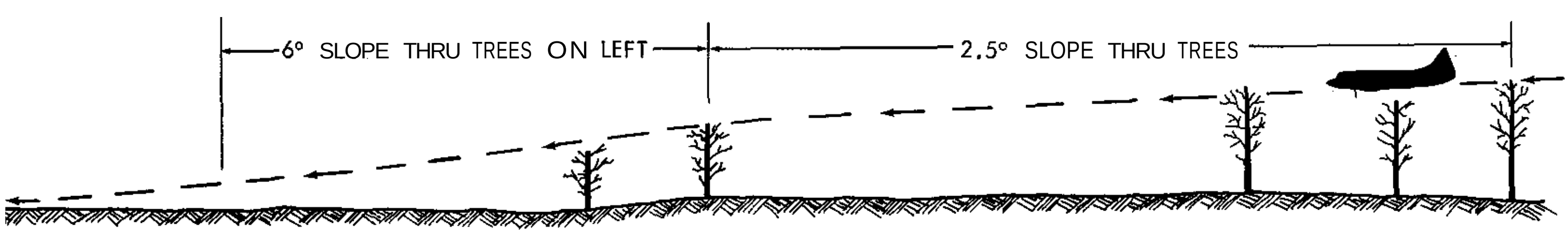


DISTRIBUTION OF WRECKAG

ST-1	Section of Left Aileron and Tab.
ST-1A	Section of Main Gear Door Actuating Rod.
ST-2	Section of Left Aileron and Tab.
ST-3	Section of Front Spar and Wing Leading Edge.
ST-4	Section of Left Wing 15' Long with Section of Aileron 11'8" Lc
PP-5	Propeller Blade, S/N B 9436.
PP-5A	Piece of Propeller Blade Cuff.
SY-6	Collins VHF Antenna P/N 37R-2
SY-7	Collins VHF Antenna, (OMNI)
ST-8	Vertical Fin Tip.
ST-9	Section of Upper Wing Skin.
ST-10	Section of Left Wing Leading Edge.
ST-11	Flop Beaver Tail Including One Flap Track With Rollers.
ST-12	Section of Left Flap with One Flap Track.
ST-13	Upper Section of Rudder.
ST-14	Section of Right Wing Panel 12' Long Fmm Outboard of Nacell
ST-15	One Nose Gear Door.
ST-16	Nose Wheel.
ST-17	Propeller Blade S/N B 9018.
ST-19	Left Horizontal Stabilizer Including Complete Elevator and Fligh
ST-18	Section of Left Outboard Flap.
ST-20	Nose Wheel and Axle.
ST-21	Lower 5' Section of Rudder Including 3' Section of Flight Tab.



DISTRIBUTION OF WRECKAGE (PLAN VIEW)



DISTRIBUTION OF WRECKAGE [ELEVATION]

WRECKAGE DISTRIBUTION LIST

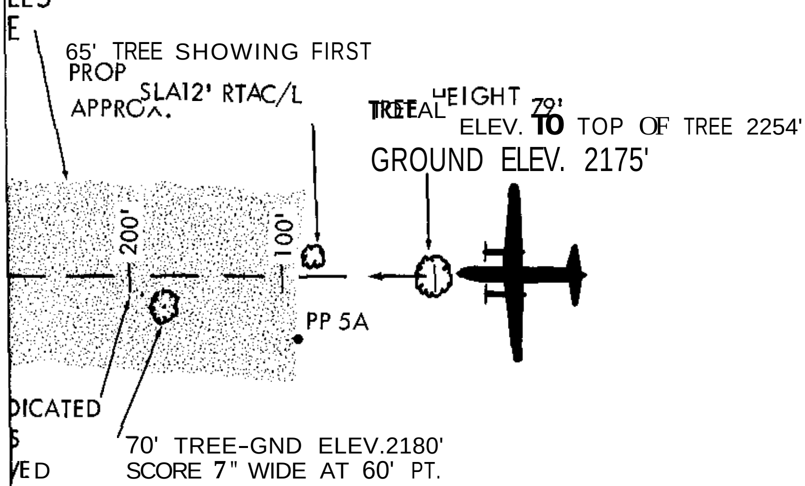
on and Tab.
r Door Actuating Rod.
on and Tab.
and Wing Leading Edge.
15' Long with Section of Aileron 11'8" Long.
B 9436.
ade Cuff.
P/N 37R-2
, (OMNI)

g Skin.
Leading Edge.
uding One Flap Track With Rollers.
with One Flap Track.
der.
g Panel 12' Long Fmm Outboard of Nacelle.
.

B 9018.
izer Including Complete Elevator and Flight Tab.
oard Flap.
.
Rudder Including 3' Section of Flight Tab.

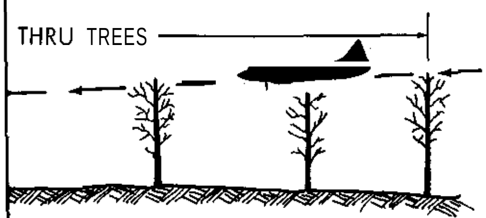
ST-22	Right Wing Section From Tip to W.S. 22, Including Aileron.
ST-23	Section of Dorsal Fin.
ST-24	Section of Fuselage Structure Including One Complete Window and 1/2 of ar Emergency Exit Frame at Each End of the Section.
ST-25	Piece of Wing False Structure.
ST-26	Section of Wing Leading Edge.
ST-27	Section of Fuselage From Right Side.
ST-28	Section of Propeller Spinner.
ST-29	Section of Wing Trailing Edge.
ST-30	Section of Wing Lower Structure Including One Fuel Access Plate.
ST-31	Section of Wing Leading Edge.
ST-32	Section of Flop.
ST-33	Left Engine Tailpipe.
ST-34	Left Q.E.C. Lower Access Door.
ST-35	Passenger Door AFT Bulkhead Including Door Actuating System.
ST-36	Station 227 Bulkhead.
ST-37	Left Gear Inboard Door.
ST-38	Section of Engine Nacelle Lower Longeron, 4' 2" Long, with Matching Portic of Londing Gear Door Actuating Assembly Designated ST-1A.
ST-39	Nose Geor Right Hand Door.
PP-40	Left Q.E.C.
ST-41	Section of Flap.
ST-42	Passenger Entry Stairs. Lying Adjacent to PP-40.

EES
E



DICATED
S
VED

Attachment 3



NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
Washington, D.C.

DCA 69A11 WRECKAGE DISTRIBUTION CHAR
ALLEGHENY AIRLINES, CV580, N5825
BRADFORD REGIONAL AIRPORT, PA.
JANUARY 6,1969