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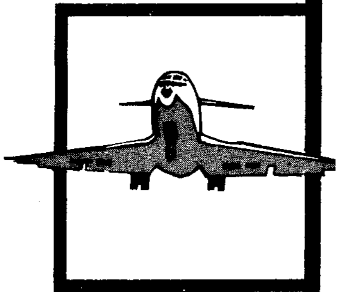

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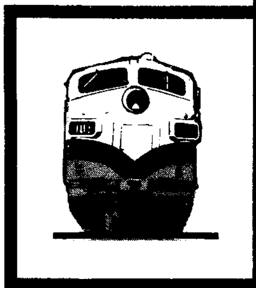

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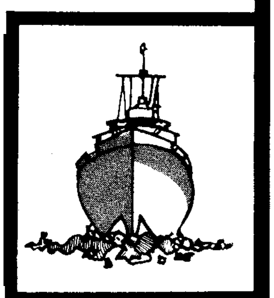
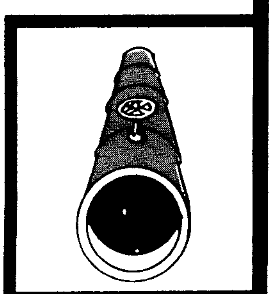
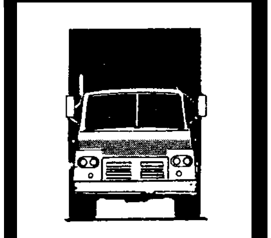


AIRCRAFT ACCIDENT REPORT

FISCHER BROS. AVIATION, INC.,
dba NORTHWEST AIRLINK, FLIGHT 2268
CONSTRUCCIONES AERONAUTICAS, S.A. (CASA)
C-212-CC, N160FB
DETROIT METROPOLITAN WAYNE COUNTY AIRPORT
ROMULUS, MICHIGAN
MARCH 4, 1987



NTSB/AAR-88/08



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NATIONAL TRANSPORTATION SAFETY BOARD
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March 4, 1987

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15. Supplementary Notes

16. Abstract:

On March 4, 1987, Fischer Bros. Aviation, Inc., doing business as Northwest Airlink, flight 2268, a Construcciones Aeronauticas, S.A. (CASA) C-212-CC, N160FB, crashed just inside the threshold of runway 21R at the Detroit Metropolitan Wayne County Airport. Nine of the 19 persons on board were killed. The airplane was destroyed by impact forces and postcrash fire.

The safety issues discussed in this accident report are the captain's failure to follow approved Flight and company procedures, his use of the powerplant beta mode in flight, company maintenance procedures and propeller overhaul practices, Federal Aviation Administration (FAA) bilateral aircraft type certification, and FAA surveillance.

17. Key Words:

flight procedures, beta mode, maintenance, propeller overhauls, certification, surveillance, seat installation, restraints, fire-blocking materials, training

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EXECUTIVE SUMMARY

On March 4, 1987, Fischer Bros. Aviation, inc., doing business as Northwest Airlink, flight 2268, a Construcciones Aeronauticas, S.A. (CASA) C-212-CC, N160FB, crashed just inside the threshold of runway 21R at the Detroit Metropolitan Wayne County Airport. Nine of the 19 persons on board were killed. The airplane was destroyed by impact forces and postcrash fire.

The safety issues discussed in this accident report are the captain's failure to follow approved flight and company procedures, his use of the powerplant beta mode in flight, company maintenance procedures and propeller overhaul practices, Federal Aviation Administration (FAA) bilateral aircraft type certification, and FAA surveillance.

The National Transportation Safety Board determines that the probable cause of the accident was the captain's inability to control the airplane in an attempt to recover from an asymmetric power condition at low speed following his intentional use of the beta mode of propeller operation to descend and slow the airplane rapidly on final approach for landing. Factors that contibuted to the accident were an unstabilized visual approach, the presence of a departing DC-9 on the runway, the desire to make a short field landing, and the higher-than-normal flight idle fuel flow settings of both engines. The lack of fire-blocking material in passenger seat cushions contributed to the severity of the injuries.

As a result of this investigation the Safety Board made recommendations to the FAA concerning the CASA airplane in the areas of stall warning information, passenger-seat installation, flightcrew restraints, head clearance, and door controls. The Safety Board also made recommendations to the FAA concerning fire-blocking material on seats, surveillance of propeller overhaul facilities, of turbopeller flight idle blade angle maintenance, design of propeller pitch controls, flightcrew training, and on the bilateral aircraft type certification program.

AIRCRAFT ACCIDENT REPORT

FISCHER BROS. AVIATION, INC.
dba NORTHWEST AIRLINK, FLIGHT 2268
CONSTRUCCIONES AERONAUTICAS, S. A. (CASA)
C-212-CC, N160FB
DETROIT METROPOLITAN WAYNE COUNTY AIRPORT
ROMULUS, MICHIGAN
MARCH 4, 1987

1. FACTUAL INFORMATION

1.1 History of the Flight

On March 4, 1987, about 1200 local time, the flightcrew of Northwest Airlink flight 2268 reported for duty at the airline's headquarters at Galion Municipal Airport, Galion, Ohio. Flight 2268 was a regularly scheduled passenger flight between Mansfield, Ohio, and Detroit, Michigan, with an intermediate stop in Cleveland, Ohio. The airplane, a 22-passenger CASA-212-CC, N 160FB, was operated by Fischer Bros. Aviation, Inc., of Mansfield, Ohio. At 1250 following a crew change, N160FB was flown from Galion to Mansfield to begin its scheduled flight at 1300 with the three previous flight crewmembers who were deadheading to Detroit.

At 1305, flight 2268 departed Mansfield for Cleveland with two pilots, a flight attendant, four passengers, a company manager, and the three deadheading crewmembers. According to standard company procedures, the captain and first officer alternated flying legs of the flight. On this leg of the flight, the first officer should have been flying the airplane, and the captain should have flown the leg from Cleveland to Detroit. The flight arrived at the gate in Cleveland at 1331 after a 20-minute routine flight. One passenger deplaned and nine passengers boarded. The flight departed for Detroit at 1355 about 15 minutes late on an instrument flight rules (IFR) flight plan. The flight was scheduled to land in Detroit at 1420.

About 1400, the first officer reported flight 2268 level at its assigned cruising altitude of 7,000 feet mean sea level (msl). At that time, he obtained routine air traffic control services from the Cleveland Air Traffic Control Tower and the Cleveland Air Route Traffic Control Center (ARTCC). At 1414, the flight contacted the Detroit Terminal Radar Approach Control (TRACON), Arrival Radar East (AR-E) controller as instructed by the ARTCC. The first officer advised the AR-E controller that the flight had received Automatic Terminal Information Service (ATIS) "Charlie," which was as follows:

> 2,500 thin broken, visibility 20 miles, temperature 38°, dew point 19"; wind 180 at 9, altimeter 30.54, landing and departing runway 3.

Two seconds later, the AR-E controller advised the flight to expect radar vectors for a visual approach to runway 21 L. The flight was following a USAir DC-9, which had been cleared for a visual approach to runway 21R at 1413:50 and had reported commencing its left base turn at 1414: 16.

At 1421:25, the first officer advised the AR-E controller that flight 2268 had the airport in sight. It was approaching the airport from the southeast. For about 6 minutes, from 1422: 14 to 1428, the flight was given right turn vectors for a left downwind base leg turn for landing on runway 21 R. The AR-E controller initially gave the flight a heading of 330". At 1424:07, flight 2268 was instructed to descend and maintain 6,000 feet. At 1425:10, the AR-E controller advised flight 2268, "...[ATIS] information 'Delta' is now current, wind at two one zero at seven, altimeter is three zero four seven. I thought Charlie said twenty-ones [runway 21 UC/R)." At 1428:55, the AR-E controller instructed the flight to descend to 3,000 feet, and seconds later, the controller gave it a routine traffic advisory. At 1430, the flight was told it would be issued a turn to join the final approach course in about 3 miles, near the outer marker, and that it was number one for landing on runway 21 R.

At 1430: 10, Simmons Airlines flight 2789 reported to the AR-E controller that it was at 7,000 feet and had received ATIS information "Delta." Flight 2789 was on a regularly scheduled flight from Cleveland, departing on time at 1400 and scheduled to land at Detroit at 1440. (The runway closest to Fischer Bros. and Simmons Airlines arrival gates was runway 21 R.) At 1430:20, the AR-E controller responded by giving Simmons flight 2789 a vector heading of 310" for a visual approach to runway 21L, but the crew requested 21C. The AR-E controller informed them that he would keep them advised and might be able to give them 21 R. The crew responded, "That'll be great. Thanks."

At 1430:32, the AR-E controller cleared Northwest Airlink flight 2268 for the visual approach and instructed it to contact the control tower. At 1431:08, the first officer of flight 2268 contacted the Local Control East (LC-E) controller and reported, "...six out for 21 R." At 1431: 14, the LC-E controller replied, ".. runway two one right, cleared to land. Winds one seven zero at five." The first officer's immediate acknowledgment was the last transmission received from the flight.

At 1431:21, the LC-E controller instructed Northwest flight 530 (NW530), a DC-9-50, to "...taxi into position and hold" on runway 21 R. The flight acknowledged the LC-E controller's instructions at 1432:25. At this point, the LC-E controller began copying the inbound landing sequence for all the flights from the TRACON coordinator (Cl-2) over internal communication lines when he advised the Cl-2, "Okay, gotta go." At 1432:47, the LC-E controller instructed NW530, "...turn left heading one eight zero. Runway two one right cleared for takeoff." The flight acknowledged at 1432:52, subsequently began its takeoff roll, and departed from runway 21 R.

About 1434, flight 2268 struck the ramp area 1,010 feet inside and to the left of the runway 21 R threshold. It then skidded 398 feet, struck three ground support vehicles in front of gate F10 at concourse F, and caught fire. The fire prompted the control tower supervisor and the LC-E controller to activate the crash/fire/rescue phone simultaneously. At 1434:33, the LC-E controller transmitted, "Hold everything, hold everything. Got a fire on the airport."

The LC-E controller reported that flight 2268 was the first airplane to land when he assumed the LC-E operating position at 1425. The previous airplane to land had been a Pan Am Boeing 737, which had taxied onto the International Terminal ramp area about 1430. The controller stated that he first observed flight 2268 on the Bright Radar Indicator Tower Equipment (BRITE) radarscope when it was near the outer marker for runway 21 L and angling toward the final approach course for runway 21 R. He stated that after observing the airplane on radar, he instructed NW530 to taxi into position and hold on runway 21R. NW530 had a release time of 1435 from the Cleveland ARTCC, and the LC-E controller was allowed to release the airplane within 2 minutes before or after that time. He stated that when he cleared NW530 for takeoff, he observed flight 2268's radar target at the 2-mile dot (2 miles from the actual end of runway 21 R) and lined up on the runway centerline.

The LC-E controller reported that he observed NW530's takeoff roll and watched its departure until it started to make a left turn to the east. He did so because he had to determine when it had cleared the departure path of runway 21C so that he could issue a takeoff clearance to another flight holding on that runway, which he did at 1434:41. He said that as he looked toward the airplane holding on runway 21C, he noticed fire and smoke to his left. At that time, he shouted, "Fire" and immediately activated the crash/fire/rescue (CFR) phone.

The LC-E controller first thought that the fire was a fuel truck at the gate area of concourse F. He stated that for almost a minute after first observing the fire, he did not realize that the fire might be coming from flight 2268. He said he did not recall observing the flight after spotting it on radar nor did he hear any unusual sounds before spotting the fire. He stated that a Simmons Airlines flight had been positioned in the run-up area of runway 21R when he first noticed the fire. He also said that the smoke from the fire was "going straight up" and then it dissipated.

The ground control west controller reported observing flight 2268 on the BRITE radarscope only when it was about 1 mile on final approach. He said that it appeared to be on course at that time.

The flight data/clearance delivery controller reported that when he first observed flight 2268, it was about 1.5 miles from the runway and appeared to be on a normal approach path and in a normal attitude. However, he said that he did not see the accident. A developmental controller in the control tower cab who was not yet assigned to a position reported glancing at the airplane when it was about 1 mile from the runway. He, too, said it appeared to be on a normal approach at that time.

The control tower cab supervisor said he was not initially aware that there was an accident after first observing the fire. He did not observe flight 2268 on its landing approach. He stated that about 1410, he had coordinated with the TRACON a change from a runway 3 operation to a runway 21 operation based on the current and forecast winds. At the time of the change, he noted that the wind was from 2 IO" at 3 knots.

The captain who had flown N160FB on previous flights earlier in the day and who was deadheading to Detroit was seated in 7B. He reported that he was aware that the airplane was being vectored for a left downwind approach. He said that at 60 to 70 feet the airplane yawed violently to the left and banked left 80" to 90" in a descent. He said the airplane then banked to the right and hit the ground.

The deadheading first officer seated in 7A reported that the flaps were extended, the airplane was 75 to 100 feet above the ground, and it was between the International Terminal Building and the runway 21 R threshold when it rolled abruptly into a 60°- to 90°- left bank in a nosedown attitude. He said that power was reduced on the right engine, but the sound of the left engine remained constant. He said the airplane rolled quickly into a right bank and then struck the ground.

The deadheading flight attendant, seated in 7C, reported that during the final approach, the airplane "swooshed" left and that it kept wanting to go left. She also reported hearing an unusual cyclic noise from the engines (like brrr. . .brrr. . .brrr. . .).

Another company employee, seated in 2A, said the flight was normal until the airplane ". . .made a maneuver to abort the landing." He said that he could feel a climb and left turn, and near the end of the turn, he heard a noise similar to reverse pitch on the left side. He reported that the airplane then rolled to the right and into a right bank as if the flightcrew had overcompensated.

An off-duty TRACON controller, who was south of the approach end to runway 21 R and driving northeast, noticed flight 2268 when it was about twice the height of the terminal building. At that time, he said the airplane was in about a 30°-nose-down attitude and in a 45°- to 60°- left bank. He saw the airplane roll to the right and then disappear below the top of the building. Five to 10 seconds later, he saw the smoke.

Most other ground eyewitnesses reported that the airplane appeared higher than normal as it approached the runway threshold. Several reported that the airplane appeared to level off at a point approaching the threshold; they thought the pilot had started to make a go-around. Several individuals observed the airplane make a slight right bank before it made a very steep left bank, descending toward the terminal building to the point of impact. Two individuals reported hearing unusual engine noises. One said there was a sound like “a prop going real fast” and the other described “a high pitch on one of the engines.”

The captain of Simmons Airlines flight 2811, the airplane holding short of runway 21 R awaiting takeoff clearance, reported that the airplane appeared very high on final approach. The nose then pitched up as if the pilot were about to make a go-around. This was followed by a 15°- to 20°-right bank, and then the airplane rolled into about a 60°-left bank. The left bank continued and the airplane descended in a “slip” or “skid” until it was about 50 feet above ground level. The airplane then rolled into a right bank. He said the right wing struck the ground and broke at about midspan. A flash fire erupted immediately from that area of the wing.

A Fischer Bros. captain, standing on the ramp of their gate area and about 3,500 feet east of the threshold of runway 21R, stated that flight 2268 appeared to be on a normal approach when NW 530 taxied onto the runway and took off without stopping. He said the interval between the departing DC- 9 and flight 2268 appeared “slightly snug.” He reported that flight 2268 leveled off momentarily over the freeway and service road and then resumed its descent. He heard an increase in engine noise as the airplane neared the normal approach path. He next noticed that the left wing dipped, the airplane started toward the ramp area, the nose pitched up appreciably, and the left bank increased 45” to 60”. He noted that the airplane decelerated rapidly as it passed over the grassy median between the runway and the ramp. He said the airplane then snapped back to a wings-level attitude before it continued to about a 70°-right roll. The nose then dropped and the airplane struck the ramp.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	2	7	0	9
Serious	0	7	0	7
Minor	1	2	3	6
None	0	0	0	0
Total	3	16	3	22

1.3 Damage to the Aircraft

The airplane was destroyed by impact forces and postcrash fire. The estimated value of the airplane was $1.2 million.

1.4 Other Damage

Three ground service vehicles were destroyed in the accident. The estimated value of the vehicles was $35,000.

1.5 Personnel Information

The flightcrew was qualified to conduct the flight. The captain had been employed by the airline since March 1970. He held an Airline Transport Pilot certificate and was qualified in the CASA C-212 on September 6, 1980. His last proficiency check in the airplane was on January 28, 1987, and his last recurrent training was completed on February 21, 1987. He held a current first-class medical certificate with the limitation that he wear corrective lenses for near vision. The pilot was 5 feet

5 inches tall and weighed 140 pounds. He had accumulated a total flying time of about 17,953 hours, of these, about 3,144 were flown in the C-212. (See appendix B.)

The first officer was hired by the airline in July 1986. He held a commercial pilot certificate with airplane single- and multi-engine land and instrument ratings. He completed his initial training in the C-212 on August 28, 1986. He held a current first-class medical certificate with no limitations. He was 5 feet 7 inches tall and weighed about 140 pounds. He had accumulated a total flying time of 1,593 hours, of these 282 hours were in the C-212. (See appendix B.)

1.6 Aircraft Information

The CASA C-212-CC was the second built by Construcciones Aeronauticas, S.A. (CASA) of Spain. It received U.S. type certificated on May 16, 1980, under the bilateral provisions of Title 14 Code of Federal Regulations Part 21. It was a civil version of an earlier military airplane. The airplane was equipped with two Garrett Turbine Engine Company turbo propeller TPE-331-10R-511C engines and Hartzell Propeller Products HC-B4MN-5AL, constant-speed, hydraulic, full-feathering, reversible, composite, four-bladed propellers. The engines develop a take-off power rating of 900 shaft horsepower each. The accident airplane, N160FB, was configured to carry 22 passengers and 1 flight attendant. It was issued a standard airworthiness certificate in the transport category on July 18, 1980. (See appendix C.)

1.6.1 Weight and Balance

Based on company records and airplane performance information, flight 2268 departed Cleveland at a takeoff gross weight of 16,033 pounds with a center of gravity of 25.4 percent mean aerodynamic chord. This was within the weight and balance limits for the airplane. Fuel burn calculations showed that at the time of the accident, the landing weight was about 15,500 pounds, and the CG was within limits. The maximum allowable takeoff gross weight for the C-212-CC is 16,976 pounds, and the maximum allowable landing gross weight is 16,424 pounds.

The landing reference speed (V_{ref}) was calculated to have been about 97 knots indicated airspeed (KIAS) with 15" or 37.5 percent of flaps. Fischer Bros. flightcrews normally use a company recommended 15°-flap setting for landings at Detroit. A V_{ref} of 99 KIAS was computed for an approach with flaps at IO". The minimum controllable airspeed (V,,) was computed to be about 85 KIAS. The wings-level power-off (1G) stall speed was computed to have been about 75 KIAS for a flap setting of 15". The wings-level power-off (1G) stall speed at a flap setting of 10" was computed to have been 76 KIAS and 82 KIAS with flaps up.

1.6.2 Maintenance History

The airplane was maintained under the airline's continuous airworthiness maintenance and inspection program approved by the Federal Aviation Administration's (FAA) General Aviation District Office (GADO) in Cleveland, Ohio. The program consisted of six consecutive and recurring inspection intervals designated A, B, C, D, E, and F checks including a maintenance preflight inspection. The last inspection (interval A) was performed on February 22, 1987, and the last maintenance preflight was performed on March 2, 1987, at a total airframe time of 12,907.3 hours. A review of the maintenance records showed that with the exception of one Airworthiness Directive (AD 87-03-04), the airplane was in compliance with all applicable ADs. AD 87-03-04 required compliance within 8 months of the effective date of February 19, 1987. This AD required replacing trim control markings and placards to reduce the potential for a mistrimmed takeoff.

The open deferred maintenance items listed in the airplane flight log were an inoperative air conditioning system, inoperative weather radar, and an inoperative left engine fuel flow meter. There were no significant maintenance carry-over items.

The left engine was installed in N160FB on January 19, 1987, at a total time since overhaul (TSO) of 4,481.5 hours. The engine had accumulated 133.5 hours since installation and had operated 10.6 hours since its last inspection on March 2, 1987. The left propeller had operated 972.7 hours since it was overhauled on June 12, 1986. It had accumulated 280.2 hours since its last inspection.

The right engine was installed in N160FB on February 20, 1987, at a TSO of 4,881.5 hours. The engine had accumulated 51.1 hours since installation and had operated 183.5 hours since its last inspection on January 17, 1987. The right propeller had operated 607.2 hours since it was overhauled on September 27, 1986. It was installed on the right engine on February 20, 1987, and had accumulated 280.2 hours since its last inspection.

A flight idle descent check disclosed that, on February 23, 1987, after the right engine change was completed, the rate of descent was 1,250 feet per minute (fpm), fuel flows were 205 (L) and 210 (R) pounds per hour (pph), and the torque settings were 17 (L) and 18 (R) percent.

The captain who flew the airplane on the previous flights reported that the left fuel flow meter indication had dropped between 200 pph and 0 pph, intermittently. He said that the left power lever (PL) was about "1/2 knob width" forward of the right lever when power was matched between the two engines. He and his first officer both stated that N160FB was slower than the other C-212s. The captain added that the cruise speed had been about 150 to 160 KIAS, but after the engine changes it was cruising up to 170 to 175 KIAS. Several other pilots had commented previously about N160FB being slow and underpowered. A company flight dispatcher reported that a recurring remark about the CASA was that it was too slow. He also said that there were occasional complaints about PL rigging, like a half knob split (one PL forward or aft of the other).

1.7 Meteorological Information

Surface weather observations at the Detroit Metropolitan Wayne County Airport were made by National Weather Service personnel. The office is located about 3,000 feet northeast of the approach end of runway 21C. The pertinent observations made at the times indicated are as follows:

1353 - Sky condition--25,000 feet, thin broken; visibility--20 miles; temperature--37" F; dew point--19" F; wind--130" at 8 knots; altimeter- -30.54 inHg; few stratocumulus.

1450 - Sky condition--25,000 feet, thin broken; visibility--20 miles; temperature--38° F; dew point--19" F; wind--140" at 6 knots; altimeter--30.47 inHg; few stratocumulus.

The wind gust recorder record showed that at 1430, the wind was 4 knots, at 1435 it was 6 knots, and at 1440 it was 10 knots. Ten knots was the maximum wind speed recorded during this IO-minute period. The wind sensor is located about 5,100 feet east of the threshold of runway 21 R.

The upper air data recorded from Flint, Michigan, the closest station, showed that the wind direction and speed gradually changed from 322" at 13 knots at 5,270 feet to 180" at 3 knots at 774 feet.

1.8 Aids to Navigation

There were no reported discrepancies with navigation aids.

1.9 Communications

There were no reported problems with communications between the accident airplane and FAA air traffic control service facilities.

1.10 Airport Information

Elevation at the Detroit Metropolitan Wayne County Airport is 639 feet msl. The airport has three northeast/southwest parallel runways (3R/21L, 3C/21C, 3L/21R) and one east-west runway. Runway 21C is about 2,000 feet to the left of runway 21R. Runway 21R is 10,501 feet long and 200 feet wide. The elevation of the touchdown zone of runway 21 R is 636.7 feet msl.

Runway 21R is equipped with a full instrument landing system with associated distance measuring equipment. A visual approach slope indicator is not installed for runway 21 R.

A low level wind shear alert (LLWAS) system is installed at the airport. At the time of the accident, the east and northeast boundary sensors were out of service after having been released for routine maintenance at 1338. The remainder of the LLWAS system was operating. Control tower personnel reported that the LLWAS system did not alarm during the entire shift nor were there any reports of atmospheric turbulence from arriving or departing airplanes.

The airport is an Index E[7] facility for CFR capability. The primary means of communications between the control tower cab and the CFR facility is by land line phone. A secondary means is by activation of an aural alarm at the CFR station by control tower personnel.

1.11 Flight Recorders

No cockpit voice or flight data recorders were installed in the airplane, nor were any required by Federal regulation. As a result, the Safety Board had to rely on witness observations, ground scar and impact damage information, flight test data, and recorded radar information to reconstruct the flightpath and performance of the airplane during its landing approach.

1.12 Wreckage and Impact Information

1 .12.1 General

The airplane struck a concrete apron 674 feet to the left of the runway centerline and 1,010 feet beyond the approach end of the runway. (See appendix D.) Scrape marks in the ramp were on a magnetic heading of about 178°. Propeller strike marks in the ramp indicated that both propellers were rotating at the time of impact. The airplane came to rest inverted among several ground support vehicles, 398 feet from the point of initial impact on the ramp.

1.12.2 Airframe Damage

The nose section of the fuselage sustained the brunt of the impact forces. The right side of the nose structure was crushed inboard and aft in nearly a vertical plane.

The entire wing structure separated from all four main fuselage attachments. The right wing had separated and bent upward at points outboard of wing stations 4700 and 5600. The outer

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[7]The applicable index is determined by the longest large aircraft operated by an air carrier user, with an average of five or more scheduled departures per day, served or expected to be served by the airport (14 CFR 139.49).

portions of the wings were damaged by fire. The flaps were found extended 25 percent or about 10". No evidence was found of an asymmetric flap condition.

The vertical stabilizer had separated from the empennage and the tip and rudder were found bent to the right; the rudder was bent to about a 30"-angle. The horizontal stabilizer and elevators sustained relatively minor impact damage.

Examination of the flight control system, including the flaps and trim controls, revealed no evidence of a preimpact failure or malfunction.

1.12.3 Powerplant Damage

Both engines and engine nacelles remained attached to their respective wing mounts. The left engine sustained more fire damage than the right. The only visible impact damage was confined to the left engine air inlet duct, a portion of which was fractured. All of the accessories appeared undamaged. The mechanically operated fuel shutoff valve position levers were found in the open position. The firewall fuel shutoff valves and the manually operated fuel crossfeed valves were found in the open position.

The propellers remained attached to the engines. Three of the blades on the right propeller and the four blades from the left propeller had separated outboard of the blade's shank plugs. The blade clamps and counterweights were found intact and securely fastened with no evidence of blade slippage. The blade angle positions could not be changed by hand pressure. The left engine PL was found against the flight idle gate, and the right engine PL was found 3/4 of the way forward of the flight idle gate. The beta latch[2] mechanisms were found intact and functioned normally.

1.12.4 Flight Path and Speed

An estimate of the airplane's flightpath angle and attitude at the time of impact was based on matching the ground scars with the projected points of contact on the airplane. The right wing struck the level pavement of the apron first, followed by the right engine propeller at a point 72 feet beyond the initial right wing strike. The right side of the nose section struck the pavement 45 feet beyond the right engine propeller impact strike. The impact scars were in line with one another and oriented on a magnetic heading of 178° indicating that the angle of bank was nearly vertical (90°-right bank). The location of the ground scars with respect to airplane dimensions indicated that the flightpath angle at the time of impact was 15" to 16". The crush line damage of the nose section was 43° in reference to the fuselage longitudinal axis and 0° in reference to the vertical axis. This information revealed that the airplane was at a pitch attitude of about 12" nose down and in a right roll of 65" when it struck the ramp.

The ground speed of the airplane at the time of impact was calculated based on the number of propeller strikes, the distance between the strikes, and the presumed constant speed (rpm) setting of the engine. The horizontal speed of the airplane was computed to have been from 106 to 141 feet per second (fps) or 63 to 84 knots. The vertical speed was estimated to have been 29 to 38 fps. The total crush sustained by the nose section of the airplane was 30 inches, 25 inches of which appeared to have provided effective impact deceleration.

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[2]The beta latch is a lever mechanism that allows the pilot to move the power levers on the engine control quadrant rearward into the beta mode of propeller operation. The beta mode is a range of engine operation speeds below the point where propeller governing occurs and requires control of the propeller blade pitch angles by the pilot.

1.13 Medical and Pathological Information

The six revenue passengers who survived the accident sustained first-, second-, and third-degree burns on their heads and extremities. The off-duty flight attendant sustained first- and second-degree burns. These persons were admitted to area hospitals. The on-duty flight attendant, the off-duty captain, and the off-duty first officer sustained minor injuries and were treated at area hospitals and released.

Postmortem examinations of the nine fatally injured occupants performed by the Wayne County Medical Examiner's office revealed that all of the nine fatally injured occupants died from smoke and soot inhalation. The fatally injured persons did not sustain traumatic injuries. Toxicological tests on the flightcrew were negative for drugs and alcohol. There was 19 to 28 percent carboxy hemoglobin in blood samples taken from all fatally injured occupants. Levels of cyanide in the blood samples ranged from 0.6 percent for the captain, 1.4 percent for the first officer, and 1 .1 to 2.0 percent (microgram per milliliter) for the passengers.

During the postmortem examination of the captain, the pathologist found a 75 percent atherosclerosis of the left anterior descending artery, 2 centimeters below the ostium. Further examinations by the Armed Forces institute of Pathology (AFIP) confirmed the luminal narrowing of the artery. However, they reported no evidence of a myocardial fibrosis or necrosis, and no anatomical evidence of an acute event.

The first officer sustained a 2-inch-diameter contusion on the right temple. There was no evidence of fractures or other evidence of traumatic injuries to the flightcrew.

Three ground service personnel whose vehicles were struck by the airplane received minor injuries, and they were treated at an area hospital and released.

1.14 Fire

Witnesses observed a fire associated with the ground impact, but did not see any sign of an in-flight fire. Examination of the wreckage revealed no evidence of an in-flight fire. The ground fire occurred when the right wing ruptured at initial ground impact, causing fuel to spill from the point of ground impact to the point where the airplane came to rest. The fuel in the wing tanks continued to feed the fire when the airplane came to rest upside down. About 1,600 pounds of Jet A fuel was on board the airplane at the time of the accident.

The CFR station No. 1, located adjacent to runway 21 R and 3,000 feet southwest of the accident site, was alerted by the control tower of a large fire at the end of concourse F. The control tower initiated the second alarm. A rapid intervention vehicle was on scene within 1 minute 30 seconds. It was followed 15 seconds later by three CFR trucks. The fire was extinguished within 2 minutes of the first alarm.

A mixture of 5,950 gallons of water and 240 gallons aqueous film forming foam was used to extinguish the fire. In addition, 130 gallons of protein foam were used. (See figure 1.)

1.15 Survival Factors

The passengers were evacuated through the exits on the left side of the airplane. The exits on the right side apparently remained closed. Surviving passengers stated that fire and smoke were in the cabin soon after the airplane came to rest. The flight attendant was not able to ascertain conditions outside of the airplane before passengers exited. She reported that she had difficulty opening the left forward emergency exit door because she was disoriented. She initially tried to open the door by pushing the handle down before she realized the handle had to be pulled upward

Figure 1.--Crash scene in front of Concourse F, Gate 0.

because the airplane was upside down. Once it opened, she escaped through extensive fire in the vicinity of the door.

Because the airplane was upside down, passengers fell to the cabin ceiling after they released their seatbelts. The ceiling area that had to be used as an exit path was obstructed by loose debris and wing flap actuator fairings, which protruded through the ceiling. They reported that they could see light through open exits and rapidly escaped through the exits. The flight attendant and four passengers, including a company ground employee, exited through the left forward emergency exit, and five passengers, including two off-duty pilots and a flight attendant, exited through the rear main entry door on the left side of the fuselage which had sprung open during the impact sequence. (See figure 2 for cabin seat arrangements.)

The interior of the fuselage was damaged extensively by fire, and all of the cabin interior materials showed evidence of fire damage. Most of the carpet, dress covers, cushion foam, and side wall materials were consumed in the fire. Some of the cushions were partially melted. All seven cabin windows on the right side of the cabin were melted. Except for the front window on the left side of the cabin, all other windows were missing.

None of the passenger seat cushions were covered with fire-blocking material. This material was not required to be incorporated into this airplane or others of its size and weight class until November 26, 1987. The benefits of seat cushions with fire-blocking material have been demonstrated to be effective in reducing the onset of fire flashover during a fuel fed external fire. Thermal radiation can breakdown the outer upholstery covering of seat cushions, and thereafter, penetrate into the relatively large mass of cushion material (polyurethane foam core). When the foam material burns, the byproducts include toxic gases, dense smoke, and combustible gases. The FAA has demonstrated that unprotected seat cushion material is the dominant factor in the propogation of cabin fire.[3]

FAA Research has shown that fire-blocking material in seat cushions even with a major fuel spill could provide at least 40 seconds of additional time for survivors to escape. This is possible because the fire blocking delays the time when the cushion material will outgas toxic fumes, smoke, and combustible gases.

The flight attendant's retractable seat was installed on the left side of the forward cabin bulkhead, adjacent to the left forward Type II emergency exit. (See figure 3.) In the extended position, the seat blocked passage to the exit. The seat was found retracted, but it was not equipped with an automatic folding mechanism feature. The seat was designed and certified by the airplane manufacturer, but there was no data plate visible on the seat frame. The FAA issued AD 87-05-07, effective March 25, 1987, requiring installation of an automatic retract mechanism in the seat in accordance with the manufacturer's Service Bulletin (SB) 212-25-32 of October 23, 1985.

The double passenger seat at row 1 (1-BC) which had been occupied by one person was dislodged from all attachment points. Double seat 5-BC and 6-BC was detached from the inside floor track, but remained attached to the side wall. Seat 4-A was also dislodged from all its attachment points. Most of the passenger restraint systems, which were manufactured by American Safety, Inc., were consumed by the fire. The remains of the only seatbelt found was buckled.

Except for the crushing of the right side of the nose section, which deformed the first officer's rudder pedals, the cockpit maintained sufficient occupiable area for survival. The three-piece windshield remained in place. The captain's side windows were dislodged and a portion of the first

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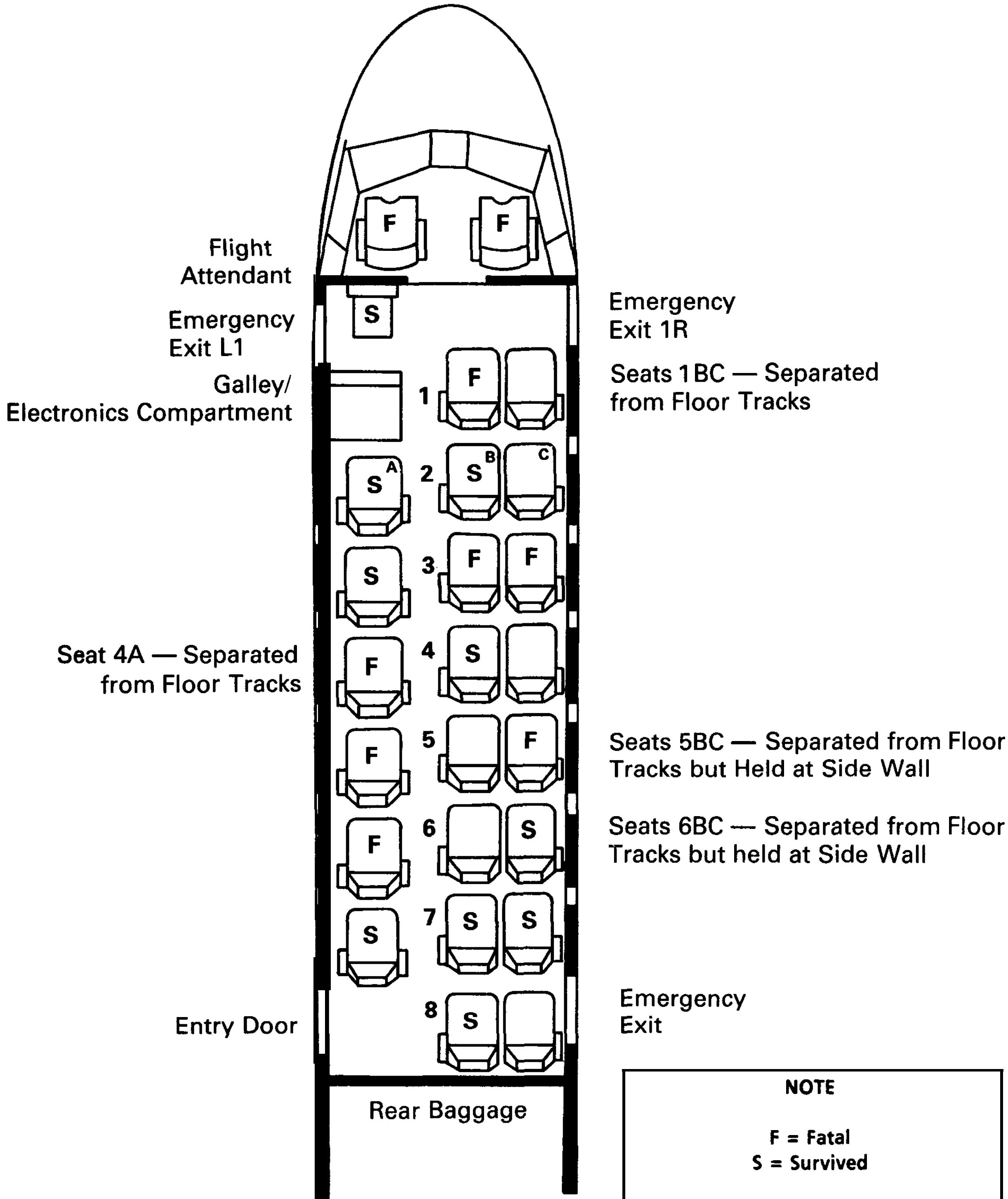
[3]C.P. Sarkos and R.G. Hill, *Effectiveness of Seat Cushion Blocking Layer Materials Against Cabin Fire*, Society of Automotive Engineers, Technical Paper 821484, Warrendale, Pennsylvania, 1982.



NOTE

F = Fatal
S = Survived

Passengers in Row 7, Seats A, B, C, and Row 8, Seat A exited through the aft door.
Passengers in Row 6, Seat C; Row 4, Seat B; Row 2, Seats A and B; and the flight attendant in Seat S exited through the foward door.

Figure 2.--Fischer Bros. CASA C-212-CC cabin seat configuration.

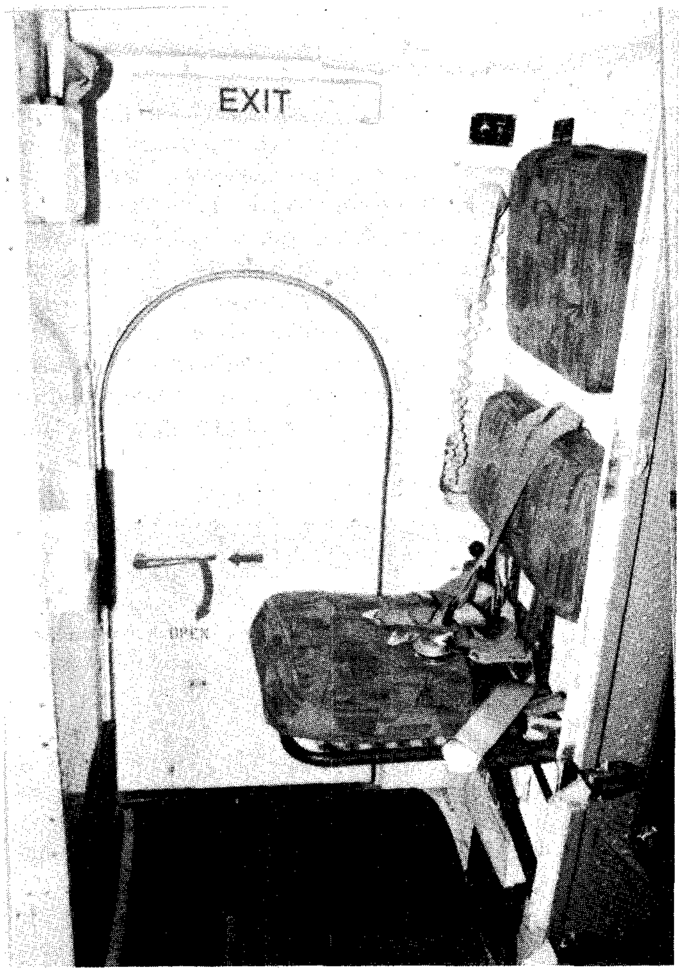


Figure 3.--Flight attendant's seat adjacent to the left forward exit taken from a similarly-equipped CASA-212.

officer's side window was pushed outward. Although the instrument panel was displaced somewhat, the flight control columns and control wheels were in place and the panel did not show any evidence that the crew struck the panel. The crew seats were in place and secured in the seat tracks, and the floor structure was not deformed. The four-point restraint systems were destroyed in the fire. Manual override handles for the shoulder harness inertia reels were in the inertia reel position. The captain's shoulder harness and lapbelt were found released, and the first officer's shoulder harness was found released with the lapbelt connected. The lapbelt anchor fittings for both seats remained intact.

The flightcrew cockpit seat restraints were manufactured by Autoflug, GmDh, Rellingen, West Germany. Examination of another CASA C-212-CC revealed that the seat restraints operated by means of an inertial reel and a manual override handle. The inertial reel mechanism contained a self-locking rachet device. The straps, with the handle in the manual override position, tightened whenever the occupant moved which created slack in the harness. When the straps tightened automatically, the harness was uncomfortable and restricted the occupant's movement. To reach certain controls and switches, the occupant had to either move the seat or place the handle in the inertial position. However, the stitching that connected these straps was bulky, and the straps frequently snagged inside the reel each time the occupant moved forward with the handle in the inertial position. This prevented the harness from retracting consistently, and thus created a lot of slack in the harness.

The Safety Board examined another Fischer Bros.' C-212-CC and compared some of the installations with Federal regulations. The Board examined the boarding stairs that were hinged at the floor just inside the left main cabin entry door. When they were folded with the door closed, the stairs obstructed the view and operation of the door handle. (See figure 4.) N160FB contained the same installation which was approved by the FAA under a supplemental type certificate (STC) obtained by the carrier. The Safety Board also found that the clearance between the left front passenger seat (2-A) and the galley/electronics bulkhead was 28 inches, whereas 14CFR 25.785(c) prescribes an injurious-free environment. A torso flexion envelope of 35 inches is the commonly accepted criterion. (See figure 5). The galley/electronics compartment was also approved under an STC. Further, the armrest of passenger seat 8-C extended into the projected opening of the Type III emergency exit at the aft right side of the airplane. Title 14 CFR 25.813(c)(1) requires that openings be free of protrusions. (See figure 6.)

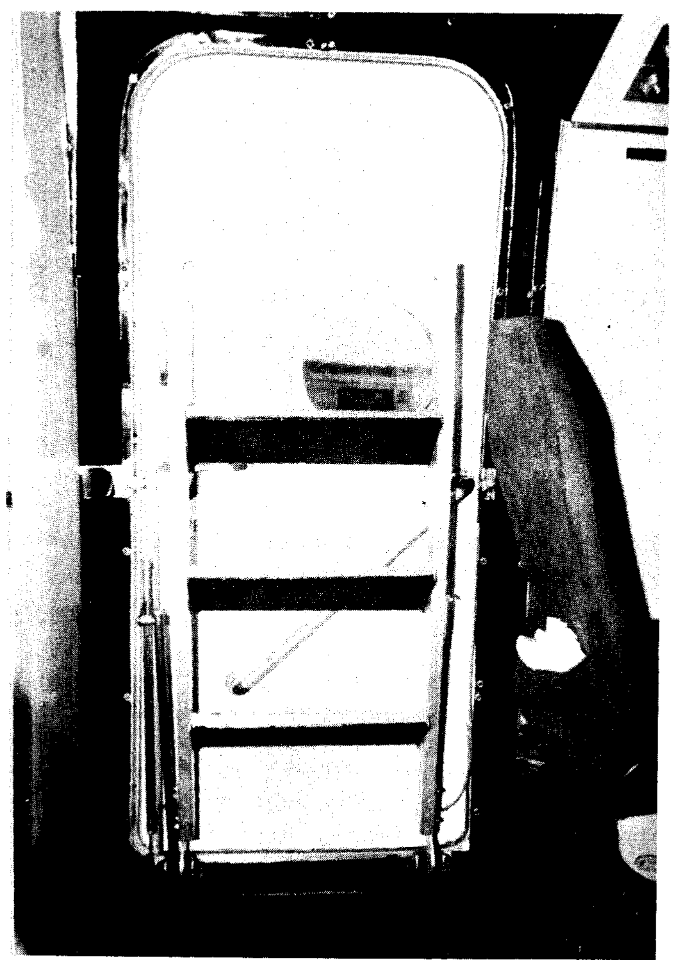


Figure 4.--Position of the folding stairs at the left main cabin entry door taken from a similarly-equipped CASA-212.

Figure S.--Rear view of seat 2-A behind the galley/electronic compartment.

Figure 6.--View of the right rear Type III emergency exit adjacent to Seat 8-C.

1.16 Tests and Research

1.16.1 Powerplants and Propellers

On March 11, 1987, the engines and accessories, along with the propeller governors and pitch controls, were examined and tested at the facilities of the Garrett Turbine Engine Company, Phoenix, Arizona. No evidence of preexisting discrepancies or abnormalities was found that would have interfered with normal engine operation. There was evidence of normal gas path soot deposits, of rubbing between the compressor impeller and impeller shroud, of rubbing between the tips of the turbine blades, and of torsional shearing of the power section-to-reduction gear coupling shafts, which indicated that the engines were operating at the time of the accident.

On March 31, 1987, the propellers and associated components were examined at the Hartzell facility in Piqua, Ohio. The blades were a composite construction made from Kevlar®. Except for some very small pieces, broken sections of the blades could be pieced together. There was no evidence of preexisting delamination of the blade material. Although the right propeller pitch change arm was bent, there was no evidence that this rod or the left propeller pitch change rod failed before impact. Damage noted to exterior components was attributed to impact forces. The left propeller was cycled through its full operating range. The right propeller was restricted from moving to its full feather position due to impact distortion and heat damage. Except for the inner spring retainer (mushroom) cup guide sleeves, the remaining internal components of both propellers were intact. The cup guide sleeves were fractured as a result of impact damage.

Impact marks found on the pitch change rods of both propellers and on the internal diameter surface of the right propeller piston, indicated that the angle of the blades was from 10° to 11" at the time the propellers struck the concrete ramp.

Control of the propeller blade angle is achieved through governed engine oil pressure and aerodynamic forces which counterbalance feathering spring and counter weight forces. Oil pressure and aerodynamic forces move the blades to a low pitch (high RPM position), and the feathering spring and counterweight forces move the blades to a high pitch (low RPM position). The propeller blade angle is limited by two physical stops located in the propeller: one for the feather position (high pitch limit 83" +/- 0.39; and one for the full reverse position (low pitch limit 10" +/- 0.59. The start lock positions the blades to -1.5" +/- 0.2" to reduce the aerodynamic load on the propellers during engine start. The static flight idle blade angle is 7° +/-0.3") and is hydraulically positioned by metered oil pressure through the "beta" tube. The beta tube is mounted concentrically in the propeller shaft and extends from the propeller piston through the engine reduction gearbox assembly to the propeller pitch change unit which is mounted on the rear of the reduction gearbox. Establishing the flight idle blade angle requires placing the corresponding PL at the flight idle gate before an adjustment is made. The pilot controls the propeller with the PLs and the engines with the speed levers (RPM levers). With the PLs at or above the flight idle gate, the propeller governor regulates the blade angles as a function of airspeed and load on the engine to maintain a desired constant engine RPM. With the PLs in the beta range, below the flight idle gates, the pilot has direct control over the propeller pitch because the propeller governor is mechanically locked out of the pitch control system in this configuration. Beta mode operation and use of full reverse is designed for ground operation only, that is, for deceleration after landing and for taxiing.

CASA reported that the flight idle blade angle was determined by adopting a 7°-flightpath angle at 1.3 V_{SO}[4] (85 KIAS typically) in the landing configuration (full flaps) which results in a descent rate

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[4]V_{SO} is the stalling speed or the minimum steady flight speed in the landing configuration.

of 1,500 fpm (+/-100 fpm) at about 5,000 feet msl. This rate of descent is established by adjusting engine fuel flow. The normal setting is 170 pph per engine. Since propeller blade angle will vary as a function of airspeed, the blade angle with the PLs at the flight idle gates will vary also. Propeller blade angle setting at 1.3 V_{SO} had not been measured by the manufacturer. CASA estimated that near 90 KIAS, the blade angle would be about 10". If the airplane was to slow to about 70 KIAS, the blade angle would move to 7°, and the beta light would illuminate to indicate to pilots that they now have direct control over propeller blade pitch for ground operation.

According to the CASA maintenance manual, setting of the propeller blade angles in the static condition to the corresponding flight idle position of the PLs involves a 13-step set-up procedure followed by a 9-step adjustment procedure. The maintenance manual cautions the operator to perform the procedure in windless conditions. The procedures require use of a ground power unit, and the engine(s) must be operated until oil temperatures reach at least 85°C. The engine is then shut down with the propeller feathered. The relevant PL is placed in the flight idle position and a rigging pin is installed. The adjustment procedure requires operating the unfeathering pump until the propeller unfeathers and stabilizes at an angle as measured at the 42-inch blade station indicated by a line painted on the blade face (back of blade). (The procedure in the maintenance manual specified measuring the blade at the 30-inch station also indicated by a line on the blade face. This was the correct position for the measurement on the earlier model C-212-CB Hartzell propeller, but not for the C-212-CC. The manual was later corrected by CASA.) If the blade angle is incorrect, the blades are adjusted by removing the beta tube lock pin and by turning the beta tube in the appropriate direction. The manual noted:

> One complete clockwise turn of beta tube decreases blade angle by 2 degrees. One complete counter-clockwise turn increases blade angle by 2 degrees.

If the blade angle is too high, the previous six steps must be repeated, and if it is too low, nearly the entire procedure, beginning with restarting the engine, must be repeated. Once the correct adjustment has been made, a nine-step close-up procedure is performed.

The preflight check requires the flightcrew to examine the PL and beta latch mechanism for freedom of movement and latch spring operation. A detailed visual inspection is a required "C" check every 3,600 hours of flight operation. The latch spring tension cannot be adjusted and the spring must be replaced if it malfunctions or fails.

In addition to the general adjustment procedure, a flight idle descent flight test must be performed each time a propeller is replaced on an engine. In the test, flight is established briefly between 4,500 feet and 5,500 feet msl with full flaps (40°). The speed levers are advanced to 100 percent RPM, the PLs are retarded to the flight idle gate, and an airspeed of 85 KIAS is established. The resulting rate of descent should be between 1,400 and 1,600 fpm. If the rate of descent does not fall within the range, then the flight test must be repeated after the fuel flows are readjusted. The pilot is required to note if any asymmetric thrust exists (yaw in one direction or another), if the beta light remains off, and the fuel flow readings per engine.

Teardown of the propellers disclosed that they did not contain the correct feathering spring assemblies; each propeller had only a single spring (P/N 831-43) instead of the required double spring (P/N 831-54). The single spring is a typical feathering spring used on most Hartzell 4-bladed aluminum propellers installed on Garrett TPE-331 engines. The slightly stronger double feathering spring is unique to the Garrett powered CASA C-212-CC installation. Its purpose is to provide additional force to speed movement of the blades out of the full reverse range during landing roll-out.

Hartzell Service Center had last overhauled the left propeller (S/N CD838) on June 12, 1986, and the right propeller (S/N FL277) on September 22, 1986. Propeller serial No. CD838 was installed on the left engine of N160FB on July 6, 1986 (AK total time of 11,945 hours). Its TSO was 973 hours. Propeller serial No. FL277, along with engine serial No. 37018, was removed from airplane N169FB and installed on the right wing of N160FB on February 20, 1987 (AK total time of 12,867 hours). The TSO for this propeller at that date was 556 hours. At the time of the accident, the TSO was 607 hours.

Propeller serial No. EA930 was removed from the right engine of N160FB on February 20, 1987, and installed on the replacement right engine of N169FB. This propeller and the left propeller (S/N DC1685) on N169FB were also found to have the incorrect feathering spring assemblies installed by the Hartzell Service Center.

According to the executive vice president of maintenance for Fischer Bros., they had accumulated 79,040 hours and 148,927 cycles of service experience with the Hartzell HC-B4MN- 5AL propeller from August 1980 to March 1987. During that period the only reported instances of "propeller action of sticking into or out of reverse position below flight idle power setting" were "several isolated incidents that occurred on CASA N160FB on the 11 th and 22nd of December, 1986." The airplane had accumulated 235 hours and 402 cycles from December 22, 1986, up to the time of the accident. Fischer Bros. reported that, ". . . maintenance crews at no time could duplicate the discrepancies (December 11 and 22) either by ground run or test flight." They also reported that propellers S/N CD1685 and S/N EA930 had no such history of sticking in the reverse mode.

1 .16.2 Propeller Overhaul Service

The Hartzell Service Center overhauled the propellers installed on N160FB under an exchange program. During the overhaul, the feathering spring assemblies were pre-assembled in a separate area, according to personnel involved, and then were verbally identified and given to a stockroom attendant who placed them in a specifically designated storage bin. When the feathering spring assemblies were ordered for the propellers, the stockroom attendant provided the incorrect assemblies with the single feathering spring, P/N B-831-43 (used for aluminum propeller blade design LT10282) instead of the double feathering spring, P/N B-831-54 (used with the composite propeller blade design LM10585). The stockroom attendant's actions reportedly were based on memory and previous experience with CASA C-212-CB propeller installation requirements. The feathering spring assemblies were not identified by an assembly part number. Based on the assembler's previous experience with the aluminum blade propeller configuration, he installed the incorrect assemblies and erroneously checked off the Assembly Inspection Check-Off record, Form No. 1237, as being the correct assembly.

The propellers were subsequently inspected by a Hartzell Service Center employee who is an FAA-certified inspector. The feathering spring assembly is one of the few parts that cannot be inspected after the propeller is assembled. The inspector was not required to verify that correct parts were being installed during the assembly process.

As a result of these mistakes, Hartzell Propeller issued an instruction on January 19, 1988, establishing new procedures to use during propeller assembly. The stockroom attendant and the assembler are now required to verify from the propeller assembly print that the correct parts are being supplied and installed. A feathering spring parts card will be used to document the parts listed for installation, and it will be attached to the Final Inspection Record.

According to Hartzell Service Center representatives, the FAA visits their facility about three times each year. The inspector(s) examine documentation and review overhaul procedures and manuals. The representatives reported that the FAA also inspects to ensure that the various new and overhauled parts are correctly segregated.

1.16.3 Aircraft Type Certification History

On March 11, 1987, personnel from the FAA Office of Airworthiness briefed Safety Board representatives on the type certification history of the CASA C-212. It was type certificated in the U.S. under the Bilateral Airworthiness Agreement (BAA) with Spain, dated September 23, 1957, and updated in 1978, and in accordance with Title 14 Code of Federal Regulations Part 21, *Certification Procedures for Products and Parts, Section 21.29, Issue of type certificates: import products.* The basis under which the CASA C-212 was certificated was 14 CFR Part 25, effective February 1, 1965, including Amendments 25-l through 25-35, and 14 CFR Part 36, effective December 1, 1969, including Amendments 36-l through 36- 4, and Special Federal Aviation Regulation (SFAR) No. 27.

A BAA is an executive agreement between governments. An executive agreement is less formal than an international treaty and is made between chiefs of state without senatorial approval. A BAA with the U.S. is normally developed when another country has an aeronautical product manufacturing industry and a competent civil airworthiness authority and intends to export its product to the U.S. BAAs are a part of international conventions and trade agreements between countries (Multilateral Trade Negotiations under the General Agreement on Tariffs and Trade). However, since they are technical agreements rather than trade agreements, they are intended to prevent unnecessary repetitive certification activities by facilitating cooperation between the exporting country's airworthiness authority and the FAA and by making full use of the country's type certification system. When a foreign country requests a BAA or a revision to a BAA, the U.S. Interagency Group on International Aviation must review the request. In addition, the FAA, on behalf of the State Department, must evaluate the technical competence, capabilities, regulatory authority, and efficacy of the foreign country's airworthiness authority. Further, the FAA assesses the foreign country's airworthiness laws and regulations, and the general state-of-the-art in design and manufacturing capability including the need for a BAA. Title VI of the Federal Aviation Act of 1958 requires the Secretary of the Department of Transportation (DOT) to be consistent in exercising duties and responsibilities under the act with respect to international agreements.[5]

When CASA sought to market the CASA 212 in the U.S., the FAA European Region Aircraft Engineering staff in Brussels, Belgium, evaluated the type design in several meetings with personnel from CASA and from the lnstituto Nacional de Tecnica Aerospacial (INTA), the responsible Spanish civil airworthiness authority. The certification meetings began on November 5, 1974, and pertained to the C-212-CB. From November 1974 to February 1977, the airplane was flown by the FAA on three separate occasions; by two test pilots in November 1974 and June 1976 and by the chairman of the Flight Operations Evaluation Board in January 1977. There were no serious unacceptable or unsafe features reported as a result of those flight tests. Type certificate No. A43EU for the C-212-CB was issued on February 22, 1977. Subsequently, the director general of Civil Aviation approved and the United States amended the type certificate by adding other models. The other CASA C-212 models were the CC, CD, CE, and CF.

The FAA reported that there was no test pilot on the staff in the Brussels office and no engineering flight evaluations were made when the model CC was undergoing certification evaluation. The FAA amendment of the type certificate to add the model CC was based on the INTA's certification on May 17, 1979, that, "the type design had been examined, tested, and found to meet 14 CFR Part 25, effective February 1, 1965, including Amendments 25-l through 252-35." Model CC was given a U.S. type certificate on May 16, 1980. The model CD, CE, and CF were given U.S. type certificates on September 6, 1985, September 9, 1985, and December 6, 1985, respectively.

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[5]FAA Advisory Circular 21-18.

The C-212-CC has a takeoff gross weight of 2,644 pounds more than the CB model, and the engines each have 150 shaft horsepower more to handle the extra gross weight. Also, the CC uses the Kevlar® composite propeller blade material, whereas the CB model uses an aluminum alloy blade material. The composite blade design was approved on September 12, 1978. According to the FAA, in order to handle the increase in asymmetric thrust that could be generated in the CC model over the CB, V_{mc} (minimum control speed with the critical engine inoperative) was increased from 78 to 85 KIAS, and the rudder deflection in both directions was increased from 25" to 27.5".

Before a U.S. airworthiness certificate can be issued, the law requires that the FAA find that the aircraft conforms to the approved type design and is in a condition for safe operation. By Federal regulation (14 CFR 21.183 and 21.185), an import aircraft is entitled to a U.S. airworthiness certificate if the exporting state certifies and the FAA finds that the aircraft does conform to the type design and is in a condition for safe operation. The FAA can make a determination based in whole or in part on the exporting state's certification, provided a BAA exists between the U.S. and that state permitting such an arrangement. The FAA does not have to flight test the airplane. N160FB was issued an airworthiness certificate on July 18, 1980.

However, during Fischer Bros.' proving tests with the airplane on September 15, 1980, the FAA GADO in Cleveland, Ohio, which was responsible for the airline's operating certificate, found reason to believe that the airplane did not meet certain sections of 14 CFR Part 25. The areas of possible noncompliance dealt with fivesections in Subpart D, Design and Construction of personnel and cargo doors (25.783 (b)(d)(e)); seats, seatbelts, and harnesses (25.785 (h)); emergency provisions for emergency exit arrangement (25.809 (f)); emergency exit marking (25.811 (e)(2)(i), (e)(3), (e)(4)(i), (iii), and (f)); and emergency lighting (25.812).

During the interim period of the airplane's service, the FAA underwent a reorganization of its airworthiness departments which resulted in the "lead region" aircraft type certification concept. Consequently, primary responsibility for the C-212 project was transferred from the Brussels office to the FAA's Northwest Regional office in Seattle, Washington, which was responsible for 14 CFR Part25 type certification. After an inspection of another airplane on August 23, 1983, the FAA Northwest Mountain Region found other areas of possible noncompliance. Since flight characteristic issues were also involved, the FAA decided to have a flight test pilot evaluate these issues as part of a trip to Europe involving other projects. As a result, on March 19 and 23, 1984, a flight test pilot and flight test engineer evaluated the model CC on two different flights of 2.5 hours duration. They reported that the airplane did not have adequate stall warning, that the stall characteristics were unsatisfactory, that it did not meet the directional stability requirements, and that it had insufficient rudder control in the engine-out takeoff, climb condition. Additionally, proposed modifications by CASA to correct other possible noncompliance discrepancies in the cockpit were evaluated by the test pilots. These discrepancies were trim control indicator, gust lock provision, power lever jamming provision, and the flap system. The test pilots noted that the flap system :

> . . .is powered by a single hydraulic pump which is turned ON prior to selecting flaps and turned OFF after flap selection. It was noted on the aircraft tested that after flap selection and the hydraulic pump turned off, the flaps would not hold position but would tend to creep down to a greater flap setting.

By the time of the Fischer Bros. accident and following another inspection of a CASA C-212 on May 14, 1984, the FAA had compiled an additional 14 areas of possible noncompliance in addition to the 5 identified in the Fischer Bros. proving tests in September 1980. According to the FAA personnel in the Northwest Mountain Regional Office, they were not successful in resolving all possible noncompliance items that were noted in its evaluation of the airplane because there were differences of opinion between FAA and INTA on how to interpret the rules, because the certification basis had already been determined, and because the FAA had already issued the type certificate.

ADs were issued to correct many discrepancies found in the airworthiness evaluations of the airplane. One AD was issued in 1983, two in 1984, one in 1986, and six in 1987. One of the ADs issued in 1984 (84-02-30) was to correct the door and exit discrepancies identified by the Cleveland GADO in September 1980.

At the time of the March 4, 1987 accident, 5 of the 19 items remained open; of these 2 were in the final Notice of Proposed Rulemaking (NPRM) stage and the findings of the flight test evaluation evidently remained in dispute. The two in the NPRM stage concerned Part 25.629, flutter, deformation, and fail- safe criteria, and Part 25.809, emergency exit arrangement. The three areas that remained in an open status pertained to Part 25.671(c)(1), flap drive system; Part 25.735(b), brakes; and Part 25.1415(e) approved flotation means.

As a result of the Fischer Bros. accident, the FAA reported to the Safety Board that they were forming a multiple expert opinion team (MEOT) to conduct a special flight certification review of the airplane. This team did not include the test pilot and flight test engineer who had made the March 1984 flight test evaluation. On March 24, 1987, the MEOT briefed FAA and Safety Board representatives on the results of the flight tests. The findings in their report of June 16, 1987,[6] are as follows:

- Stall characteristics, directional stability, and directional control were found to comply. (Data reviewed by the team indicated that there was a wide central band from about the middle 1/3 to 1/2 of the rudder travel where pedal forces were very light. Beyond this band, rudder pedal forces increased substantially, up to 150 to 160 pounds at full rudder deflection. A flight test showed that the rudder would tend to float with feet off the pedals and that pedal forces are very light. The airplane showed a clear tendency to return to straight flight when the wings were held level when the rudder was released, but it would not return to coordinated flight. The airplane would return to a steady state flight condition with 1/2 ball displacement depending on the initial amount of sideslip introduced and the rate at which the rudder was released.)

- Stall warning was found to be inadequate and not in compliance; moreover, the team considered the deficiency to be an unsafe feature, and recommended mandating improved stall warning.

During the MEOT briefing, the Safety Board was advised that all operators and flightcrews would be made aware of the results of the MEOT evaluation. However, during the next few days of the investigation, the Safety Board learned that some operators were not aware of the MEOT findings. The Safety Board concluded that steps should be taken to inform operators and FAA aviation safety inspectors of the MEOT findings immediately. Therefore, the Safety Board issued Safety Recommendations A-87-27 and -28 to the FAA on March 31, 1987:

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[6]The flight tests were performed in the C-212-CC. CASA began immediate development of an artificial stall warning system kit. On April 1, 1987, the director of the Northwest Mountain Region issued an NPRM requiring installation of a stall warning system. The comment period closed on May 15, 1987. On July 29, 1987, an AD requiring installation of an artificial stall warning system was issued.

A-$7-27

issue a general notice (GENOT) immediately to all U.S. owners and operators of the CASA C-212 airplanes describing the background and significant findings of the recent flight test of the CASA C-212. The notice should provide an evaluation of the existing CASA C-212 stall characteristics, operational precautions, and training procedures to preclude inadvertent stalls until an approved artificial stall warning system is installed.

A-87-28

Expedite the rulemaking action to require installation of an artificial stall warning system on the CASA C-2 12 airplanes.

1 .16.4 Service History

According to CASA, at the time of the accident, they had sold over 400 C-212s which were operating in 30 countries. The airplanes had accumulated over 870,000 flight hours. To CASA's knowledge, no in-service operational difficulties relating to the natural stall warning had been reported.

At the time of the accident, 30 C-212s were operating in the United States. Twenty-six were being operated by four scheduled commuter air carriers. The largest air carrier, with 10 C-2125, was Executive Air Charter, Inc., operating as an American Eagle carrier.

According to the International Civil Aviation Organization, there were eight reported accidents of the C-212 worldwide before the Fischer Bros. accident: three controlled collisions with the ground; two hard landings; one engine failure/forced landing; one nose gear collapse; and one where a person was fatally injured after being struck by a propeller.

In November 1987, FAA surveillance of Executive Air following the accident at Mayaguez, Puerto Rico,7 by the San Juan Flight Standards District Office (FSDO) disclosed a flap discrepancy trend involving uncommanded flap movement. During an associated en route inspection by the FSDO of seven airplanes from November 4-6, the FSDO found that the flaps failed to maintain their selected positions on 15 consecutive flights. In the take-off phase of the flight, the flaps bled down 5 percent from the selected position in five instances, and they bled up 5 percent during take-off roll in four instances. On landing, the flaps bled up 3 to 6 percent in 7 instances, and after landing, the flaps bled down 2 percent. Other factors associated with incremental movement of the flaps in some of the occurrences were positioning of the selector inadvertently, a faulty flap indicator, and rapid movement of the flaps during selection.

The Safety Board was made aware of this situation in December 1987 and conducted a special review of these recurring flap discrepancies in January 1988 at Executive Air. A review of the maintenance records of nine aircraft revealed that during the previous 5 months, there were 74 flap system write-ups, 59 of which were reported as uncommanded flap movement either airborne or on the ground or both. Forty of the flap system write-ups resulted in a component change. In addition, a review of the maintenance manuals revealed several inconsistencies or inadequacies for assuring correct flap component installation.

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[7]Aircraft Accident Report--*Executive Air Charter, Inc., dba American Eagle, Flight 5452, CASA C-212-CC, N432CA, Mayaguez, Puerto Rico, May 8,1987* (NTSB/AAR-88/07).

According to CASA, because of the mechanical transmission of the flap system linkage in the C-212, insignificant movements in the selected flap position are produced when there is considerable variation of the aerodynamic loads over the flap surfaces. This occurs from the elasticity in the system, including the elasticity in the mechanical linkage (rods and bellcranks) and the compressibility of the hydraulic fluid. Even though the C-212 series airplane has been certified with this inherent defect, and no changes in the flap system design have been made since it was certificated, CASA conducted flight tests to quantify the flap actual position variation and to assess its effects on flight safety. The results of the tests were:

- During takeoff there was a variation of flap position indication from the selected 25 percent on the ground to 22 percent in the air.
- There was no flap position indication variation during approach.
- Only a 97 percent flap position could be achieved when full flaps were selected for landing. When the airplane was on landing rollout at about 50 KIAS, the flap position indication went to 100 percent.

CASA reported that during the type certification flight tests, the position of the flaps was determined using the flap indicator. Thus, the performance information in the flight manual includes the extra movement due to elasticity. In CASA's opinion, movement greater than 3 percent from the selected flap position should not occur, and that previous reported instances of this having happened were due to inadequate maintenance.

CASA subsequently issued revised maintenance and inspection procedures and revisions to the maintenance manuals. In addition, Executive Air's Operations Specifications have been amended requiring a functional flight test of the flap system of each CASA C-212 every 50 flight hours.

The FAA was concerned that a failure of the flight control system could render the C-212 uncontrollable (14 CFR 25.671 (c)(l)). If the flap system failed, a sudden asymmetric reaction of the flaps during landing approach would result. This issue was resolved by CASA through a damage tolerance examination, flight tests, a fleet inspection, a study of adverse effects in flap system from human errors in maintenance, corrosion and fatigue, and overload, and a request of the FAA by CASA to make mandatory SB 212-27-22.

According to the CASA maintenance manual, the pressure relief valve is the only on-condition component of the flap system and requires an inspection every 2 years or at every 3,000 hours or whichever occurs first.

Chaparral Airlines, another C-212 operator, reported to the Safety Board that they had experienced flaps bleeding up and down. They believed the problem was associated with a leaking check valve, which they replaced four times a year.

In light of the service difficulty reports from Executive Air and Chaparral, all of the flap system components from N160FB were examined and tested. There were some damaged and broken filter screens in some of the restrictor valves. The flap actuator revealed numerous small particles similar in size and composition to the restrictor valve screens in the cylinder and residual hydraulic fluid. Otherwise, the flap system components were capable of normal operation.

1.16.2 Flight Tests

On April 3, 1987, CASA performed several flights to simulate the accident flight's approach to runway 21R. Four flights were performed in a C-212-CDICE with Dowty Rotol propellers to determine the rate of deceleration. In all four flights, the RPM was set at 100 percent and the rate of descent was 600 FPM. Two of the flights, which were flown with 10” of flaps from a trimmed airspeed of 120 KIAS, showed that with the PLs set at 32 percent torque, the airplane decelerated to 74 KIAS in 54 seconds, and that at flight idle, the airplane decelerated to 76 KIAS in 35 seconds. In the two other flights, the flaps were set at 15° at a trimmed airspeed of 118 to 119 KIAS. The airplane slowed to 74 KIAS in 38 seconds, and with a power setting of 33 percent torque, the airplane did not reach a stalled condition. In all four flights, the RPM was set at 100 percent and the rate of descent was about 600 fpm.

In an attempt to determine how the airplane would react in flight when the PLs were placed in the beta mode, the airplane was trimmed at 120 KIAS and a symmetrical reduction of power was made to a position one notch or about 1 inch behind the flight idle gate into the beta mode. The following was observed:

- Torque indications went to 0.
- There was a characteristic cyclic propeller and powerplant noise, coupled with oil pressure fluctuations due to the NTS[8] system operation.
- The airplane pitched down to 12” (stick free).
- The rate of descent reached 4,000 fpm with the airspeed held constant at 120 KIAS. Pitch attitude control is positive with elevator input, and higher elevator forces are required to maintain an attitude as compared to normal conditions. The airplane will decelerate rapidly when leveled.
- There was about a l-second delay in power recovery when the PLs are moved forward into the flight idle gate.

Further aft movement of the PLs into the beta mode produced oil pressure fluctuations in both engines, the NTS lights did not illuminate, and the airplane pitched down more than 12”. With the PLs retarded further behind the flight idle gate, powerplant and propeller cyclic noise disappeared while engine RPM increased to 105 percent. The airspeed had to be reduced in order for the engines and propellers to recover from this condition after the PLs were returned to the flight idle gate. There was a delay in symmetric engine operation after the PLs were advanced simultaneously.

Assymmetric application of power, with one PL at flight idle and the other in the ground idle range, produced a descending yaw and roll in the direction of the propeller in the ground idle position which was easily controlled with aileron. Additional tests determined that with the PLs in the flight idle gates, the net thrust was about 0 at 120 KIAS. The net thrust became proportionally more negative as the PLs were moved toward the ground idle gate, and in the ground idle gates, the net thrust was -4,000 pounds at 120 KIAS.

1.16.5 Aircraft Performance Study

1.16.5.1 Flight Path Reconstruction

The airplane’s flightpath was reconstructed using recorded radar data from the FAA ARTCC in Cleveland which periodically provided the airplane’s position at lo-second intervals in terms of

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[8]NTS means negative torque sensing system. Negative torque is a condition wherein the propeller drives the engine instead of vice versa. The NTS system detects the condition and moves the propeller blades automatically to high pitch to reduce drag on the airplane.

latitude, longitude, altitude, and time. In addition, one data point was obtained from an eyewitness's observation, another from the point where the airplane initially struck the ground, and the third from the location where the airplane came to rest.

Manual calculations and airplane performance computer programs defined a range of flightpaths consistent with the accuracy of the recorded radar data. The data showed that at 1432:43, the airplane was at a point 2.5 miles from the threshold of runway 21R, descending from 2,000 feet at 1,000 fpm and traveling at 170 KIAS. About 1 mile from the threshold, the airplane's speed was about 150 KIAS, and it continued to descend at a rate of 1,000 fpm. At about 1/2 mile from the threshold, it started slowing from about 140 KIAS to about 80 KIAS within 20 seconds. The airplane started leveling off during the last part of the deceleration. The descent increased about the time 80 KIAS was reached.

Another computer program combined aerodynamic data and performance data to calculate the thrust levels required to produce the airplane's computer-generated flight profile. The program calculated the net forces that would generate the accelerations and rates of climb derived from the performance program, and then subtracted the known forces such as lift and drag in order to obtain the required thrust levels. Various drag levels were calculated by using standard drag coefficients modified by assuming sideslip angles and flap extension angles of various magnitudes. The program was also used to correlate the PL positions, thrust levels, and airplane performance from flight test information obtained from a test of an airplane flown with the PLs in the beta and reverse range.

Computations indicate that about 3,000 pounds of negative thrust were required to decelerate the airplane to match its computer-generated profile. The PLs would have been in the beta mode near the ground idle gates for 15 to 20 seconds in order to have produced the 3,000 pounds of negative thrust. (See figures 7 and 8).

1.17 Additional Information

1.17.1 Company Organization

Fischer Bros. Aviation, Inc., (formally GCS Air Service) began operations in 1948 primarily as a fixed-based, charter operator from Galion, Ohio. In 1952, it became a scheduled commuter operator flying various types of twin engine airplanes between Galion, Mansfield, and Cleveland, Ohio. In 1969, it became an Allegheny Commuter, and by the early 1970s, it had developed into a regional carrier with a fleet of seven deHavilland Herons. In 1976, the company no longer operated charter flights and concentrated on the scheduled commuter operation.

Fischer Bros. took delivery of its first turbine powered airplane, the CASA C-212, in September 1980 and then began phasing out the Heron airplanes. In 1983, the company purchased two Shorts SD360 airplanes and operated them until 1986 when they were replaced with the Dornier DO228 airplanes. Fischer Bros. was the second U.S. operator of the CASA C-212, and at the time of the accident, it was operating three C-212s and six Dornier DO 228s which also use the Garrett TPE-331 engine.

Fischer Bros. entered into a contractual marketing agreement with Northwest Airlines on December 23, 1985. The purpose of the agreement, in part, was to coordinate their scheduled flights to maximize the number of passengers who connected with each other's airplanes at Romulus, Cleveland, and Grand Rapids. The agreement extended to Fischer Bros.' use of the Northwest logo, ticket stock and boarding envelopes, reservation system, and adjacent airport facilities and equipment. Northwest Airlines did not provide any operational or training assistance for crewmembers. By the agreement, Fischer Bros. was to use the Northwest logo and other identifiers on Fischer Bros.' other routes to Columbus, Mansfield, and Galion, Ohio, and Flint, and Lansing, Michigan. On February 10, 1986, the FAA FSDO in Cleveland, issued a new air carrier operating

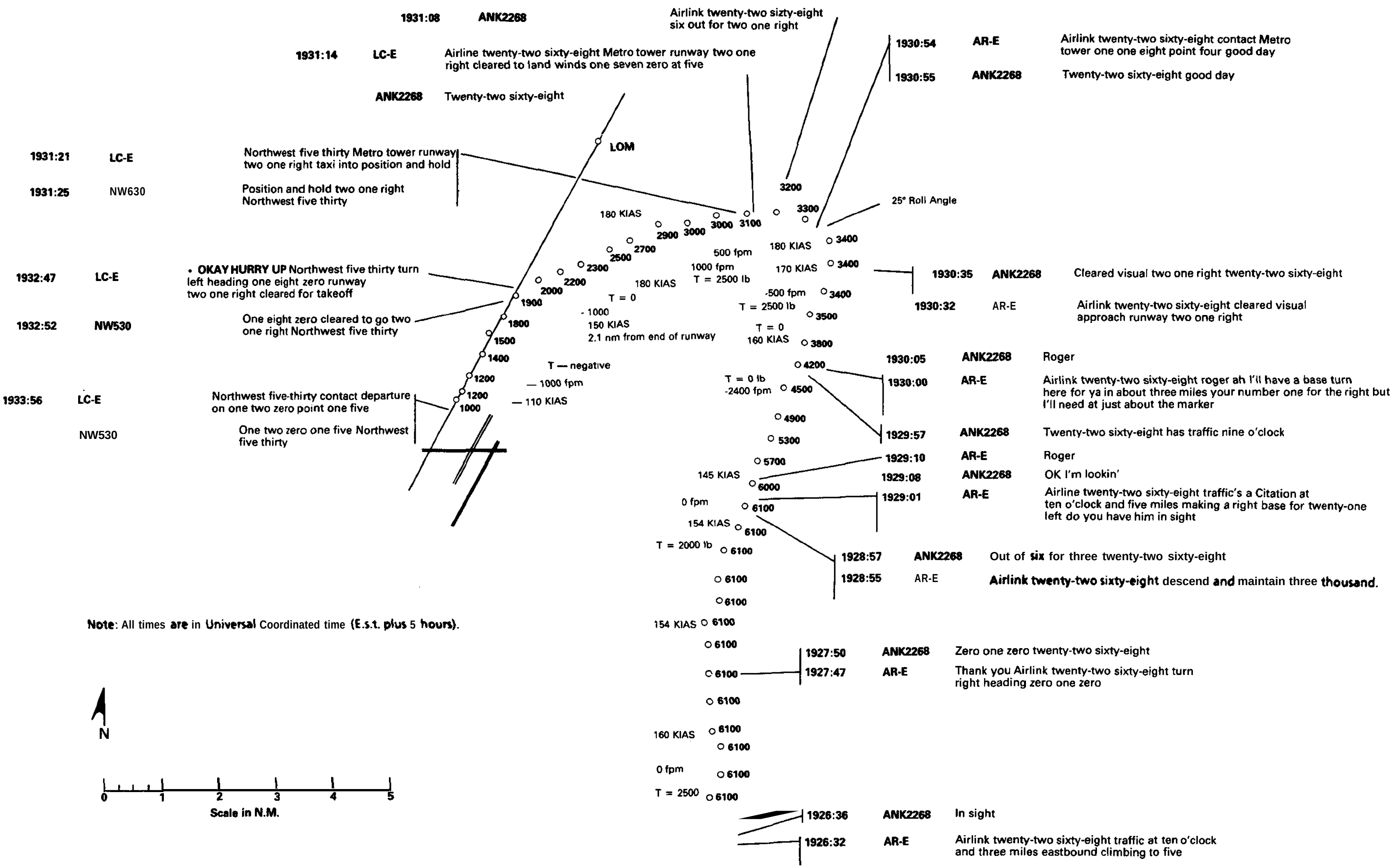


Figure 7.--Computer-generated ground track plot.

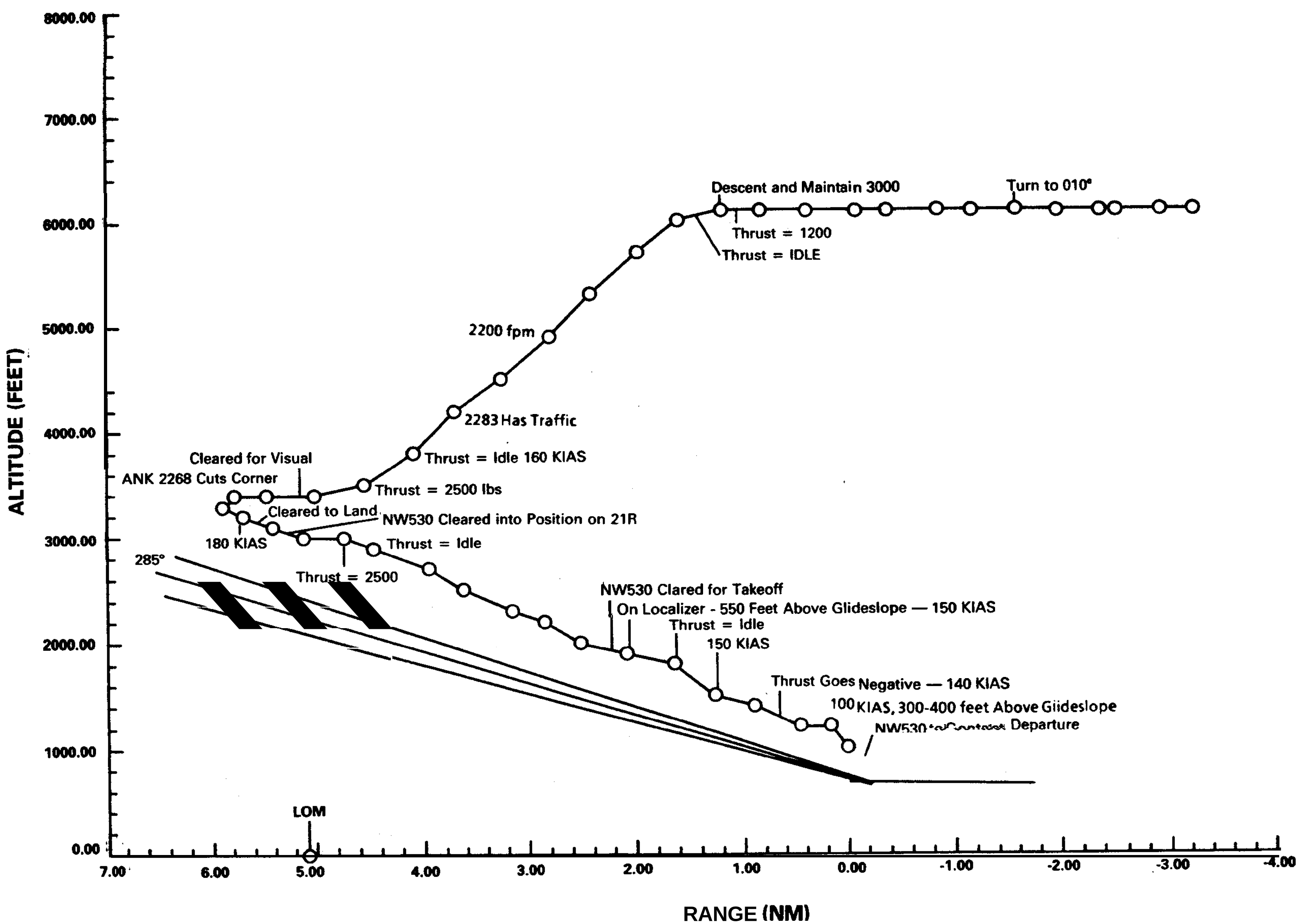


Figure 8.--Computer-generated flight profile.

certificate to Fischer Bros. doing business as (dba) Northwest Orient Airlink. However, on February 4, 1987, Northwest Airlines notified Fischer Bros. that the agreement would be terminated on March 24, 1987, and a termination schedule was proposed and subsequently accepted.

During the period of the agreement between Fischer Bros. and Northwest Airlines, Simmons Airlines had a marketing agreement with Republic Airlines and was operating as Republic Express. However, on August 12, 1986, Northwest Airlines purchased Republic Airlines. Soon thereafter, Simmons Airlines also became a Northwest Airlink commuter and was operating as such at the time of accident.

Fischer Bros. had a total of about 150 employees at the time of the accident. The operations department consisted of the director of operations, the director of training, the chief pilot, 4 check airman, 3 licensed dispatchers, 17 line captains, 17 first officers, 1 chief flight attendant, and 5 other flight attendants.

The maintenance department consisted of 29 personnel: the vice president of maintenance, director of maintenance, assistant director of maintenance, chief of quality control, a supervisor of overhaul and repair, a parts manager, a trainee, 6 mechanic/inspectors, 13 mechanics, a secretary/records clerk, and 2 aircraft cleaners. Most of the mechanics and inspectors received their training on the CASA C-212 from the manufacturer, who presented the training at the airline's headquarters. The training for engine maintenance was provided at the Garrett Turbine Engine Company facility.

1.17.2 Crewmember Training

Fischer Bros. developed its own FAA-approved flight training program for crewmembers, check airman, and instructors as required by Federal regulation. The company's program consisted of basic indoctrination, ground and emergency training, flight training, and flight checks for crewmembers. Flight training was performed in the airplane with a factory instructor pilot.

In September 1980, CASA conducted initial flight training for about 12 pilots, a mix of captains, and first officers. The factory training program consisted of 40 hours of ground school and a minimum of 5 hours of flight training. A minimum score of 70 percent was required to pass the ground school written examination.

The airline reported that the basis for crew coordination training was the use of the approved checklists and standard callouts which were designed to reduce workload and to identify crew errors and system malfunctions at the earliest moment. The standard callouts were designated as memory items and the responsibility of making them was assigned to the nonflying pilot. The flying pilot was responsible for verifying the callout and acknowledging the appropriate action. Failure to follow the appropriate procedures should alert either pilot to correct a mistake. For example, an airspeed indication of 10 knots below or above V_{ref} would require a callout by the nonflying pilot.

According to Fischer Bros.' procedures, a normal visual approach to the Detroit Metropolitan Airport would consist of first completing the descent and in-range checklists before entering the downwind leg of the approach. The airspeed should be stabilized at 120 KIAS on the downwind leg. Just before approaching a position abeam the runway threshold, the flaps should be extended to 15" or 37.5 percent and the approach and landing checklists completed, except for moving the engine speed levers full forward. The speed should stabilize at 105 KIAS without having to change the power. After the crosswind turn, a rate of descent of 400 to 600fpm should be maintained at 105 KIAS. Beginning with the turn onto final approach, flaps should be maintained at 15° and power should be adjusted to maintain V_{ref} + 5 KIAS and a 3"-glide path to the runway established at a point about 1 mile from the threshold. The approach should be planned to cross 50 feet above the threshold at V_{ref}.

However, the operator reported that the versatility of the CASA C-212 permitted flying the airplane at a wide range of approach speeds. A slow speed with full flaps (40”) was used for operations to short runways at small airports although this speed and flap setting would be inappropriate for operations at a major airport under heavy traffic conditions. It was noted that 105 knots is 6 knots above V_{ref} with 15” flaps and 12 knots above V_{ref} with 40 ° flaps at the airplane's maximum landing weight. Under the circumstances of the accident, the operator reported that they would have expected the airplane to be at 100 to 120 KIAS about 1/2 mile from the runway threshold.

The chief pilot for CASA Aircraft USA who provided the initial factory training for Fischer Bros. reported that he considered 110 KIAS on final approach to be fast but easily manageable. He also reported that he would be uncomfortable at a speed above 110 KIAS on an approach. He thought 100 knots would be about an average V_{ref} for the airplane. He said he taught pilots to perform the landing approach by establishing a 3°-glideslope with 10” of flaps at V_{ref} + 10 KIAS. They were then to cross the runway threshold at V_{ref}, reduce the power levers to flight idle, and flare the airplane for touchdown. As for stall training, he reported that only approach to stalls were performed with 0”, 15°, and 40” flap settings, but that he would demonstrate full stalls to applicants for the C-212 type rating.

One Fischer Bros. captain who was interviewed reported that the company had used a previous incident of improper use of beta as a training session for all pilots. The incident involved an approach to Columbus, Ohio, where a pilot (not the captain involved in the accident) had intentionally retarded the PLs into the beta mode to see what would happen. Although the airplane was at several thousand feet in a descent at the time, it yawed violently and the experience startled the crew and passengers. The airline advised “all hands“ of the incident and issued a strongly worded memorandum forbidding such actions in the future.

1.17.3 Crewmember Interviews

Twenty-two company pilots who had flown with the captain were interviewed to determine his flying habits and piloting techniques and the company's operational practices. Of the 22 pilots, 13 were first officers and the remainder were captains. The majority thought highly of the captain. He was a senior pilot in the airline and one of the most experienced. He was reported to have been an employee loyal to the company who flew “pretty much by the book,” was a “good stick and rudder man,” and was a good stable pilot well liked by his peers. However, most of these same pilots also made the following comments:

- He never used the shoulder harness in the CASA, and he was considered a “cowboy” by some.

- He used steeper angles in descents and high rates of descents on visual approaches than other company pilots.

- He frequently made short field landings, flying at or below V_{ref} to see if he could use the least amount of runway, and he always turned off at the first taxiway (Oscar) for runway 2 1 R at Detroit.

- He handled the CASA “sportier” than others, used 2,000 feet per minute rate of descent especially at Detroit, “pressed” approaches more aggressively than other pilots in order to salvage an approach rather than go-around. He had “his own method and philosophy concerning the tactic of flying the unpressurized ‘slam dunk’ arrival ([air traffic control] handling of traffic) into [Detroit].”

- He was known to reduce the fuel condition levers on the Shorts 360 to obtain a faster deceleration, and to occasionally ease the PLs aft of the flight idle gate in both the CASA and the Shorts just as the main landing gear touched the runway. (In the Shorts, it required releasing another safety lock [air/ground lever] before the power levers could be retarded below the flight idle gate.) First officers were shown how to do this in the Shorts in order to achieve better deceleration on landing.

- He had retarded the PLs in CASA 212s behind the flight idle gate inflight according to three first officers who had flown with the captain on those occasions.

- One first officer had a similar experience of using beta in flight with another captain. Another first officer and two captains had heard about similar incidents happening within the company previously, and one captain reported that he had inadvertently moved the PLs into the beta mode in flight on one occasion.

With regard to the first officer, there were no negative comments about his behavior. His coworkers described him as a sharp professional pilot, very thorough, amiable toward accepting instruction and advice, and well liked by his peers.

Interviews were conducted with employees of Chaparral Airlines in July 1987. This operator, who was also doing business as American Eagle, had operated three C-212s for 6 years and had accumulated 36,000 hours of experience with the airplane. The chief pilot, the director of training (also a check airman), a line captain/check airman, a line captain, and the vice president of maintenance were interviewed. The pilots had from 2,000 to 4,000 hours of flight time in the CASA c-212.

Flight characteristics of the C-212, transition problems, and flight procedures were discussed. The following is a compilation of various crew comments in the areas noted.

Initial Training

- Initial factory training obtained from CASA Aircraft USA, the manufacturer's customer support facility in the United States, consisted of 40 hours of ground school and 5 hours of flight training.

- The company developed its own crewmember training based on the factory school. This consisted of 45 hours of basic indoctrination, 28 hours ground school in the C-212, and 4 hours of flight training. The carrier developed a video tape presentation of the ground school, which is available at any time to crewmembers.

Fliaht Characteristics

- The airplane has a lot of drag and will decelerate quickly particularly when the PLs are positioned to flight idle. At that time, a very high sink rate will develop (1,500 to 2,000 fpm).

- The airplane appears to be stable in all flight regimes. It has light control pressures. It is sluggish and not too responsive to control deflections. Large amounts of trim are required to reduce control pressures. The rudder is effective. Changes in pitch are not very noticeable with corresponding changes in airspeed.

- It is somewhat difficult to notice the effects of changes in flap positions and one may not notice if flaps bleed up on an approach, and they tend to bleed down during long periods during ground operations. It is easy to mis-set the flaps, and the flap handle sometimes binds and is very stiff. One broke off during an operation.

- The setting of fuel flow and blade angle adjustments can change the landing characteristics of the airplane significantly.

- A stall can occur in the airplane with very little increase in pitch attitude, very little buffet, and with no wing rolloff under certain conditions (in the clean configuration or with approach flaps and at flight idle), which can result in a very high sink rate (1,500 to 2,000 fpm). The stall warning characteristics of the airplane were adequate for an experienced pilot. The airplane should be equipped with a stall warning device. It is very difficult to move the PLs into the beta mode in flight. Little movement is required to move the beta latch mechanisms into the beta mode. It is a common practice to move the PLs between beta and flight idle during taxi operations in order to control taxi speed. The captain always taxies the airplane and uses the beta latches the most and could, therefore, be more prone to use beta inadvertently in flight. The beta latches are easy to reach and move. The beta latch mechanism is a good design; it has to be a deliberate act to move the PLs into the beta mode.

Transition

- The most common problem for pilots transitioning into the C-212 is overconfidence. Students have a problem initially using the flap system.

Flight Procedures

- High density terminal airport operations preclude using flight idle on landing approach. Pilots are reluctant to use flight idle because of the high drag and high rate of descent that result.

- A takeoff flap setting of 15” is used for approach and an approach flap setting for landing. Although crews are taught to use full flaps for landing, full flaps are not used as a standard practice. No-flap landings are not recommended.

- A visual approach is flown at 120 KIAS on downwind leg with a takeoff flap setting. Approach flaps are selected, and the speed is reduced to V_{ref} + 10 crossing the runway threshold and reduced to V_{ref} for landing while using some power on touchdown. At 10 percent torque, the airplane tends to float, but at 0 percent torque it will sink quickly. Fuel flows of 160 pph will result in a high sink rate, and fuel flows of 190 to 200 pph will not.

Regarding training and maintenance experience on the C-212, the carrier reported the following:

- Ten mechanics were sent to Garrett for training on the TPE- 331-10 engine. Experience in changing numerous engines has shown that once the propeller blade angle has been set properly, any further adjustments to obtain the desired amount of power should be made only by adjusting the fuel control unit. It would be tempting to adjust the blade angles using the beta tube to make power adjustments because it is relatively easy and accessible.

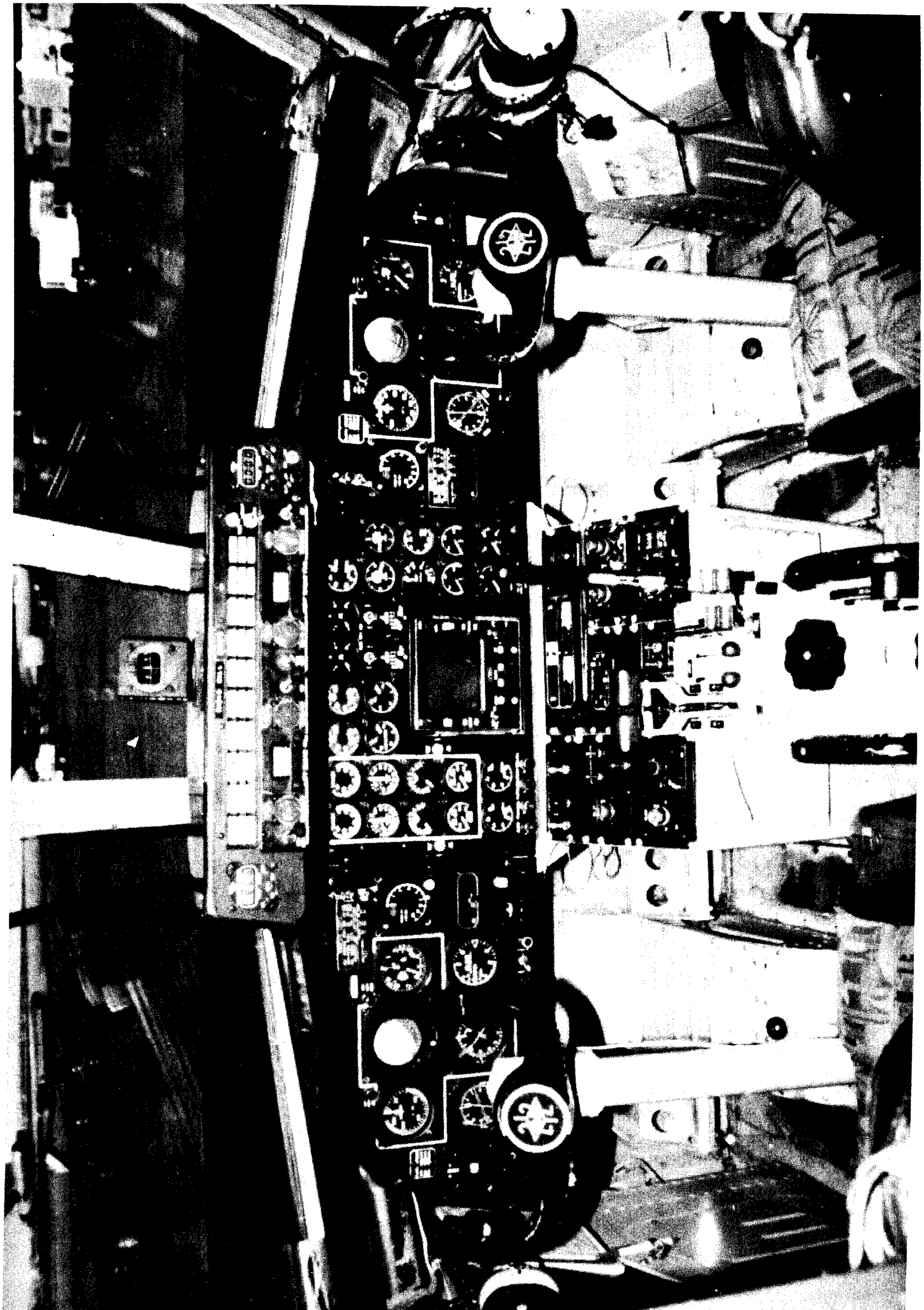


Figure 9.--Cockpit layout of a Fischer Bros. CASA C-212-CC.

- The maintenance manual contained several ‘mistakes that appeared related to the problem of not updating them completely from the 100 to the 200 series airplane. As an example, it contained the incorrect blade angle station to use for setting blade angle (30-inch station instead of the proper 42-inch station). This was corrected by CASA on July 7, 1987. The carrier has had difficulty obtaining manufacturer support, and the technical representatives were not able to expand their support.

- The most common problem experienced has been nosewheel shimmy problems; about 100 such occurrences resulted in failures. There have been some problems with [exhaust gas temperature (EGT)] gauges resulting in fluctuating readings. Engine combustion chamber and fuel nozzle modifications have caused problems with engines developing sufficient power. Propeller overhauls have disclosed that some propellers did not contain the complete feathering spring assembly, and in one case, a propeller had the improper spring assembly installed.

The PLs and beta latch mechanisms were evaluated by physically examining and manipulating them from both the captain's and first officer's seats and the following were noted:

- With the right hand placed with the palm on top of the PL knobs, the fingers can easily touch the beta latch arm (flight idle latch arm) without moving the hand and could be done unconsciously. (See figures 9, 10, and 11.)

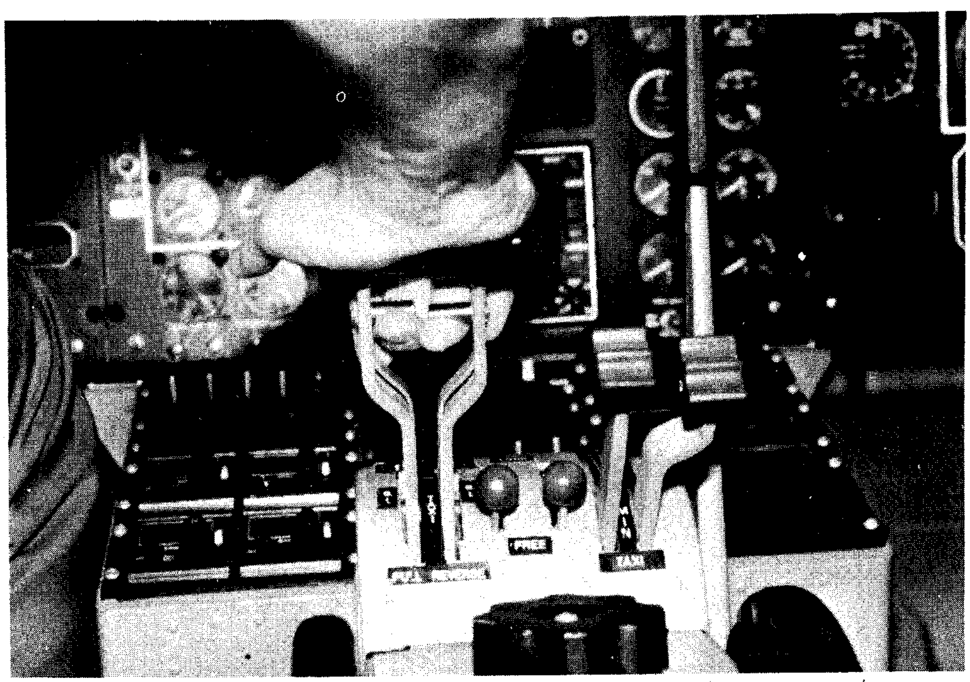


Figure 10.--Closeup of the PLs showing operation of the latch lever arms with the PLs in the full reverse position.

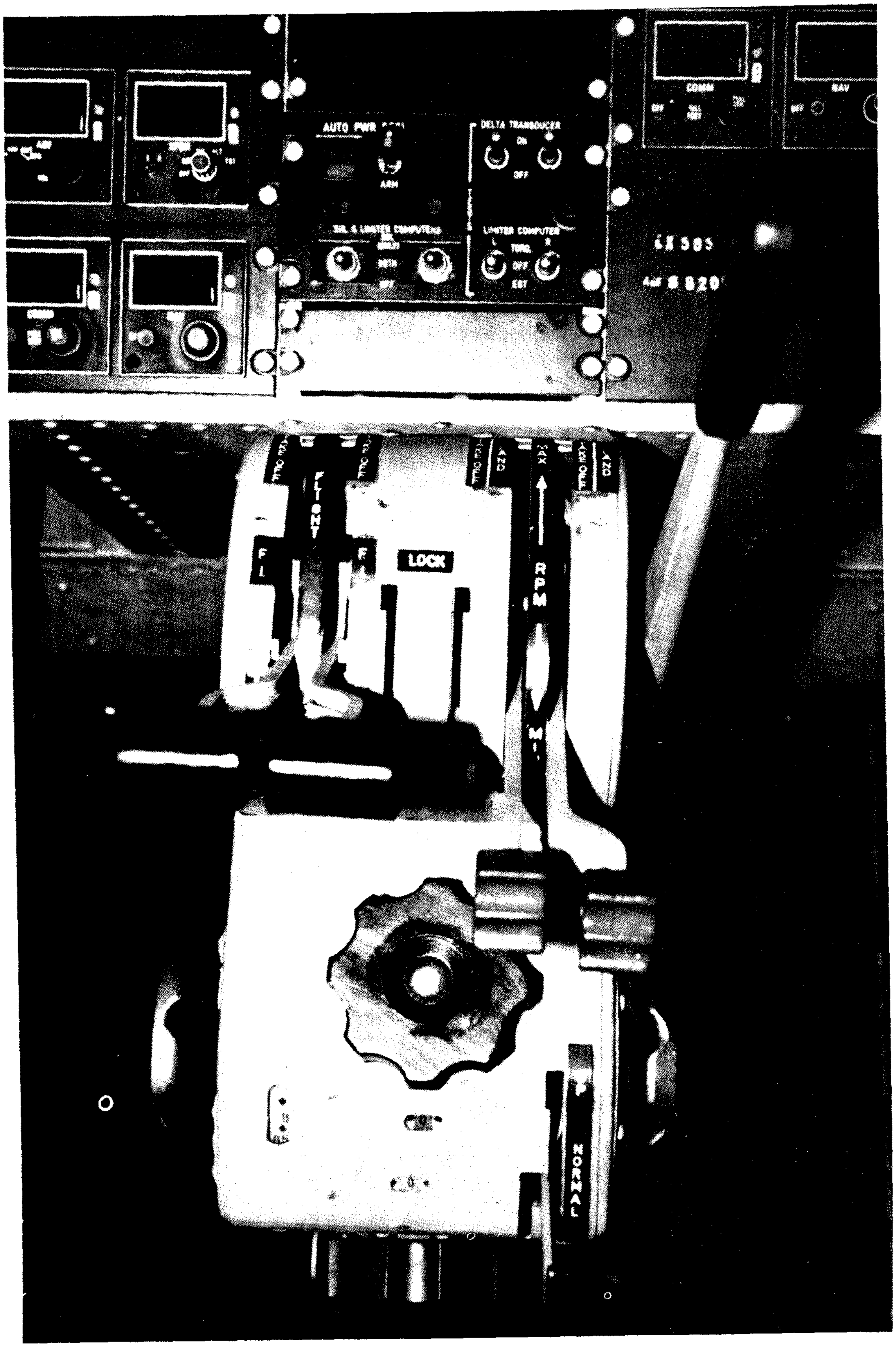


Figure 11.--Top view of PL quadrant.

- The beta latch mechanism was easy to move upward, requiring only finger movement. The latch had to move 1/2 inch, from full retraction to full extension, to clear the flight idle gate. It was noted that movement of the latches was more difficult if the PLs were against the flight idle gate than if they were at an intermediate position in front of the gate. This was attributed to the resistance of the latch plate against the gate.

- It was noted that the right PL latch tended to raise before the left latch when retarding both PLs and actuating the latch mechanisms from the intermediate and flight idle positions. This was attributed to the natural arm motion and tendency to bring the elbow closer to the body in an aft movement. The motion resulted in more pressure being applied to the outside of the aft movement resulting in more pressure to the right ring finger and thus, more pressure on the right latch arm. Also, since the ring finger is shorter, it appeared that it had more contact with, and more tension against the latch arm than the middle finger.

- When moving the PLs from the right seat, it was more difficult to actuate the latches because the PLs are further away. It required rotating the left hand forward in order to place the fingers underneath the latch arms.

1 .17.4 FAA Surveillance

On August 20, 1986, an FAA Certified Operator Performance Evaluation (COPE) was performed at Fischer Bros. The in-depth review of maintenance and operations procedures revealed that published procedures were not being followed, partly due to improper guidance and training and partly due to recordkeeping problems created by the computer record system newly instituted by the carrier. The COPE letter to the carrier stated, in part:

> While Fischer Bros. appears to operate safely flight equipment and are cognizant of importance of safety in air transportation, accomplishment with approved procedures and the means of establishing these procedures through appropriate channels is lacking. Upper management personnel is capable and dedicated, but due to personnel turnover and daily operational requirements, [they] are slowly approaching a burnout situation.

A total of 17 airworthiness discrepancies were noted in the COPE. They included problems with the minimum equipment list; the maintenance manual; the maintenance programs and inspections; operations specifications review; compliance with airworthiness directives; correlation of manuals and written procedures with actual work and inspections performed; the training program and recordkeeping; and cold weather operations. Generally, the deficiencies in some areas involved a failure to follow published procedures and a lack of guidance and training. For example, in the area of training, there was an apparent lack of flightcrew and mechanic knowledge about the use of minimum equipment list in determining airworthiness discrepancies and a lack of thorough guidance in the maintenance manual. Fischer Bros. responded to the discrepancies on December 19, 1986. Although many of the problem areas were eliminated when they stopped operating the Shorts SD360 (14 CFR Part 121), the carrier responded positively to the remaining discrepancies on January 23, 1987.

1.18 New Investigation Techniques

Experience has shown that the determination of propeller blade angles at ground impact can be useful in airplane performance considerations. However, this can be difficult when dealing with propellers that do not have "shim plates" in&led at the butt ends of the blades, like those installed in the Hamilton Standard propellers. Propellers produced by McCauley and Hartzell are examples of manufacturers that do not incorporate this feature. Therefore, accident investigators who must determine propeller blade angles at the time of ground impact will have difficulty with the McCauley and Hartzell propellers and will not in all cases be able to make a determination. Success in doing so depends on many variables and on the amount of confidence that can be placed on the distinction and correlation of "witness mark" evidence. The Safety Board was faced with this difficulty in investigating the Executive Air and the Fischer Bros. accidents and has experienced this problem with other investigations in the past. Fortunately, the consistency and the ability to correlate "witness mark" evidence with other associated data permitted the Board to arrive at such a determination in the Fischer Bros. accident.

2. ANALYSIS

2.1 General

The performance of the air traffic control (ATC) system did not contribute to the accident. The radar data showed that at the time NW530, the DC-9, was given its takeoff clearance, flight 2268 was about 2 miles from the runway threshold. ATC separation standards require that an aircraft be more than 6,000 feet down the runway on its take-off roll when an arriving aircraft crosses the threshold. In this case, the DC-9 had already lifted off and was in a left turn by the time flight 2268 crossed the threshold. Consequently, the ATC handled the flights properly and no wake turbulence or "jet blast" effects would have contributed to the accident.

The flightcrew was certificated and trained in accordance with the airline's approved training program. They were current and qualified to conduct the flight. The captain was a highly experienced pilot with over 3,000 hours in the CASA C-212. The first officer had much less flying experience, but enough to act as a second-in-command pilot. The airline's policy was to alternate flight legs between the two flightcrew members. Since it would have been the captain's turn to fly the leg from Cleveland to Romulus, and since the first officer made the radio calls during the flight from Cleveland and during the initial stages of the visual approach, the Safety Board concludes that the captain was probably flying the airplane at the time of the accident.

The flightcrew was medically qualified. Further anatomical examinations of the cardiovascular system of the captain by the AFIP disclosed no evidence in the captain of a myocardial fibrosis or necrosis, and no evidence of an acute event. Coworkers and family members did not report any physical or physiological problems related to the captain's performance. Consequently, the Safety Board concludes that the captain's performance was not adversely affected by his atherosclerotic condition.

Interviews from the flightcrew's coworkers revealed consistent positive reports on the first officer, but mixed reports on the captain's behavior and performance. On the one hand, the captain was reported as very experienced, thorough, competent, and conscientious. However, many of his reported actions as a senior command pilot with the company were contrary to some of the company's policies and procedures. He demonstrated an apparent disregard for safe operating practices in conducting visual approaches by an unorthodox practice of making steep approaches at high rates of descent where such approaches were unnecessary. This documented practice, induced by whatever motivation on the part of the captain, might explain the manner in which the approach was flown.

2.2 The Visual Approach

At the time of the accident, visual meteorological conditions prevailed at the airport. Control tower personnel statements revealed that the wind was calm to light, and there were no LLWAS alarms before or during the approach. Therefore, the Safety Board concludes that weather conditions were not a factor in the accident.

Flight 2268 was operating on an IFR flight plan and was handled routinely by the ARTCC in Cleveland. It was cruising at 7,000 feet when it contacted the AR-E controller at 1414:O0. The USAir DC-9 that flight 2268 was following was well ahead of it and any wake turbulence from the approach and landing DC-9 should not have been a factor. Flight 2268 was in level flight at 6,000 feet and about 160 KIAS on its northwesterly vector to the airport for about 4 minutes before receiving clearance to descend and maintain 3,000 feet. Based on the Safety Board's reconstruction of the airplane's flightpath from recorded radar data and of the airplane's known performance, the average rate of descent of the flight from 6,000 feet before level off at 3,000 feet was about 2,200 fpm.

The flight was at 4,200 feet descending on the downwind leg and past the runway 21 R threshold when it was told to expect a base turn in about 3 miles and that it was number one for landing on 21R. Thirty seconds later the flight was cleared for the visual approach almost abeam the outer marker for runway 21R, and it commenced a left descending turn immediately. The airspeed increased in the turn to 180 KIAS and the airplane did not proceed to the marker. Instead, it made a shortened base leg by making about a 30°-intercept angle to the runway 21 R extended centerline. Although it is not certain what the controller meant when he stated, "I'll need at just about the marker," the fact that he subsequently issued an unrestricted visual approach clearance could have been interpreted by the flightcrew to mean that there were no restrictions on the approach at that time. The rate of descent in the modified base leg was 1,000 fpm and the speed was 180 KIAS, decreasing to 150 KIAS as the airplane intercepted the extended runway centerline about 1,400 feet agl, 2.1 nautical miles (nmi) from the threshold and well above the glideslope.

When flight 2268 was 2.1 miles from the threshold, NW530 was cleared for takeoff. The flightcrew of flight 2268 would have seen the DC-9 taxiing onto the runway to begin its take-off roll. Had it appeared to them to be "slightly snug," as described by another Fischer Bros. pilot observing the approach from the ramp, the Safety Board believes that given the handling capabilities of the airplane, the captain had the time and airspace necessary to maneuver for more spacing. However, the manner in which the visual approach was flown as depicted by the radar data appears consistent with reports that the captain flew the CASA 212 "sportier" than the other company pilots and that he had his own method and philosophy about flying into Romulus. In addition, because of noise abatement considerations at Romulus, ATC keeps airplanes relatively high when they are close to the airport before allowing them to descend and land. It is this high, close-in situation that Fischer Bros.' pilots commonly referred to as the unpressurized "slam dunk" maneuver as it applied to their operation. In addition, the company's gate area was close to the threshold of runway 21R. These conditions may explain part of the reason why the captain of flight 2268 flew a steeper approach than other company pilots.

The aircraft performance study showed that about 25 seconds after NW530 was cleared into position on the runway, flight 2268's power was at idle, and it remained there until about 25 seconds before the loss of control. At a point about 3/4 nmi from the threshold, at an airspeed of 150 KIAS, and initially at a rate of descent of about 1,000 fpm, the data showed a marked rate of deceleration of the airplane followed by a level-off for about 10 seconds, after which the rate of descent increased sharply. Such a deceleration rate was calculated to require up to about 3,000 pounds of negative thrust, based on performance calculations and flight test data. This deceleration could only have been achieved through negative thrust produced by the propellers operating in the beta mode.

2.3 The Loss of Control

The Safety Board believes that the evidence shows that the pilot flew an unstabilized visual approach and that he used the beta mode in flight to decelerate the airplane rapidly. This technique was not authorized by Fischer Bros. Factors that the Safety Board believes would have led the captain to use the negative thrust available in the beta mode on this approach were the speed of the airplane, the shortened base leg approach, the location of the departing DC-9, his tendency to use this technique occasionally to make short field landings, and possibly his desire to make up for the delay in the arrival time. Also, since the airspeed was high, the captain did not have the benefit of the increased drag that the flaps could have provided because the speed was above that which would allow use of the maximum extension of the flaps (135 KIAS). Another factor which could have influenced the pilot to use the beta mode was the higher-than-normal flight idle fuel flow settings.

The Safety Board noted that the captain was about to leave the carrier to fly for another commuter airline, that there was a contract dispute between Fischer Bros. and Northwest Airlines, and that there was competition between Fischer Bros. and Simmons Airlines. Although these circumstances could have played a role in the manner in which the captain flew the approach, the evidence is inconclusive. Furthermore, since flight 2268 was already number one to land and ahead of Simmons flight 2789, the Board cannot conclude that the presence of the Simmons flight was a factor in the captain's decision to make a fast and steep approach.

Witness statements also support the conclusion that the captain selected the beta mode in flight. Some witnesses, both in the airplane and on the ground, reported hearing unusual engines sounds immediately before control of the airplane was lost. Many of the witnesses reported that the airplane appeared high on final approach, and some stated that it also appeared to level off on short final. Subsequently, some witnesses observed the airplane make a slight right bank before it banked sharply to the left. The right and left banking could have occurred when the captain encountered lateral and directional control problems from asymmetric power between the engines which can easily occur when operating in the beta mode because of differences in PL rigging and fuel control unit operation or because of differing propeller recovery rates when the PLs are returned to the flight idle gate. The Safety Board noted that the accident airplane had a difference in PL "stagger," which could have contributed to the asymmetric condition. Furthermore, the Safety Board believes that the absence of the complete feathering spring assemblies in the propellers could have delayed the ability of the propellers to achieve increased blade angles following operation below the flight idle regime.

Moving the PLs behind the flight idle stop and into the beta mode would have produced significant deceleration, propeller cyclic noise, stickfree nosedown pitch (which is correctable), and potentially high rates of descent. The CASA approved flight manual (AFM) contained this warning, "Power lever must not be retarded aft of F.I. [flight idle] when in flight. Excessive drag may result." However, the Safety Board noted that the design of the beta latch mechanism on the PLs permits use of the beta mode in flight. Therefore, based on the foregoing circumstances, the Safety Board believes the captain placed the PLs into the beta mode to slow the airplane rapidly while continuing the descent to land. This produced a significant asymmetric power condition and control difficulty from which the pilot could not recover given the low altitude of the event.

The Safety Board considered two other factors which could have contributed to the loss of control: a stall or a malfunction in the flap system. The FAA flight test pilots and other pilots who flew the C-212 noted that the natural aerodynamic warning of a stall in the airplane was insufficient. What little inherent warning existed could have been masked by noises and vibrations generated during operation in the beta mode. Furthermore, the flaps were extended only 25 percent at ground impact instead of the normal 37.5 percent used for landing. Considering the service difficulty history in the flap system experienced by Executive Air and Chaparral Airlines, it is possible that the flaps bled up during the approach. However, there was no evidence to support a significant degree of uncommanded flap retraction. It is possible that the flaps could have also been mis-set or reset to 25 percent in an attempt by the pilot to execute a go-around maneuver to recover control of the airplane. Although these factors could have possibly contributed to the accident, the Safety Board concludes that the evidence demonstrates that the high rate of deceleration associated with the use of the beta mode in flight was the predominant cause of the loss of control. Therefore, in the Safety Board's opinion, a stall warning device probably would not have alerted the pilot in sufficient time to prevent the accident.

The Safety Board also recognized that inadvertent selection of the beta mode in flight is possible based on its examination of the beta latch mechanism in the C-212 and the views expressed by some pilots. However, line pilot opinions varied on this question, and the operational history of the airplane revealed that this was a remote occurrence. The design of the beta latch mechanism in the C-212 is not unlike the designs incorporated into other turbopropeller airplanes. Federal regulation governing the design criteria, 14 CFR 25. 1155, states:

> Each control for reverse thrust and for propeller pitch settings below the flight regime must have means to prevent its inadvertent operation. The means must

> have a positive lock or stop at the flight idle position and must require a separate and distinct operation by the crew to displace the control from the flight regime.

Although the rule requires that inadvertent operation of the propeller pitch control below the flight regime be prevented, the rule relies on a positive lock or stop plus a separate and distinct operation. However, the rule is subjective because it is dependent on the degree of separate and distinct movement that prevents its inadvertent operation. Further, the rule does not provide for a positive means of preventing the in-flight selection of propeller pitch settings below the flight regime of propeller operation when such settings are prohibited by the FAA-AFM.

The Safety Board's evaluation of the beta latch mechanism on the C-212 in conjunction with the service history of the airplane indicates that the design meets the provisions of the current rule, but it is not foolproof. That is, if the pilot is not aware and conscious of how easy it is to retract the beta latch mechansim (arm and finger movements must be coordinated to prevent retraction of the beta latch arm) during movement of the PLs, inadvertent retraction of the latch arm could occur concurrently with movement of the PLs toward the flight idle position. Consequently, pilots must consciously avoid positioning their fingers on the beta latch arms during aft movement of the PLs to the flight idle position; otherwise, inadvertent movement of the PLs into the beta mode is possible.

For those airplanes certificated under the current rule, if in-flight selection of propeller pitch below the flight regime is prohibited, the Safety Board believes that provisions for certain operational reinforcements should have been an integral part of the type certification process. For instance, proper operation of the beta latch mechanism, proper use of the PLs to avoid making a mistake in selecting the beta mode in flight, and the use of crew coordination as a backup against making such a mistake should be items emphasized in training. Certainly, caution against using the beta mode in flight and the hazards associated with it should be emphasized to instill an awareness of the danger and the proper discipline in using the PLs and to foster the proper habit-pattern development. The air carrier in this case was responsible for ensuring that its pilots adhere to the limitations in the airplane as outlined in the AFM. Any deviations from those limitations, particularly in a critical flight regime, should not have been tolerated. The fact that one of the carrier's pilots attempted, with passengers on board, to find out how the airplane would react in flight while in the beta mode may be an indication that these operational reinforcements were not emphasized.

With regard to the future application of 14 CFR 25.1155 (and 14 CFR 23.1155), the Safety Board believes that from a human engineering perspective, a means to prevent inadvertent operation of a critical control should be positive or foolproof. That is, the designer should provide either a separate control that requires a deliberate act on the part of the pilot to select, under certain conditions, a function that is prohibited or an interlock mechanism that will automatically prevent the selection of a prohibited function except when the correct conditions have been established. Therefore, in airplanes where selection of propeller pitch settings below the flight regime of propeller operation is to be prohibited, the Safety Board believes that a positive means to prevent this from happening, such as incorporating an additional control or an air-ground interlock mechanism that prevents removal of the flight low pitch stops during flight should be required. Consequently, the Safety Board believes that 14 CFR 25.1155 (and 14 CFR 23.1155) should be revised accordingly.

Although, according to the manufacturer, the beta light was not designed to operate in flight to alert the pilot, the Safety Board found in its investigation that the beta light should alert the pilot of his selection of the beta mode in flight. Furthermore, the Board believes that a pilot would be alerted if the beta mode was selected inadvertently. Flight tests showed that with the PLs behind the flight idle gate, the torque readings went to 0, there was a sound of propeller cyclic noise, and the airplane pitched down. These characteristics would obviously alert the pilot once the beta mode has been selected. Such an event occurred previously to one of the carrier's flightcrew. Therefore, the Board believes that inadvertent selection of the beta mode would not go unnoticed by the pilot.

2.5 Aircraft Maintenance

Although the airplane was found to have been maintained in accordance with the airline's approved maintenance program and no evidence was found of a component or system failure, three areas concerning the airplane's performance and airworthiness do deserve comment.

The first maintenance area pertains to the last flight idle descent check. The results of this check showed that the minimum torque readings were 7 to 8 percent more than desired and that the fuel flows were 35 to 40 pph more than recommended by the manufacturer. During the postmaintenance flight test, the high fuel flows caused a rate of descent of 250 fpm less than recommended by the manufacturer. Although these differences do not appear significant, improper setting of flight idle fuel flows would result in a slightly faster approach speed and would cause the airplane to float during the landing transition. This situation would also result in faster taxi speeds, thereby creating the need to frequently use the brakes or the beta mode to control the taxi speed. Higher fuel flow settings could also lead to an insidious problem of pilots "inching" the PLs into the beta mode in flight. The Safety Board was not able to determine if the flight idle blade angles were set properly. The fact that the carrier was documenting flight idle descent checks indicated that it was attempting to follow prescribed maintenance procedures. Although achieving proper adjustments of flight idle blade angles and fuel flows can be tedious and time consuming, correct settings are critical to maintaining the proper performance and landing characteristics of the airplane.

The second maintenance area of concern pertains to the flap system. Although there was no recorded history of recurring flap system difficulties experienced by Fischer Bros. and no pilot reports of a similar nature, the Safety Board later examined the components of the flap system in light of the experiences reported by two other carriers. The only discrepancy found associated with the flap system in N160FB was damaged and broken restrictor valve filter screens. The pressure relief valve installed operated within specified limits. Although the Board did not determine the reason for the broken screens, it believes the failures could have been the result of an overpressure condition, the use of inadequate material, or a material failure of some kind. It was not caused by postaccident events. The contamination found in the flap actuator probably came from the broken filter screens. Although contamination could be a significant finding, no particles were found in the four-way selector valve assembly that could lead to unseating of a valve port, a loss of pressure, and an uncommanded flap problem.

The third maintenance area pertains to installation of the incorrect feathering spring assemblies in the propellers. The Safety Boards regards the installation of incorrect parts as a serious problem, and evidently, this was not an isolated case. Although the carrier reported that previous reports of propellers sticking in the reverse mode were restricted to "several isolated incidents," the fact remains that the propeller manufacturer incorporated the additional feathering spring to remedy this condition on landing. In view of the purpose of the additional feathering spring, the Board concludes that the incorrect feathering spring assemblies could have delayed movement of the propeller blades to higher angles during flight as well as on the ground because of the lower power of the single spring needed to counteract the increased in-flight air loads of the larger composite blade propeller. However, the degree to which the propellers' recovery could have been delayed could not be determined. Since the feathering spring assembly is inaccessible for inspection once it is installed, the carrier's maintenance department had no way of determining that the incorrect parts were installed. The Board attributed the failure of the propeller manufacturer's service facility to install the correct parts to an oversight on the part of an assembly worker and a failure of management to establish a sound quality control system to identify and verify the correct parts for use with replacement assemblies. The weakness in the repair station's quality control system should have been discovered in FAA's certification and surveillance of the facility.

2.6 Survivability

Based on the attitude of the airplane at the time of ground impact and the amount of crush to the airframe, the Safety Board determined that the vertical acceleration, with respect to the earth axis, ranged from 12 to 21 Gs during initial collision with the ground. This resulted in an acceleration range of 8.2 to 14.3 Gs along the airplane's longitudinal axis and a range of 8.8 to 15.4 Gs along the lateral axis of the airplane.

In examining the passenger seats, the Safety Board determined that double seat 1-BC became completely dislodged because of elastic deformation of the seat tracks and seat attachment damage associated with the asymmetrical loading by the single occupant in the seat. The seat was also exposed to greater impact forces because of its proximity to the crush line of the fuselage. Although there was no evidence of any blunt force traumatic injury to the occupant of the seat, the complete separation could have contributed to the passenger's disorientation.

The Safety Board could not find physical evidence to determine why seat 4-A became dislodged. Also, there was no evidence of traumatic injury to its occupant.

Seats 5-BC and 6-BC were detached from the floor tracks, but remained secured to the side wall attachments. Since there was no apparent damage to the attachment fittings and they were only displaced 8 inches downward, the Safety Board concludes that they were not occupied.

Examination of the interior configuration of the C-212 showed areas of noncompliance with 14CFR Part 25. The folding flight attendant seat would have obstructed the pathway to the left front emergency exit had it not been retracted. Had the airplane not come to rest inverted, the seat may have remained extended as a result of impact forces.

Although surviving passengers did not remark about having difficulty with the main cabin entry door stairs, the door opened during the impact sequence, and the stairs apparently did not obstruct the passengers' evacuation. However, since the stairs were found to also obstruct the view and use of the door handle, the Safety Board believes that the stairs could present a problem in an evacuation. Therefore, the Board encourages the FAA to review this installation.

Finally, the single front row seat on the left side of the cabin was not positioned far enough away from the galley/electronics compartment. The seat's neutral reference point should have been 35 inches from the compartment to provide injury-free head clearance in the event of a minor crash. However, the compartment had been installed in front of the seat under the FAA's STC and the installation provided only 28 inches clearance which was well within the envelope where serious head injury could result. This deficiency indicated that the FAA's STC had been granted without careful consideration of all the applicable regulations that enhance occupant safety, protection, and survival. Further, subsequent FAA cabin surveillance and inspections failed to detect this deficiency in the accident airplane.

Seven passengers and the two pilots died from inhalation of smoke and toxic fumes including cyanide, and with the possible exception of the first officer, none of these persons had sustained blunt force traumatic injuries that would have prevented them from escaping from the airplane. The conditions inside the inverted cabin rapidly deteriorated due to smoke and fire. The Safety Board believes that nonsurviving passengers became disoriented and were unable to escape before being overcome by the smoke and fire.

The Safety Board noted that, according to those who had flown with the captain, he did not use the shoulder harness. This was also reported about the captain in an accident involving another CASA C-212-CC, flown by Executive Air Charter Inc., at Mayaguez, Puerto Rico, about 2 months later. Both pilots were small. The captain in the Fischer Bros. accident was 5 feet 5 inches and weighed

140 pounds, and the captain in the Executive Air accident was 5 feet 4 inches and weighed 155 pounds. Since the shoulder harness restricted movement and did not always retract properly, the Safety Board believes the harness probably would have been more of a nuisance for these two captains than for larger pilots. However, it was noted that other pilots also had difficulty with the harness. It could not be determined from the physical evidence if the first officer in the Fischer Bros. accident used his shoulder harness. The 2-inch contusion on his right temple could have been the result of a flailing type injury that probably would not occur with a securely fastened shoulder harness and lap belt. Consequently, the Safety Board believes that the pilots' failure to use the shoulder harness in the CASA C-212, especially smaller pilots, have been more widespread than reported. Therefore, the Safety Board believes the FAA should inspect these harness installations in the C-212 to verify that it conforms with accepted anthropomorphic criteria of intended users.

Seat cushion fire blocking is a method used to encapsulate cushions inside a fire resistant material to delay the decomposition, outgassing, and combustion of cushion material thereby extending the critical time available for airplane occupants to escape. The fire blocking requirements became effective under 14 CFR 25.853(c), 121.312(b), and 135.169(a) on November 26, 1984, with a 3-year period for compliance. In this accident, fire-blocking materials had not been installed on the seat cushions, and the seat cushions in the rear of the cabin were completely consumed by the fire and released large amounts of toxic fumes and smoke into the entire cabin. Although it is not possible to conclude precisely how effective fire-blocking material may have been in reducing toxic fumes and smoke in this accident, research has demonstrated that fire-blocking materials that meet FAA requirements increase the time available for occupants to escape before the seat cushions begin to outgas toxic fumes and begin to burn and produce dense smoke. Nonetheless, the Safety Board believes that fire-blocking material might have been a benefit in this accident and that lives might have been saved had it been installed.

The Safety Board noted that there are no comparable regulations to require fire-blocking material for commuter type airplanes that are certificated under 14 CFR Part 21 and SFAR 41 or for new commuter airplane category in 14 CFR Part 23. For example, commuter airplanes that operate under 14 CFR Part 135 are not required to have fire-blocking material unless it is required by the airworthiness rules under which the airplane is type certificated. Fischer Bros. operated both 14 CFR Part 21 and SFAR 41 airplanes (the 19-passenger Dornier 228) as well as airplanes certificated under 14 CFR Part 25 (22-passenger CASA C-212-CC). Fire-blocking material would have been required on the CASA after November 26, 1987, but not on the Dornier 228.

This accident is an example of commuter airplane accidents in which fire-blocking material would have provided protection during a fire. The Safety Board believes that the FAA should require fire-blocking material on all commuter airplanes to provide comparable levels of fire protection to passengers and crew on board these airplanes when operated by commercial air carriers.

2.7 Airworthiness

Although very limited in scope, the Safety Board, in a review of the bilateral certification process, did not find reason for concern about the overall approach and intent of BAAs. The Safety Board noted that a system to eliminate a duplication of aircraft certification is worthwhile in view of the costs, time, and resources involved. However, some weaknesses do exist in the system that require careful implementation. For example, when the FAA performs its technical evaluation of an exporting country's airworthiness certification authority and aircraft manufacturing capability, the review forms the basis of the BAA between two countries. The Board, therefore, believes that the technical review process should have close scrutiny by the FAA and the DOT. The FAA does have the authority to withhold a type certificate and an airworthiness certificate by verifying that the aircraft conforms to the type design standards. In other words, the FAA does not have to "rubber stamp" its approval of a foreign manufactured aircraft because of an existing BAA. On the contrary, if the FAA finds that the design does not meet U.S. airworthiness standards and does not conform to the approved design, then a certificate can be withheld. On the other hand, the FAA can accept the exporting country's certification that the aircraft meets the U.S. requirements.

The Safety Board believes that it was evident that many of the airworthiness issues and resolution difficulties that occurred were not necessarily unique to the C-212. Several other type certification problems have also been encountered with other types of aircraft. Most aircraft have their share of airworthiness problems which are eventually corrected during their service life through manufacturer SBs and ADs. In this case, technical problems were not new and could have been anticipated and corrected in the early stages of the airplane's development. In some areas, the FAA did not identify problems early enough in the certification process of the civil version of the C-212. It is apparent that in regard to the model CC, which was certificated 3 years after the CB model, the FAA did a minimal evaluation. Considering the significant changes made to the model CC over the original CB model, the Safety Board believes that the FAA should have conducted a flight test evaluation of the CC model airplane.

Many of the difficulties that arose during the certification of the model CC were due primarily to the inability of the FAA at the time to manage effectively its participation in the bilateral certification program. For instance, the Board noted that while the CC model was being developed, there were no flight test pilots or engineers on the staff of the Brussels office, and there were many changes in FAA personnel assigned to the CASA project. Also, the FAA underwent a reorganization of its airworthiness departments which consequently led to a transfer of responsibility for the C-212 program from the Brussels office to its Northwest Mountain Regional Office in Seattle, Washington. This inevitably interrupted the continuity in FAA's review of the C-212, and it detracted from effective managment of the program.

For example, the first sign of reported noncompliance in the design of the C-212 was reported by the Cleveland GADO in September 1980 to the FAA's Office of Airworthiness. However, the FAA did not issue an AD to correct the problems for nearly 3 1/2 years. In view of the Safety Board's findings, FAA action to correct problems with the doors and exits of the model CC was incomplete, and its monitoring of this issue was inadequate. This issue also indicated that in the STC approval process with respect to the main cabin door stairs, FAA did not make an accurate assessment. Additionally, the STC approval of the galley/electronics compartment installation did not comply with Federal rules. There was an apparent lack of standardization and coordination, and field office certification and surveillance was incomplete. Although the Cleveland GADO did identify one of the noncompliance items found by the Board, its correction was apparently later overlooked by engineering personnel, and an AD was not issued to correct the installation discrepancy.

In addition, the March 1984 flight test evaluation disclosed several deficient areas that required followup, but some of these areas received no corrective action. Two of the deficiencies, the inadequate stall warning and the flap position integrity, were proven to be accurate evaluations of potential difficulties and were supported by expert evaluation and service difficulty history 3 years later. The Safety Board believes that, after being apprised of these deficiencies in 1980 and 1984, it would have been prudent for the FAA to have withheld issuance of U.S. type certificates for the CASA models C-212-CD, CE, and CF until the problems were resolved. As a result, resolution of the problems were delayed and three possible noncompliance airworthiness issues remained unresolved at the time of the Fischer Bros. accident. The Board believes that these problems could have been prevented by close monitoring and active participation in the overall type certification project by the FAA.

The history of the type certification of the CASA C-212 raises some doubt about the FAA's management of bilateral type certification projects. It appears that more FAA resources are devoted to foreign-manufactured aircraft of greater complexity than to aircraft in the commuter air carrier class. However, given the growth of the U.S. commuter airline industry with its demand for suitable aircraft and the efforts of foreign manufacturers to fulfill this demand, the Safety Board believes that such aircraft must be given the evaluation scrutiny they deserve. The Board recognized the FAA had made changes and improvements in its engineering and operations organizations to provide better monitoring and followup on foreign type certification projects. However, several noncompliance problems remained unresolved after the FAA's changes and improvements had been put into place.

Accordingly, questions remain about management capabilities and about the availability and allocation of resources devoted to such projects by the FAA. Since the demands of the U.S. aircraft industry occupy the majority of FAA's type certification and continuous airworthiness attention, the increase in foreign aircraft certification activity appears to have placed a less manageable burden on FAA resources. The Safety Board is aware that as a result of the CASA C-212-CC accidents in Romulus, Michigan, and Mayaguez, Puerto Rico, and some other occurrences, the FAA has conducted an in-house review of its bilateral certification program. However, a report on the review has not yet been made available to the Board. Further, the Board has not been made aware of any corrective actions taken as a result of the in-house review. Therefore, the Board believes that the FAA should complete its report on the bilateral certification review, along with any corrective actions taken or contemplated, and make it available as soon as possible.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was certificated and qualified in accordance with appropriate Federal regulations at the time of the accident.

2. The captain was an experienced CASA C-212 pilot with 3,144 hours in type, and the first officer was a less experienced C-212 pilot with 282 hours in type.

3. The carrier's maintenance and inspection of the airplane were performed in accordance with its approved maintenance program.

4. The propellers were equipped with the incorrect feathering spring assemblies during overhaul by the propeller manufacturer's service facility.

5. The propeller manufacturer's service facility installed the incorrect assemblies as a result of oversight on the part of an assembler and a failure of company management to establish a sound quality control system.

6. The air traffic controllers involved in providing service to the flight were qualified for the positions they were operating, and their actions were not a factor in the accident.

7. The airport facilities, personnel, and navigational aids involved operated normally and were not factors in the accident.

8. The weather was not a factor in the accident.

9. The captain's visual approach to runway 21 R was steep and fast.

10. The higher-than-normal fuel flow settings contributed to the speed of the airplane on the visual approach.

11. The presence of the Northwest Airlines flight 530, DC-9, departing on runway 21R had a bearing on the captain's decision to slow down rapidly.

12. The captain intentionally placed the power levers in the beta mode to slow the airplane rapidly while on final approach and to make a short field landing on runway 21 R.

13. The design of the power lever beta latch mechanisms permitted use of the beta mode in flight.

14. The captain lost control of the airplane as a result of operating the propellers in the beta mode at an altitude too low for a successful recovery.

15. The airplane struck the ground in a right wing down nose-down attitude and rolled over to an inverted position before coming to rest.

16. The impact forces were survivable.

17. The captain and the seven passengers did not sustain debilitating traumatic blunt force injuries which would have prevented their escape. They died of smoke inhalation and burns from the postcrash fire; the first officer may have sustained an injury which prevented his escape.

18. The front row single seat on the left side did not have adequate head (swing) clearance from the galley/electronics compartment.

19. The outboard armrest on seat 8C protruded into the projected opening of the Class III emergency exit on the right side of the airplane which is contrary to Federal regulation.

20. The hinged stairs mounted inside the main entry door could interfere with the operation and use of the door as an emergency exit which is contrary to Federal regulation.

21. The fire blocking of seat cushions could have reduced the smoke and toxic fumes produced during the early part of the evacuation.

22. The bilateral type certification project of the CASA C-212 was not managed effectively by the FAA. The reorganizational changes, personnel changes, and the limited availability of resources in the engineering and operations departments of the FAA are contributing factors.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the captain's inability to control the airplane in an attempt to recover from an asymmetric power condition at low speed following his intentional use of the beta mode of propeller operation to descend and slow the airplane rapidly on final approach for landing. Factors that contibuted to the accident were an unstabilized visual approach, the presence of a departing DC-9 on the runway, the desire to make a short field landing, and the higher-than-normal flight idle fuel flow settings of both engines. The lack of fire-blocking material in passenger seat cushions contributed to the severity of the injuries.

4. RECOMMENDATIONS

As a result of this investigation, on March 31, 1987, the Safety Board issued Safety Recommendations A-87-27 and -28 to the FAA:

A-87-27

Issue a general notice (GENOT) immediately to all United States owners and operators of the CASA C-212 airplane describing the background and significant findings of the recent flight test of the CASA C-212. The notice should provide an evaluation of the existing CASA C-212 stall characteristics, operational precautions, and training procedures to preclude inadvertent stalls until an approved artificial stall warning system is installed.

A-87-28

Expedite the rulemaking action to require installation of an artificial stall warning system on the CASA C-21 2 airplanes.

On June 16, 1987, the FAA responded to these recommendations stating that for Safety Recommendation A-87-27, the FAA had issued a GENOT to all flight standards field offices addressing the flight characteristics of the CASA 212 aircraft. Based on this response, Safety Recommendation A-87-27 was classified "Open--Acceptable Action" pending a final rule.

Also in the FAA's June 16, 1987 letter, it was stated that in response to Safety Recommendation A-87-28, the FAA had issued an NPRM (Docket No. 87-NM-38-AD) requiring installation of an artificial stall warning system. Based on this response, Safety Recommendation A-87-28 was classified "Open--Acceptable Action" pending a final rule.

On October 19, 1987, the FAA notified the Safety Board that an AD based on the NPRM mentioned above was issued with an effective date of August 31, 1987. Based on this AD, Safety Recommendation A-87-28 was classified "Closed- -Acceptable Action" on December 10, 1987.

As a result of this investigation and of the Executive Air Charter accident, the Safety Board recommended to the FAA:

Correct any deficiencies in compliance with Title 14 Code of Federal Regulations 25.813 regarding the installation of passenger seats adjacent to Type II and III exits in CASA C-212 airplanes with 19 seats or less. (Class II, Priority Action) (A-88-92)

Remedy the deficiencies in compliance with Title 14 Code of Federal Regulations 25.809, .811, and .813 of the supplemental type certificate for the CASA C-212-CC main door regarding accessibility to door controls during emergency conditions. (Class II, Priority Action) (A-88-93)

Require in accordance with Title 14 Code of Federal Regulations 25.785(c) adequate head clearance between passenger seats and bulkheads/partitions installed in CASA C-212 airplanes. (Class II, Priority Action) (A-88-94)

Inspect flightcrew restraints in CASA C-212 airplanes to verify the adequacy of operation, convenience, and comfort based on anthropomorphic criteria, and take appropriate remedial action. (Class II, Priority Action) (A-88-95)

Require fire-blocking materials on all passenger and crew seats on Title 14 Code of Federal Regulations 21, Special Federal Aviation Regulation No. 41, and 14 Code of Federal Regulations Part 23 commuter category airplanes that are operated under Title 14 Code of Federal Regulations Part 135. (Class II, Priority Action) (A-88-96)

Conduct a special surveillance inspection of approved Hartzell Propeller overhaul facilities and of other propeller manufacturer overhaul facilities as service difficulty historical data and experience dictate to determine that the proper quality control organization and procedures are in place and are being followed. (Class II, Priority Action) (A-88-97)

Alert all principal operations and maintenance inspectors to emphasize in their surveillance of operators of turbopropeller airplanes the need to adhere to prescribed manufacturer instructions in maintaining flight idle blade angles and to emphasize to operators the criticalness of maintaining them properly. (Class II, Priority Action) (A-88-98)

Reissue to operations and maintenance inspectors Federal Aviation Administration Notice N8320.301 of September 17, 1984, prompted by Safety Board Recommendation A-84-l 5. (Class II, Priority Action) (A-88-99)

Complete as soon as possible and make the findings available to the Safety Board the report on the in-house review of the bilateral aircraft type certification program and the corrective actions taken or contemplated as a result of the review. (Class II, Priority Action) (A-88-l 00)

Amend Title 14 Code of Federal Regulations 23.207 and 25.207 to require a stall warning device and eliminate the use of "inherent aerodynamic qualities" (aerodynamic buffeting) as a stall warning. Class II, Priority Action) A-88-101)

Amend Title 14 Code of Federal Regulations Parts 121 and 135 to require a stall warning device on those airplanes that currently use "inherent aerodynamic qualities" (aerodynamic buffeting) as a stall warning. (Class II, Priority Action) (A-88-102)

Require the aircraft evaluation group during the type certification process of turbopropeller airplanes to review carefully the design of propeller pitch controls in order to identify and establish appropriate fightcrew training guidelines and emphasis on the proper use of these controls to prevent inadvertent operation in the beta mode in flight where prohibited by the airplane manufacturer. (Class II, Priority Action) (A-88-l 03)

Require the principal operations inspectors for operators of turbopropeller airplanes to review carefully flightcrew training programs to verify that appropriate information is provided by the operators on the proper use of propeller pitch controls to prevent inadvertent operation in the beta mode in flight. (Class II, Priority Action) (A-88-104)

Amend Title 14 Code of Federal Regulations 25.1155 and 23.1155 to provide for a positive means to prevent inadvertent operation of the propellers at blade pitch settings below the flight regime in those airplanes where such operation of the propellers is prohibited. (Class II, Priority Action) (A-88-105)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES L. KOLSTAD
Acting Chairman

/s/ JIM BURNETT
Member

/s/ JOHN K. LAUBER
Member

/s/ JOSEPH T. NALL
Member

/s/ LEMOINE V. DICKINSON, JR
Member

September 14.1987

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident at 1515 on March 4, 1987. An investigation team was dispatched from Washington, D.C., the same day and arrived on scene later that evening. An organizational meeting was held the next day and investigative groups were formed for operations, air traffic control, witnesses, survival factors, structures, systems, and powerplants.

Parties to the investigation were the Federal Aviation Administration, the Spanish director general of Civil Aviation, Fischer Bros. Aviation, Inc., Construcciones Aeronauticas, S.A. (CASA), Garrett Turbine Engine Company, Hartzell Propeller Products, and the Detroit Metropolitan Wayne County Airport.

2. Public Hearing

The Safety Board did not hold a public hearing on this accident.

APPENDIX B

PERSONNEL INFORMATION

David W. Sherer

Captain David W. Sherer, 45, was employed by Fischer Bros. Aviation, Inc., in March 1970. He held Airline Transport Pilot certificate No. 1504125 issued on August 18, 1983, with an airplane multiengine land rating and type ratings in the CASA C- 212 and the Shorts 360. His also held commercial privilages for airplane single-engine land. He also held a flight instructor certificate issued February 13, 1964, which was no longer current, and an airframe and powerplant certificate issued on May 3, 1965. He received his initial type rating in the C-212 on September 6, 1980, and was designated a line check airman on April 25, 1984. His last proficiency check was completed on January 28, 1987, and his recurrent training was completed on February 21, 1987.

Captain Sherer held a first-class medical certificate issued on October 17, 1986, with the limitation that he wear corrective lenses for near vision. He was 5 feet 5 inches and weighed 140 pounds.

Captain Sherer had accumulated about 293 hours of flight time in the last 90 days, 101 hours in the last 30 days, and 3.5 hours in the last 24 hours up to the time of the accident. At the time of the accident, he had accumulated about 17,953 hours of total flight time, of which about 3,144 hours were in the C-212. He had been off duty about 24 hours when he reported for duty on March 4. He had accumulated 1.5 hours of flight time on the day of the accident.

Captain Sherer had been offered and accepted employment as a chief pilot for another commuter air carrier. He was due to report for duty on March 16, 1987.

Shawn D. Manningham

First Officer Shawn D. Manningham, 26, was employed by Fischer Bros. Aviation, Inc., in July 1986. He held a commercial pilot certificate No. 48661071, issued July 30, 1985, with an airplane single- and multiengine land ratings and an instrument rating. He also held a flight instructor certificate issued March 20, 1986, with the same ratings listed on his commercial certificate. He received his initial training in the CASA C-212 from August 25 to 27. He completed his proficiency check satisfactorily on August 28, 1986.

First Officer Manningham held a first-class medical certificate with no limitations issued on December 11, 1986.

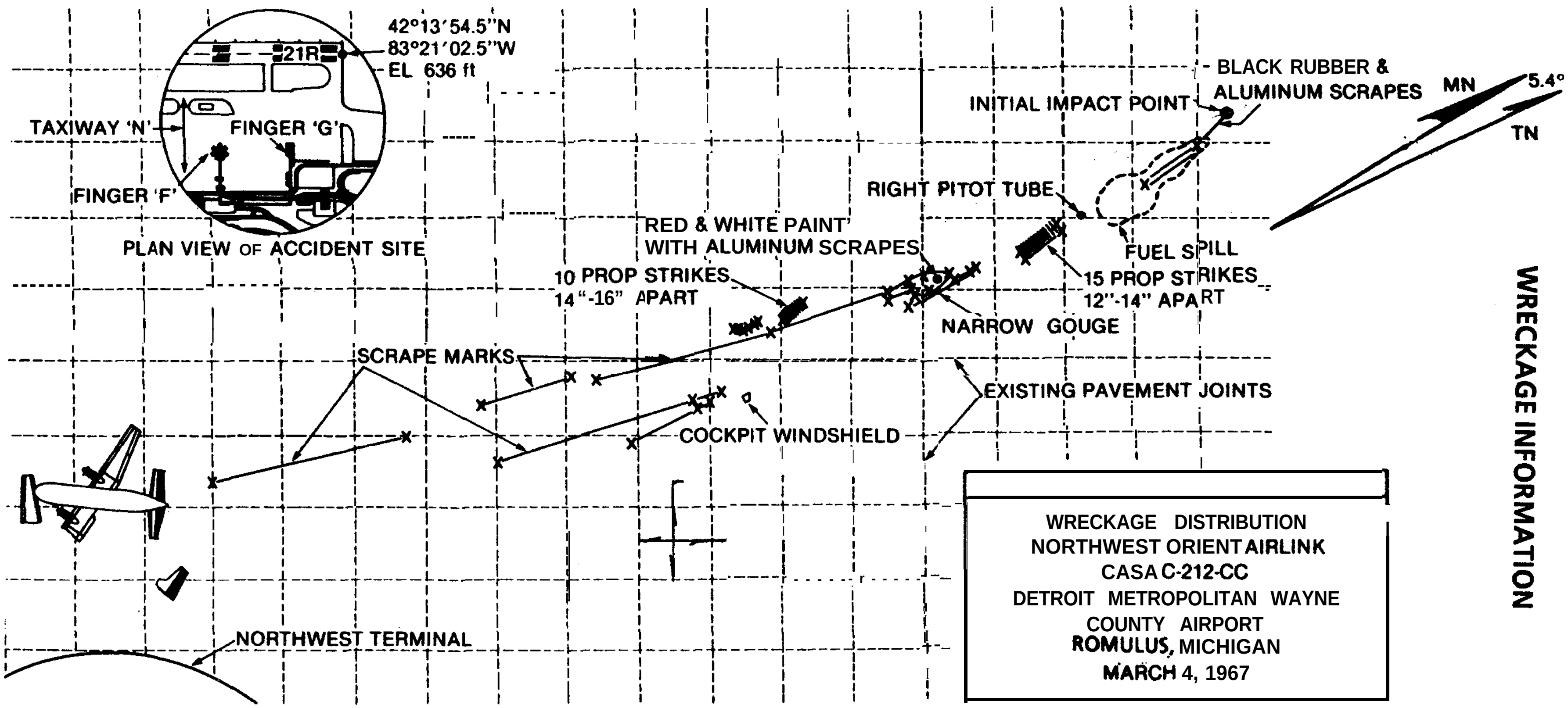
First Officer Manningham had accumulated about 242 hours of flight time in the last 90 days, 66 hours in the last 30 days, and 3.5 hours in the last 24 hours up to the time of the accident. At the time of the accident, he had accumulated a total flight time of about 1,593 hours. He had been off duty about 24 hours when he reported for duty and also logged 1.5 hours on the day of the accident.

APPENDIX C

AIRCRAFT INFORMATION

The Construcciones Aeronauticas, S. A. (CASA), C-212-CC, was first issued a U.S. type certificate on May 16, 1980, under the bilateral provisions of 14 CFR Part 21. It was configured for two flightcrew members and 22 passengers. It was equipped with two Garrett Turbine Engine Company TPE-331-10R-511C engines and the Hartzell Propeller products HC-B4MN-5AL propellers. N160FB, Serial No. 160, was issued a standard airworthiness certificate in the transport category on July 18, 1980. It was obtained by the carrier on August 28, 1980, from AIM Leasing Corporation and operated continuously by the carrier up to the time of the accident.

The airplane had accumulated a total of 12,917.9 hours and 24,218 cycles at the time of the accident. The left engine, serial No. P37047C, had a total time since overhaul of 4481.5 hours, 133.5 hours since it was installed on the airplane on January 19, 1987, and 10.6 hours since its last inspection. The right engine, serial No. P37018C, had a total time since overhaul of 4881.5 hours, 183.5 hours since its last inspection, and 51.1 hours since it was last installed on the airplane on February20, 1987. The left propeller, serial No. CD838, was installed on July 6, 1986. It had accumulated a total of 972.7 hours since it was last overhauled, and 280.2 hours since its last inspection. Its total cycles were 1,575. Records did not show the total time on the propeller hub. The right propeller, serial No. FL277, was installed on February 20, 1987. It had accumulated a total of 607.2 hours since its last overhaul, and 280.2 hours since its last inspection. Its total cycles were 1,031. The records did not show the total time on the hub.


42°13′54.5″N
83°21′02.5″W
EL 636 ft
21R
TAXIWAY 'N'
FINGER 'G'
FINGER 'F'
PLAN VIEW OF ACCIDENT SITE
BLACK RUBBER &
ALUMINUM SCRAPES
INITIAL IMPACT POINT
MN
5.4°
TN
RIGHT PITOT TUBE
RED & WHITE PAINT
WITH ALUMINUM SCRAPES
FUEL SPILL
10 PROP STRIKES
14"-16" APART
15 PROP STRIKES
12"-14" APART
NARROW GOUGE
SCRAPE MARKS
EXISTING PAVEMENT JOINTS
COCKPIT WINDSHIELD
NORTHWEST TERMINAL
WRECKAGE DISTRIBUTION
NORTHWEST ORIENT AIRLINK
CASA C-212-CC
DETROIT METROPOLITAN WAYNE
COUNTY AIRPORT
ROMULUS, MICHIGAN
MARCH 4, 1967

ERRATA

THESE CORRECTIONS SHOULD BE MADE TO THE PREVIOUSLY PUBLISHED REPORT IDENTIFIED AS FOLLOWS

AIRCRAFT ACCIDENT REPORT

**AIR NEW ORLEANS,
DBA CONTINENTAL EXPRESS FLIGHT 962,
BRITISH AEROSPACE 3101
(JETSTREAM 31) N331CY,
NEW ORLEANS INTERNATIONAL AIRPORT
KENNER, LOUISIANA
MAY 26.1987**

NTSB/AAR-88/06 (PB99-910408)

1. **Delete the last three paragraphs of section 1.16.6 and replace with the following three paragraphs:**

Following engine warmup, the RPM lever was placed in the full forward position, and the engine power lever was then advanced at a normal rate until the engine reached its temperature limit of 650” C. The engine power lever was then retarded and then advanced rapidly until temperature limiting was achieved. On reaching 650” C, it was noted on the test stand current meter fluctuation that the fuel bypass valve started bypassing fuel to hold the engine temperature at 650”. The engine power lever was again retarded to idle.

Next, the power lever was advanced until temperature limiting was achieved. then, with the use of test stand equipment, a simulated torque limit condition was sent to the TTL limiter, thereby establishing a simultaneous torque and temperature limiting condition. The current signal under these conditions was somewhat “noisy,” however, the engine operation was normal.

The last demonstration consisted of placing the RPM lever in the full aft position which establishes 94.2 percent RPM. The power lever was advanced until temperature limiting was established, at which point the engine began to oscillate mildly with a constant amplitude. Once the power lever was retarded past the point at which temperature limiting occurred, the oscillations stopped. Next, the power lever was advanced rapidly until temperature limiting was reached, whereupon the engine began to oscillate violently with diverging amplitudes. The power lever as retarded to idle and the oscillations stopped. Lastly, the power lever was advanced slowly until temperature limiting was reached and the engine oscillation was again established. The RPM lever was then advanced to establish 100 percent RPM, whereupon the engine oscillation stopped.

2. Replace the paragraph in section 2.4 with the following paragraph:

This test engine array was then used to evaluate engine operation with the RPM lever in the full aft position while the engine power lever was advanced to the temperature limiting point. Mild to violent oscillations resulted, depending on how rapidly the power lever was advanced. The oscillations stopped when either the power lever was retarded or the RPM lever was advanced to establish 100 percent RPM. The Safety Board believes the oscillations witnessed during this test were consistent with what the crew experienced shortly after takeoff in N331CY.

3. Replace the second paragraph of section 2.5 with the following paragraph:

The Safety Board, therefore, believes that if the crew attempted a takeoff with the RPM levers below the 100 percent take-off setting and the TTL system was activated for any reason (either over-torque or over-temperature), then severe engine power fluctuations would probably result sometime in the first few moments of high-power requirement. With the reported temperature of 86" F, the engine would be temperature limited, rather than torque limited. Inadvertent activation of the TTL system, therefore, resulted in the power fluctuations. It must be noted that the activation of the TTL system is a normal, protective function of the fuel control system for this engine installation and should not be construed to be an abnormal condition. Therefore, the Safety Board believes that the flightcrew failed to advance the RPM levers to the full-forward (100 percent) take-off setting before attempting to takeoff.

4. Replace finding No. 8 in section 3.1 with the following:

An engine run on a test stand along with ground and flight tests revealed that if the RPM levers were in the taxi position or any position of 97 percent RPM or less, conditions similar to what the crew described on the accident flight would likely occur.

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