

C I V I L A E R O N A U T I C S B O A R D
ACCIDENT INVESTIGATION REPORT*J. L.*Adopted: July 19, 1957Released: July 23, 1957

TRANS WORLD AIRLINES, INC., MARTIN 404, N 40428, GREATER
PITTSBURGH AIRPORT, PITTSBURGH, PENNSYLVANIA, JUNE 7, 1956

The Accident

Trans World Airlines' Flight 509 of June 7, 1956, a Martin 404, N 40428, was extensively damaged while landing at the Greater Pittsburgh Airport, Pittsburgh, Pennsylvania, June 7, 1956, about 1319. ^{1/} Two passengers received minor injuries during evacuation via emergency exits.

History of the Flight

Flight 509 was regularly scheduled between La Guardia Airport, New York, and Houston, Texas. Pittsburgh, Pennsylvania, was the first of several scheduled stops. The crew consisted of Captain Salvatore J. Gracy, First Officer Donald W. LeDuc, and Stewardess Vivian R. Magarian.

Prior to departure of the flight its crew was briefed on the en route weather and received the sequence and forecast reports. Clearance was on an IFR flight plan via airways. The aircraft departed La Guardia on schedule at 1120 with 28 adult passengers and two infants. Takeoff gross weight was less than the maximum allowable and the center of gravity was located within prescribed limits.

The flight operated uneventfully in VFR weather over the entire route from New York to Pittsburgh. Upon arrival there

1/ Times herein are eastern daylight based on the 24-hour clock and distances are in nautical miles.

the crew asked for and received clearance to make a simulated ILS approach to runway 28, the instrument runway.

During the last portion of the final approach the aircraft lost altitude rapidly. This high rate of descent continued until the main landing gear of the aircraft struck two centerline approach lights and then contacted the ground just short of and below the approach end of the overrun extension of the runway.^{2/} The main landing gear was badly damaged. The aircraft slid down the runway, without appreciable yaw, on its undamaged nose wheel and the rear portion of the bottom of the fuselage, for a distance of approximately 3,500 feet. The tail-down attitude of the aircraft on the runway blocked the main cabin door located at the rear bottom of the fuselage. Consequently, occupants could deplane only via the several escape hatches and the crew compartment loading door. A small fire had developed during the skid but was quickly extinguished by National Guard firemen who had started for the scene actually before the aircraft came to rest.

Investigation

First Officer LeDuc was in the left seat being checked for

^{2/} The following NOTAM is found in the May 29, 1956, Airman's Guide, published by the U. S. Department of Commerce, CAA Office of Aviation Information. This NOTAM was in effect at the time.

"ILS glide slope usable to approach end of Runway 28 no touchdown. (3-1) field: Extensive civil aircarrier traffic. Steep drop-off on approach end Runway 28. First 500' Runway 28 overrun; do not land short of threshold markings. The vehicular traffic crosses approach end of Runway 28. Hazardous conditions in all overrun areas. First 2500' of Runway 10 slopes downward to east. Jet traffic pattern 2700' MSL. Runway distance markers installed on Runway 10-28."

upgrading to captaincy by Captain Gracy, a company qualified check pilot. This was the first flight they had made together. LeDuc had made other simulated ILS approaches at Pittsburgh but from the right seat, and with other captains. His total left seat time in Martins was about nine hours acquired during transitional training at Kansas City. It is company policy not to give first officers left-seat time except during this transitional checking for captaincies.

The computed gross weight of the aircraft at the time of the accident, allowing for fuel burnoff, was 39,700 pounds; the maximum allowable gross landing weight at Pittsburgh was 43,000 pounds.

Runway 28, the one used, is approximately 7,500 feet long with a 600-foot paved overrun area on its approach end. This end of the runway is 1,137 feet above sea level; the far end of the runway is 1,168 feet above sea level. A horizontal row of high intensity approach lights leads to the approach end of the overrun area. The weather at the time was good. Specifically (at 1321, two minutes after the accident), it was: Scattered clouds at 5,000 feet; visibility 7 miles; wind calm; temperature 78 degrees; altimeter 30.00.

Investigation at the scene disclosed that the right main gear wheels struck the last two high intensity centerline approach light towers located 800 feet and 700 feet from the threshold of the runway. These lights, as well as others beyond them, are substantially at the same elevation as the

runway and its overrun area. A fresh cut, three-quarters of an inch wide and one-half inch deep, in the outboard rim of a right main landing wheel was made when that wheel struck the tower 800 feet from the threshold. Guard rails on the other tower were broken and bent in the direction of flight and one of its right-hand lights was broken off. Tire marks were found on both light tower railings and a six-inch section of inner tube was found on the ground below the light tower 700 feet short of the runway threshold and 100 feet from the beginning of the overrun area.

Both main landing gears struck the embankment about 50 inches short of the overrun area, and approximately 22 inches below its level. Marks at the start of the pavement indicate that the nose wheel made first contact at that point. Both main gears were displaced rearward as their drag struts failed, with the left gear separating at the strut cylinder and coming to rest on the runway forward of the threshold. Blades of the left propeller were bent rearward and their tips were ground down. The right propeller blades were also bent rearward, to a lesser extent, and their tips were also ground down, likewise to a lesser extent.

One of the tubular members of the left engine mount was broken and another was bent and cracked forward of its fitting. The entire landing gear support structure and the shear shelf of the left nacelle were bent and torn loose and the strut cylinder was swung rearward.

The following readings were taken from the crew compartment: Gear handle, neutral; carburetor heat, both engines, cold; both engine ignition switches, off; throttle levers, one-half inch from closed position; both engine fuel selector handles, off; emergency flap selector switch, forward and safetied; electrical gang bar, off; generators, off; inverters, off; cabin pressure switch forward, normal; aileron boost, on; sun visor, up; "no smoking" and "fasten seat belt" switches, on; ventilating fan, on; both engine cowl flap switches, neutral; mixture, idle cutoff. Certain of these readings reflect emergency action taken by the crew to prevent fire following the accident.

After the accident the wing flaps were found up, the flap handle was in its up detent, and the flap position indicator in the cockpit read up. The trailing edges of the flaps were not damaged by contact with the runway. However, the rear portion of the right inboard flap was deformed downward at its trailing edge by a pair of concavities closely mating with the contour of the outer curvature of the pair of right tires.

Following the accident, the airplane was placed on jacks in the Trans World Airlines hangar, and an intensive investigation was made of the flaps and their operating mechanisms and associated components. No irregularity of any significance was found during this examination.

While the aircraft was in the TWA hangar on jacks, the right gear was moved rearward in an effort to match the

fractures, abrasions, and deformities of the gear with the bottom skin of the wing and flap. This was accomplished. Both hinge joints of the right landing gear were intact; however, the support bracket of the right side of this gear was fractured. The Y section of the main landing gear was displaced upward and rearward, leaving its imprint in the bottom of the wing skin aft of the wheel nacelle. The T door unit that is normally attached and remains with the gear while it is in the full down position was found crushed and displaced. It had broken free from the lower attach point on the gear strut cylinder. This lower attach fitting is approximately 33 inches below the hinge point of the gear strut. When the gear was placed in position, this fitting on the cylinder matched a puncture in the lower skin of the trailing edge of the wing. The trailing edge of the wing had been deformed and displaced to some extent. The landing gear scissor was extended full length. The upper end of the piston portion of the landing gear strut had bottomed against and fractured the retaining unit at the lower extremity of the main strut cylinder. A grease fitting located on the hinge position of the scissor matched a puncture in the lower skin of the flap. This puncture was elongated by the flap moving upward. Damage to the underside of the wing and to the flap mated with the landing gear when the flaps were extended about 12-1/2 degrees.

Certain hydraulic system components were removed from the aircraft and bench checked. Among these was the wing flap load

relief valve, a spring-loaded hydraulic relief valve that relieves hydraulic pressure in the flap extension mechanism when the flaps are subjected to high airloads. This unit prevents full flap extension and/or allows partial flap retraction before excessive airloads are developed, thus preventing damage to the mechanism or the wing structure. All components tested were found to operate in a normal fashion with no significant variations from accepted performance tolerances being noted.

Investigation of the structure and of the many functional components of the aircraft disclosed nothing to indicate that there had been any failure or any malfunctioning of any sort prior to initial impact with the ground. The aircraft had been properly and currently maintained.

Crew testimony was substantially in accord and as follows: From La Guardia to the vicinity of Pittsburgh the flight was normal in all respects. Upon approaching the localizer course, the captain lowered the flaps to takeoff position and verified that position by the flap indicator. Approach control advised the flight of its position, and told it to continue the approach and to contact the tower. When established on the localizer course the landing gear was lowered, also by the captain, and checked down and locked, with three green lights showing. The propellers were set at the customary 2,300 r. p. m., and the remainder of the checklist was completed.

The tower was contacted about one minute east of the River radio beacon (about 5.6 miles east of runway 28), and the flight

was cleared to continue its approach to runway 28, with the tower advising that traffic was a jet aircraft making a low approach to the runway and about three miles out. Upon approaching the glide path the flaps were extended by the captain to the approach position and this position was verified by the flap indicator. According to the crew, the ILS approach was normal. The left transparent sun visor was in the down position to lessen outside visibility as is customary during simulated ILS approaches. The right sun visor was up. The captain testified that at approximately 1,400 feet m. s. l., about 250 feet above the level of the runway, he raised the left sun visor with his left hand and extended the flaps to landing position, the latter at the request of the first officer.

Shortly thereafter, the airplane lost altitude more rapidly. This was apparent to both pilots by sensation and ground reference. Airspeed at that time was noted to be about 110 knots (about five knots more than normal because the long runway permitted a longer landing roll). Captain Gracy started to advise the first officer of the settling, but the latter was already taking corrective action by applying power. This was satisfactory to the captain. The airplane sink appeared to be arrested momentarily, but it then resumed despite the application of power. The amount of power applied was nearly full throttle - almost to the stops. Although the airplane was low, and getting lower, it appeared to both pilots that they would reach the runway without difficulty.

As power was applied, the nose of the airplane came up more and more. The first officer, along with applying power, was also bringing back the control wheel. This nose-up attitude was such that the runway threshold was lost to view from the cockpit, although the far portion of the runway could still be seen. A tower controller who observed the settling estimated that it started about one-fourth mile short of the approach end of the runway and about 50 feet above the row of approach lights.

The sinking continued until contact with the approach lights, 200 and 100 feet from the end of the overrun. It was the impression of both pilots that they had first contacted the runway proper. Captain Gracy testified that he believed that he started the flaps up upon sensing the runway contact, but did not recollect specifically raising them at any time.

The aircraft continued straight ahead with little or no yawing. When it had nearly stopped, the hostess quickly went to the cockpit and informed the pilots that the cabin was filling with smoke. Switches were opened and fuel valves were closed as the aircraft slid to a stop. Before the crew left the aircraft they supervised the quick evacuation of the cabin by all occupants. As mentioned, firefighters speedily had the situation under control.

The only other traffic in the vicinity at the approximate time was an Air Force jet fighter, also making a simulated ILS approach. When TWA Flight 509 reported to the tower as passing the outer marker inbound, it was told that the jet aircraft was

about three miles ahead. Neither pilot saw it. When the jet aircraft discontinued its approach, TWA 509 was cleared to land. Observation of the path of the jet by the tower controller leads to his estimate that it passed over the approach end of runway 28, where TWA 509 first made ground contact, at an altitude of from 200 to 300 feet, and that it did so between one and two minutes before TWA 509 reached that location. Both pilots stated that there was no significant turbulence either from the jet aircraft or from any eddying of air just beyond the approach end of the runway where the terrain falls away rather sharply. An Air Force pilot who landed an F-86D on runway 28 just seven minutes prior to this accident encountered no appreciable turbulence or downdrafts.

Passengers were questioned concerning any observations they may have made relative to flap position or flap travel during the approach. One thought that the flaps were extended some five or ten minutes before the accident. None of them recall seeing flap position or travel just prior to the accident.

Analysis

The rapid settling should not have been caused by natural turbulence because the jet that landed seven minutes previously experienced none of any importance. Also, the lack of wind - reported as calm - coupled with a rather normal noonday temperature of 78 degrees militate against it. The rapid settling seems most certainly not to have been caused by the jet making the low pass over runway 28 just ahead of Flight 509 because

neither of the pilots of Flight 509 reported trouble from that source. Considering this primarily, and recalling there was some three miles separation between the flight and the jet, the Board believes that insufficient jet wash or natural turbulence existed to cause the sink.

The first officer stated that the airspeed was 110 knots and that engine manifold pressure was 20 inches when he called for "landing" flaps. Bench testing of the wing flap load relief valve disclosed that its cracking pressure was 870 p. s. i. A valve so adjusted would prevent full flap extension at speeds above 98 knots, with engine power as reported. At 20 inches of manifold pressure, and at an airspeed of 110 knots, the flaps would not extend fully, but due to load relief valve action they would cease their downward movement and become stabilized at an intermediate position of approximately 36 degrees. An increase in engine power at this time would cause further flap retraction; however, flight tests have shown that such retraction is accompanied by a slight increase in airspeed and little or no settling of the aircraft is experienced.

Because it is believed that neither jet wash nor natural turbulence were factors and because no defect was found in the aircraft or its components, the reason for the low altitude appears to be operational. However, the physical evidence available to us concerning the flight path of the aircraft cannot be reconciled with the testimony of the flight crew concerning airspeed, flap management, and time of power application.

If the airspeed of the aircraft was as testified, 110 knots, and sufficient power was applied at the proper time and the flaps were not retracted, there is no known reason why the aircraft descent could not have been arrested in time to avoid undershooting the runway and striking the lights. In the light of the testimony of the pilots, along with the physical evidence available, the Board is left with no other conclusion than that the landing approach was so poorly executed by the copilot as to have made it obligatory for the captain to have taken, or caused to be taken, earlier corrective action.

In reconstructing this accident it is necessary to premise certain happenings upon possibilities rather than known actualities. A reconstruction so constituted would be as follows:

At or shortly before the time when the captain raised the copilot's sun visor and then lowered the flaps, the copilot increased his rate of descent. This is understandable inasmuch as he had only then changed from instrument to visual reference. At that time, seeing ahead of him a 600-foot overrun area short of the runway and indistinguishable from it in color, it may safely be presumed that he increased his rate of descent so that his touchdown would be at the proper place on the runway, but in relation to the approach end of the overrun area rather than in relation to the approach end of the runway proper. Then, when it became apparent that this resulted in the airplane sinking too rapidly, the corrective application of power was made too late to arrest the descent before the lights were

struck. These lights, as previously stated, are substantially at the same altitude as the runway and its overrun area. As has been pointed out, the attitude of the aircraft at that time was such that only the far end of the runway could be seen, the approach end being blocked off by the intervening nose of the aircraft.

The above hypothesis seems to be strengthened by an incident which occurred at the identical place some time after the accident. In the latter case, the main wheels also struck just below the level of, and just short of, the approach end of the overrun area. A successful go-around was executed.

Since this last incident and as a result thereof, the subject overrun area has been conspicuously marked to distinguish it from the runway proper.

Findings

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

1. The carrier, the aircraft, and the crew were currently certificated.
2. Weather, downdrafts, and turbulence were not factors in this accident.
3. The aircraft and all of its components, including the flap system, were functioning normally up until the time of impact.
4. During the final approach the aircraft lost altitude too rapidly.

5. Power was applied but it was too late to prevent striking the approach lights.
6. The aircraft next struck just short of and just below the runway's overrun.
7. The main landing gear collapsed and the aircraft settled to the runway.
8. The aircraft slid to a stop on the runway and its weight on the main cabin door prevented use of that door, forcing evacuation through emergency exits.
9. A fire developed during deceleration, but was quickly extinguished.

Probable Cause

The Board determines the probable cause of this accident was that during the final approach the Captain permitted the First Officer to descend too low before power was applied to arrest the aircraft's descent.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE

/s/ HARMAR D. DENNY

/s/ G. JOSEPH MINETTI

/s/ LOUIS J. HECTOR

Vice Chairman Chan Gurney did not take part in the adoption of this report.

S U P P L E M E N T A L D A T A

Investigation

The Civil Aeronautics Board received notification of the accident a few minutes after occurrence. An investigation was immediately started in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. As part of the investigation, depositions of both pilots and other persons were taken at the Federal Building, Idlewild Airport, New York, on June 21, 1956.

Air Carrier

Trans World Airlines, Inc., a Delaware corporation, is a scheduled air carrier with its principal offices at Kansas City, Missouri. It possesses a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration. These certificates authorize the carrier to transport by air persons, property, and mail over various routes including the route involved in the accident.

Flight Personnel

Captain Salvatore J. Gracy, age 38, had been employed by TWA since October 1942. He completed satisfactorily a company course of training for student first officer and was promoted to regular first officer in April 1943, and to captain in November 1945. He completed qualification on Martin equipment, as captain, in February 1952. Captain Gracy served in the capacity of line check pilot from June 1948 to November 1948, then from March 1954 to August 1954. On February 4, 1956, he was again appointed line check pilot and satisfactorily complete the company's indoctrination course therefor. At the time of this accident Captain Gracy had a total of 10,609 hours of piloting, of which 1,832 hours had been in Martins. He

held a valid airman certificate with airline transport rating and all other pertinent ratings, without waivers. His rest period prior to the subject flight had been in compliance with CAA requirements, and his last physical examination was passed on January 27, 1956.

First Officer Donald J. LeDuc, age 34, was first employed by TLA in May 1947. He completed his Martin equipment qualification as first officer in November 1952. Mr. LeDuc had flown a total of 8,888 hours, of which 201 hours had been in Martins. He held all necessary and pertinent certificates and ratings, without waivers, and his last physical examination was passed on August 30, 1955.

Hostess Vivian R. Nagerian, age 28, was first employed by TLA as a student hostess in June 1952. She completed her training satisfactorily and became a line hostess in that same month. She had attended her last emergency evacuation training program in April 1956.

The Aircraft

The aircraft involved was a Martin model 404, N 40428, designated by TLA, owner and operator, as their plane No. 428. It had been fully maintained in all respects in accordance with company and with CAA requirements. The engines were Pratt and Whitney model C616 with 785 hours and 151 hours for left and right, respectively, since overhaul. Propellers were Hamilton Standard model 43E60.