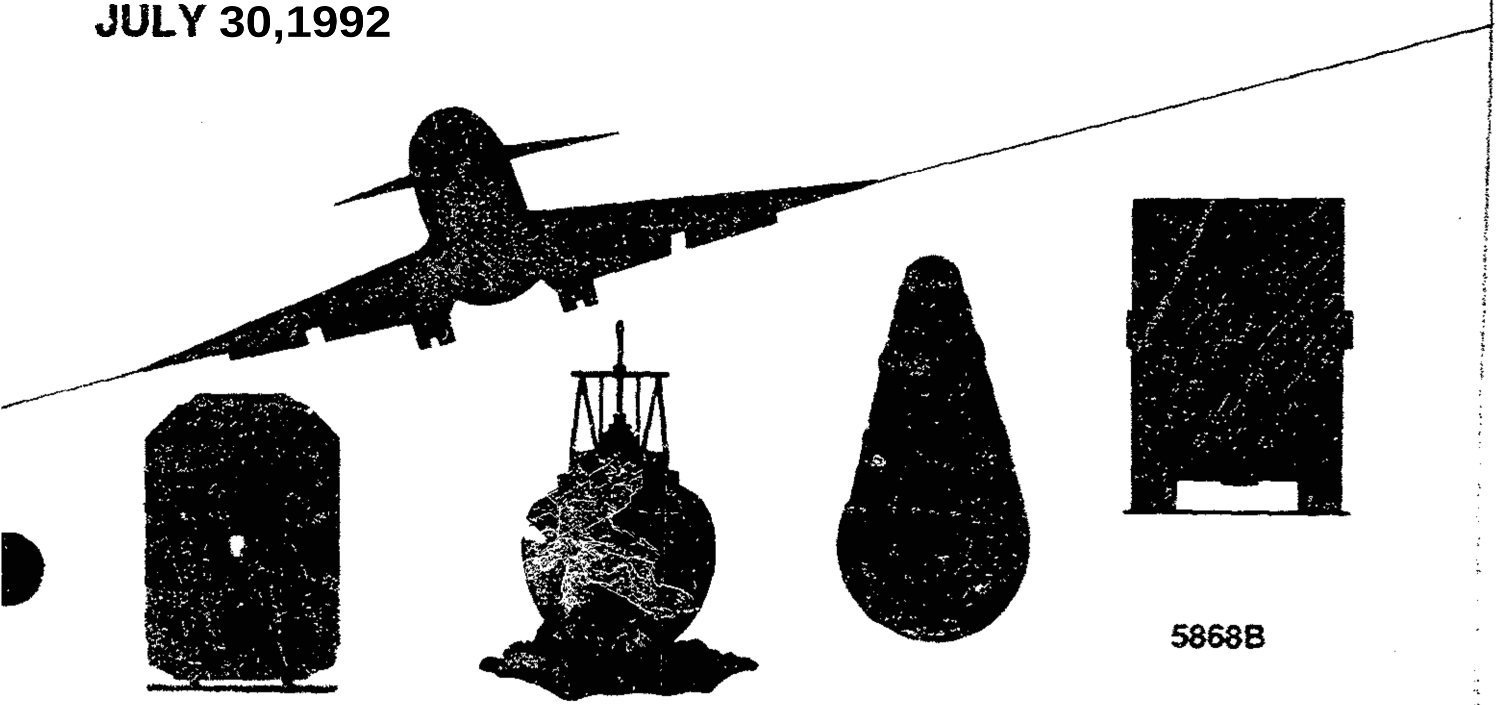
PB93-910404
NTSB/AAR-93/04

NATIONAL TRANSPORTATION SAFETY BOARD

WASHBNGTQN, D.C. 20594

AIRCRAFT ACCIDENT REPORT

ABORTED YAKEOFF SHORTLY AFTER LIFTOFF
TRANS WORLD AIRLINES FLIGHT 843
LOCKHEED L-1011, N11002
JOHN F. KENNEDY INTERNATIONAL AIRPORT
JAMAICA, NEW YORK
JULY 30,1992



5868B

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Adopted: March 31,1993
Notation 5868B

Abstract: This repon explains the aborted takeoff and destruction of a Trans World Airlines L-1011 airplane, which was scheduled passenger flight **843,** shortly after **liftoff from** John F. Kennedy International **Airport.** Jamaica, New York, on July 30, 1992. **The** safety issues discussed in the report include training and procedures for flightcrews in abnormal situations during the takeoff and initial climb phases **of** flight, flightcrew control responsibilities for **all** takeoffs, trend **monitoring** in airline maintenance and quality assurance programs, the failure of the stall waning system during ground or flight operations, and the location of an airport **blast** fence. Safety recommendations concerning these issues were made to the Federal **Aviation** Administration **and** the Port Authority **of** New **York** and New Jersey.

ERRATA

THE FOLLOWING CORRECTIONS SHOULD BE MADE TO THE PREVIOUSLY PUBLISHED REPORT AS FOLLOWS:

AIRCRAFT ACCIDENT REPORT
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JAMAICA, NEW YORK
JULY 30, 1992

(NTSB/AAR-93/04 PB93-910404)

Page 19, last paragraph, line 1, first sentence

Change

The No.2 engine sustained....

To

The No.2 engine exterior was heavily sooted, but there was no fire or heat damage evident.

Page 19, last paragraph, last line

Change

...reversers were fully deployed.

To

...reversers were fully deployed and the thrust reverser cowl had sustained severe fire damage.

Page 74, Appendix C, table, Serial No. column

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10293

To

10295

CONTENTS

EXECUTIVE SUMMARY

On July 30, 1992, at 1741 eastern daylight time, Trans World Airlines scheduled passenger flight 843, an L-1011, N11002, experienced an aborted takeoff shortly after liftoff from John F. Kennedy International Airport, Jamaica, New York, en route to San Francisco International Airport, California. The airplane came to rest, upright and on fire, on grass-covered soil, about 290 feet to the left of the departure end of runway 13R. There were no fatalities among the 280 passengers on board the airplane, but there were 10 reported injuries that occurred during egress. The flight was operating under 14 Code of Federal Regulations Part 121.

The National Transportation Safety Board determines that the probable causes of this accident were design deficiencies in the stall warning system that permitted a defect to go undetected, the failure of TWA's maintenance program to correct a repetitive malfunction of the stall warning system, and inadequate crew coordination between the captain and first officer that resulted in their inappropriate response to a false stall warning.

The safety issues in this report focused on training and procedures for flightcrews in abnormal situations during the takeoff and initial climb phases of fiight, flightcrew control responsibilities for all takeoffs, trend monitoring in airline maintenance and quality assurance programs, the failure of the stall warning system during ground or flight operations, and the location of an airport blast fence.

Recommendations concerning these issues were addressed to the Federal Aviation Administration and the Port Authority of New York and New Jersey. Also, as a result of the investigation of this accident, on March 8, 1993, the Safety Board issued safety recommendations to the Federal Aviation Administration that pertained to emergency exit windows, seatbelts in cockpit observer seats, and fire blocking materials.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

ABORTED TAKEOFF SHORTLY AFTER LIFTOFF TRANS WORLD AIRLINES FLIGHT 843 LOCKHEED L-1011, N11002 JOHN F. KENNEDY INTERNATIONAL AIRPORT JAMAICA, NEW YORK JULY 30,1992

1. FACTUAL INFORMATION

1.1 History of the Flight

On July 30, 1992, at 1741 eastern daylight time, Trans World Airlines (TWA) scheduled passenger flight 843, an L-1011, N11002, experienced an aborted takeoff shortly after liioff from John F. Kennedy International Airport (JFK), Jamaica, New York, en route to San Francisco International Airport (SFO), California. The flight was operating under 14 Code of Federal Regulations (CFR) Part 121.

There were 280 passengers and a crew of 12 on board. The flightcrew consisted of a captain, first officer, and flight engineer. There were nine fight attendants. When the accident occurred, the flight attendants were seated for takeoff throughout the cabin. Included in the 280 passengers were two off-duty TWA pilots and five off-duty flight attendants. The off-duty pilots were seated in the cockpit jumpseats. Three of the off-duty flight attendants were seated in extra cabin attendant positions. Two were seated in passenger seats. Every available seat was occupied.

The flight was cleared to push Sack from the gate at 1716:12. At 1725:37, JFK ground control cleared the flight for taxi to "runway one three right, taxi left outer, hold short of [taxiway] November." The length of runway 13R/31L was 14,572 feet. (See figure 1). The first officer was at the controls for takeoff. At 1740:10, the captain acknowledged a call from JFK tower that the flight was "cleared for takeoff."

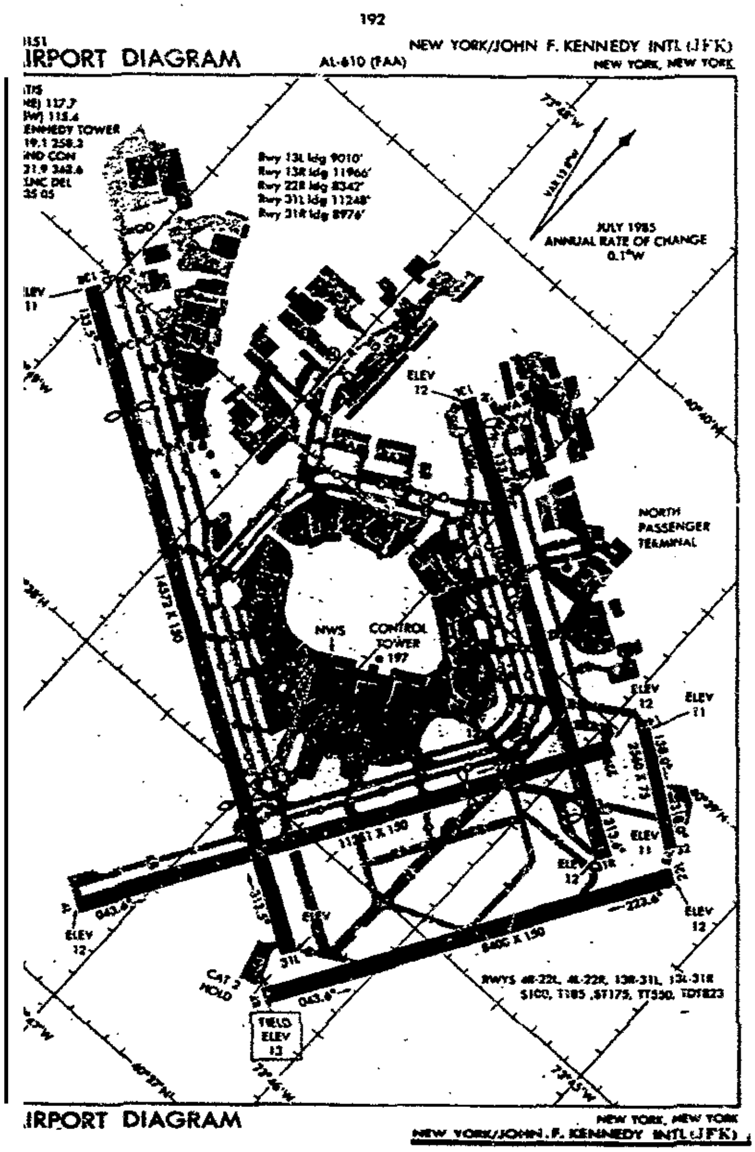


Figure 1.--Airport diagram.

As recorded on the cockpit voice recorder (CVR), at 1740:58, the captain called out "V_1." (See appendix D). At 1741:03, he called "V_R." At 1741:11, the first officer said, "Gettin' a stall," and 1.4 seconds later he said; "You got it." The captain said "O.K." at 1741:13. At 1741:15, there was a sound of a snap, followed by the captain saying, "Oh Jes--." The first officer then said, "Abort, get it on." ... flight engineer said, "Get it off." The first officer again said, "Get it OIL." The flight engineer again said, "Get it off." At 1741:20, the captain said, "What was the matter?" The first officer said, "Getting a stall." At 1741:32, the first officer said, "Stay with it." Then he said, "Stay on the brakes, stay on the brakes." At 1741:38, the JFK tower broadcast, "TWA eight forty three heavy, numerous flames." As recorded on the flight data recorder (FDR), the airplane was airborne for about 6 seconds. Figure 2 depicts selected CVR and FDR derived times and events during the takeoff and landing back on the runway.

The captain told the Safety Board that the takeoff was made using standard TWA procedures. That is, when the first officer is making the takeoff, the captain maintains control of the thrust levers until the landing gear is retracted. The captain stated that he advanced the power for takeoff and that acceleration was normal. He called V_1 and removed his hand from the thrust lever knobs and placed it behind the levers. He called V_R, and the rotation was made smoothly and normally.

The first officer told the Safety Board that he felt the stall warning stickshaker activate on the control column as the airplane lifted off the runway. He said that after becoming airborne, he sensed a loss of performance and felt the airplane sinking. The captain told the Safety Board that when the airplane broke ground, the stickshaker remained on and the airplane began to sink back toward the runway. He said that the "first officer stated something to the effect of it's not flying or it won't fly, 'you've got it'." He turned control of the airplane over to the captain. The captain stated that he had a split second to decide either to continue to take off or to abort, when he probably would not be able to stop on the runway. He saw a considerable amount of runway remaining and chose to abort. The captain also stated that the airplane had the proper attitude and air speed but was not flying. He said he positively did not believe that the airplane would fly.

The captain stated that he closed the thrust levers and put the airplane back on the runway. He applied full reverse thrust and maximum braking. The airplane began to decelerate, but not as fast as he had expected. He said that the

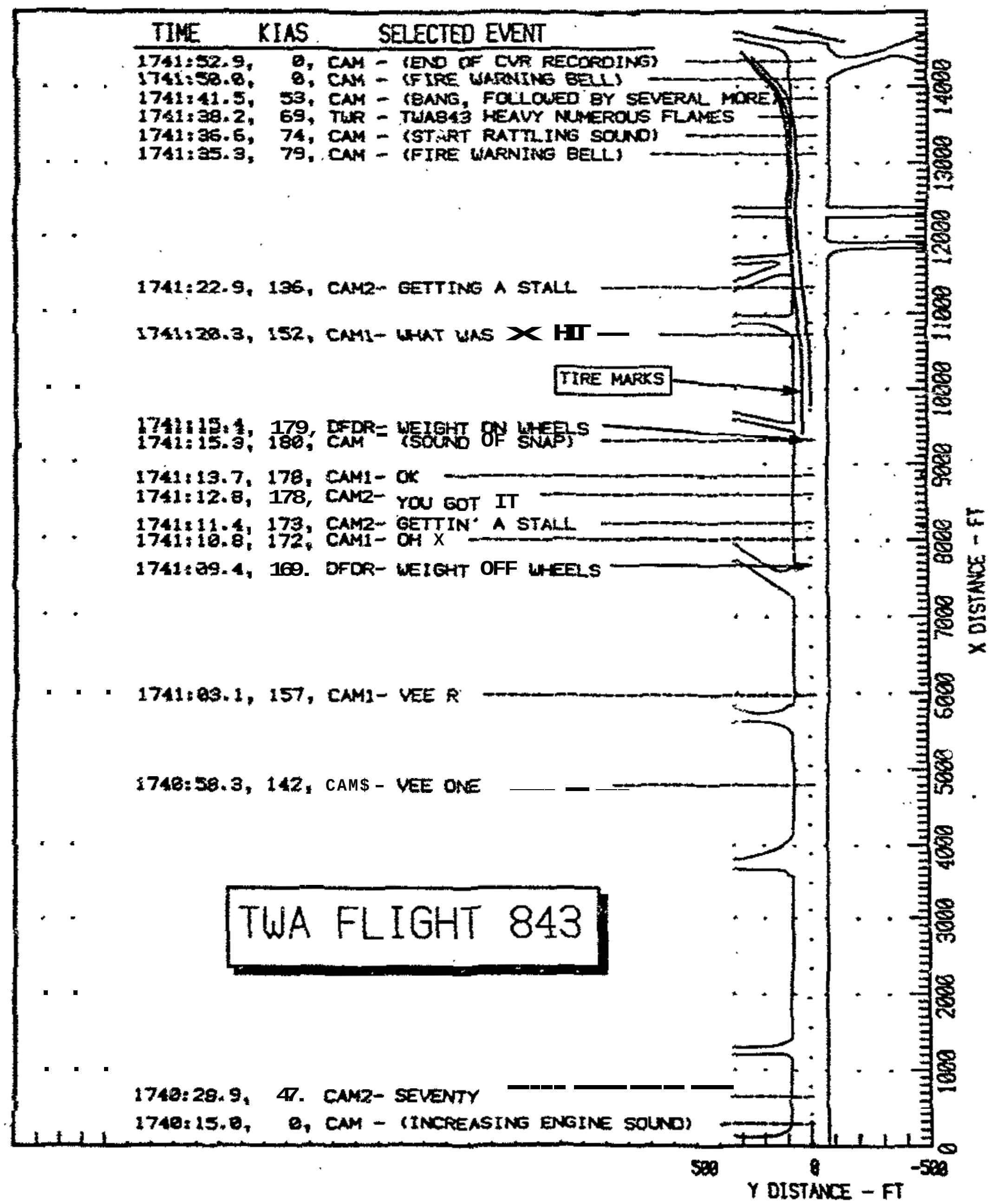


Figure 2.--Selected CVR and FDR data.

brakes seemed to be losing their effectiveness. He concluded. that with approximately 1,500 feet of mway remaining and the air speed still about 100 knots, he would not be able to stop before reaching the blast fence at the end of the runway. He was able to maintain directional control throughout the landing. When it became apparent that he would not be able to stop before hitting the barrier at the end of the runway, he turned the airplane left off of the'mway onto an open area covered with grass. Beyond the grass was concrete; he was sure he would be abie to stop either on the grass or concrete.

The captain stated that a fire warning went off either before or after he turned off the runway. The flight engineer silenced the warning bell and the captain directed him to pull the appropriate handle and activate the extinguisher. agent bottles.

The captain stated that he sensed a "sharp thump" about the time the airplane departed the runway. At the time, he was intent on maintaining directional control and stopping, but he knew later that the thump was the collapse of the nose wheel. Examination of the airplane revealed that the nose gear strut fractured so that it collapsed back and up, against the underside of the forward fuselage.

About the time the airplane came to a stop, the captain turned off the fuel and ignition switches, and .directed the first officer to pull the handles on the other engines and activate their extinguisher agent bottles.

The captain stated that the evacuation alarm went off as the flight engineer was reaching to activate it. The captain got on the public address system (PA) and stated, "This is the captain, evacuate the aircraft." The captain entered the cabin to direct the evacuation.

The crew quickly evacuated all of the passengers through the most forward right and the two forward left cabin exits. The second cabin exit hatch on the right side was opened during the evacuation, but because smoke and fire were immediately outside the exit, it was quickly closed. The captain examined the cabin for any remaining passengers and was the last person to exit the airplane.

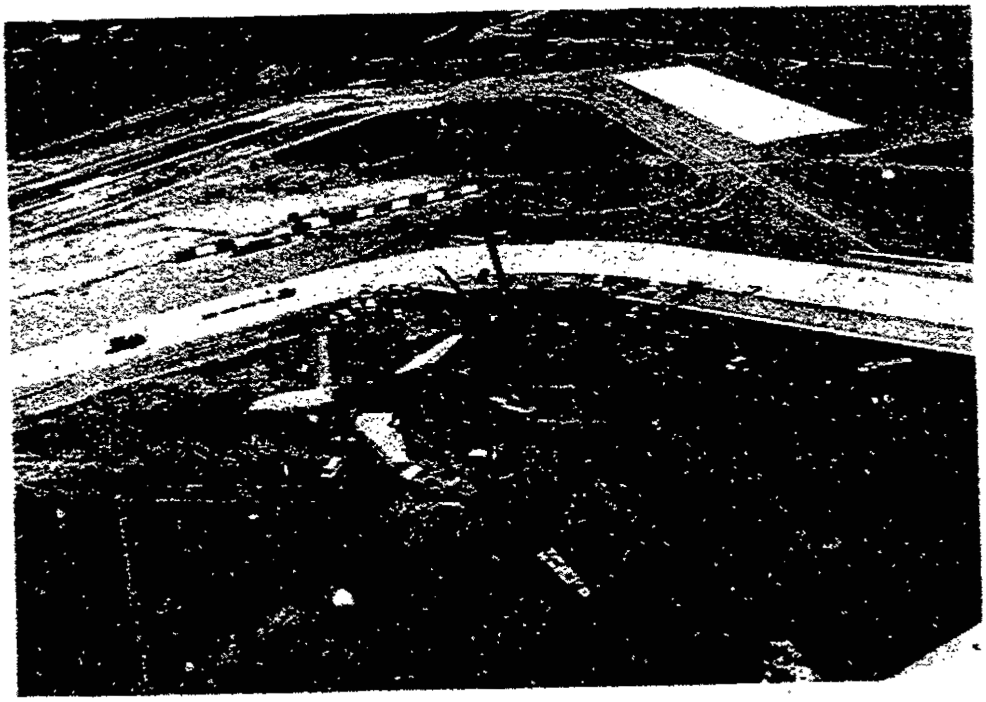
Pilots of other airplanes were part of the witness group. Some of them described the airplane as landing fast and far down the runway. A pilot of an airplane waiting on taxiway Lima Alpha, facing perpendicular to about the 8,500-foot mark on runway 13R, stated that he did not see anything abnormal about the airplane, other than an excessive rate of descent. He stated that the extremely hard landing caused a large puff of smoke to come from the main gear, with a great deal of strut compression and wing flex.

Some of the witnesses stated that they saw debris come from the underside of the airplane or a main wheel area about the *time* of touchdown. Other witnesses, most notably those in the JFK control tower, observed a similar sequence of events. However, some of the witnesses m the control tower stated that the first time they saw debris come from the airplane was about the time of rotation.

Witnesses had similar descriptions of the events that followed touchdown; they saw debris, smoke, or mist *come* from the airplane about the time of touchdown and following touchdown. The substance continued to come from the underside of the *airplane* or right wing area as the airplane continued down the runway. A large fireball developed on the outside of the fuselage. One witness described seeing the fireball travel aft and possibly enter the inlet of *the* No. 2 engine.

As indicated by tire marks on the runway and subsequent furrows in *the* soil, the left main landing *gear* departed the left side of the runway about 11,350 feet from the runway threshold. The right main landing gear departed *the* left side of the runway about 13,250 feet from the threshold. There was also a blackened and burned streak on the runway, beginning about 12,650 feet from the threshold. The *streak* ran in conjunction with the *tire* marks off the left side of the mway. The burned streak continued to the point where the airplane came to rest. The airplane came to rest, upright and on fire, on grass-covered soil, about *2%* feet to the left of the departure end of mway 13R, on a heading of about 100 degrees, approximately 14,368 feet from the threshold of the departure runway.

Within 2 minutes of the time the airplane came to rest, airport rescue and fire fighting (ARFF) trucks arrived at the site. However, the airplane continued to burn. Before the fire Could be extinguished, it consumed the entire *aft* fuselage, in the area behind the wings and above the cabin floor. The fire also burned through the lower fuselage m *two* places, so that two sections fell separately to the ground. After the fire was extinguished, the airplane rested on the wheels from the two main landing gear and the structure and *skin* beneath the forward cockpit and nose. Figures 3 and 4 are photographs of the wreckage.



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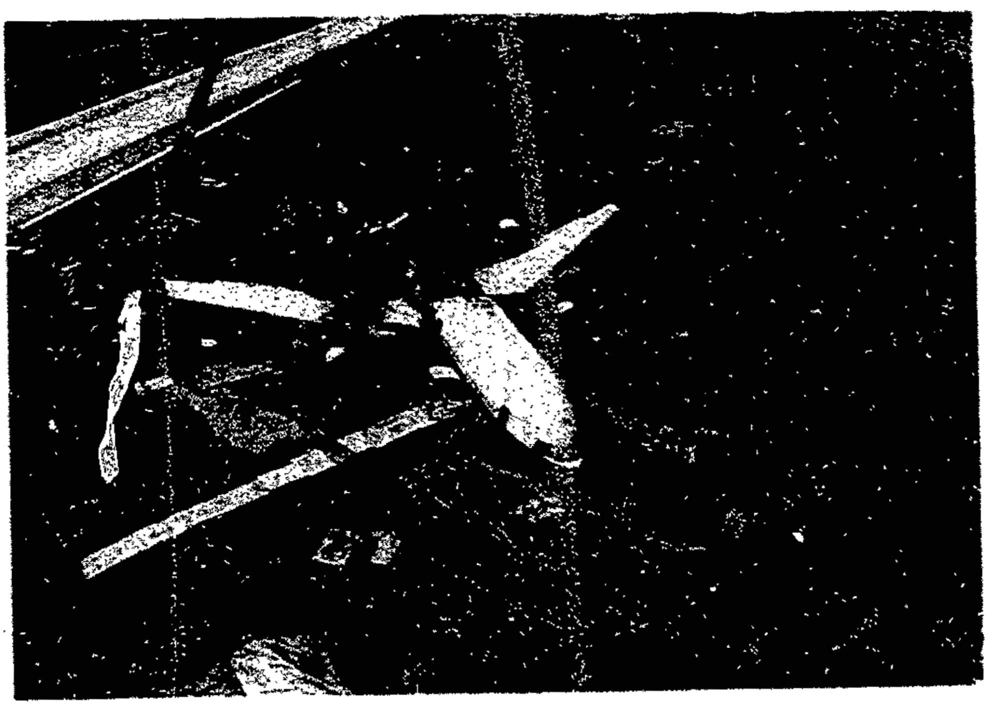

Figure 3.--Airplane wreckage.

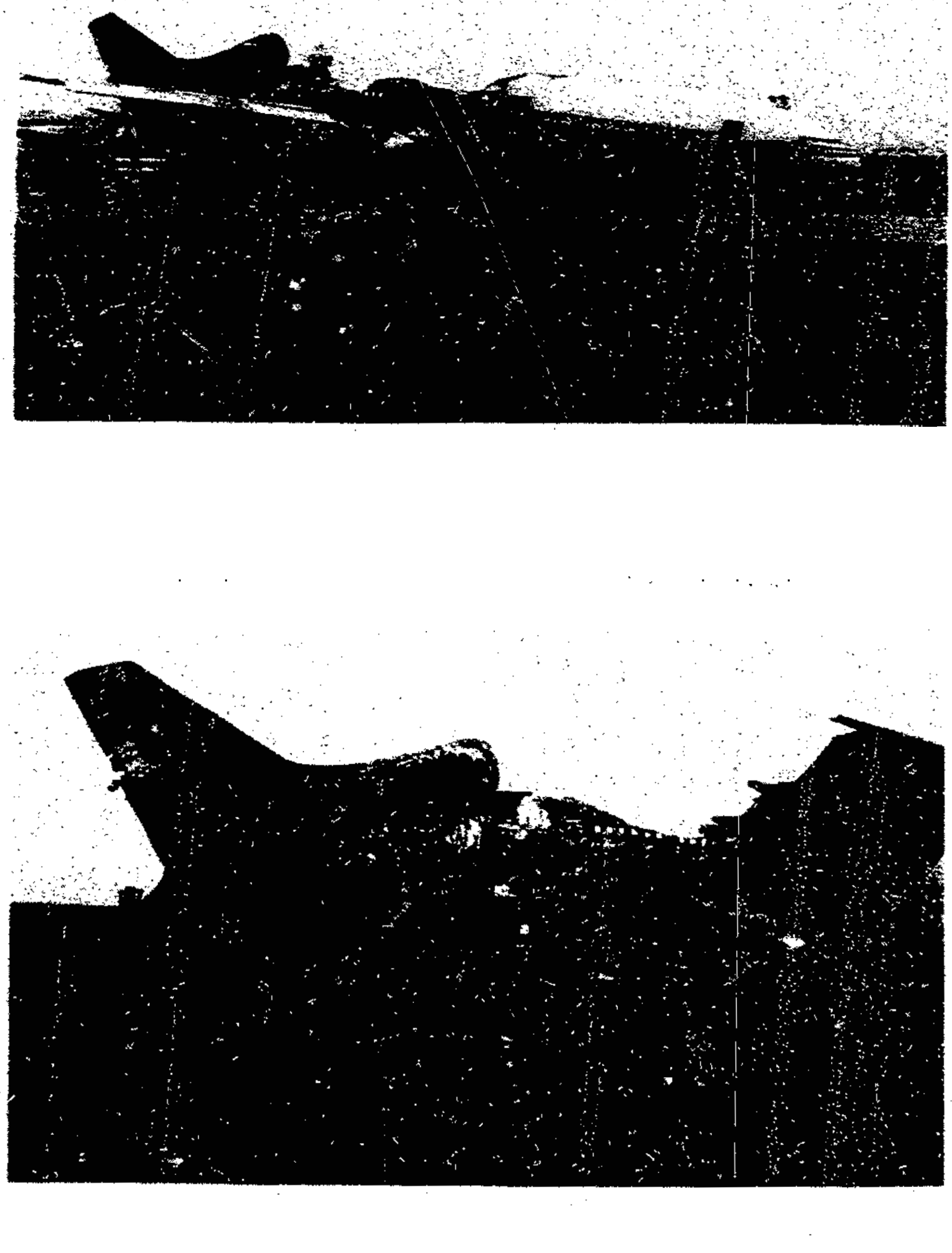

Figure 4.--Airplane wreckage.

There were no fatalities. Of 280 passengers on board the airplane, there were 10 reported injuries that occurred during egress. Of the injuries, most were minor. There was one fractured leg. Of the 12 crewmembers, there were no reported injuries.

The accident occurred during daylight hours. The airplane came to rest at 40 degrees, 37.7 minutes north latitude, and 73 degrees, 46.3 minutes west longitude.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabin Crew	Passengers*	Others	Total
Fatal	0	0	0	0	0
Serious	0	0	1	0	1
Minor	0	0	9	0	9
None	2	e	270	0	282
Total	3	9	280	0	292

*Includes two occupants of the cockpit jumpseats and five off-duty flight attendants.

1.3 Damage to Aircraft

The airpiane was destroyed by fire. Its value was estimated at $12 to $13 million.

1.4 other Damage

Damage to the runway and surrounding terrain was minimal. One runway edge light and two taxiway lights on the left side of the runway were destroyed. There was no estimate available regarding the cost of the damage to the mway and surrounding terrain.

1.5 Personnel Information

1.5.1 The Captain

The captain was born on May 2, 1938. He was employed by TWA on Nay 24, 1965. He possessed a First Class Aviation Medical Certificate. dated

March 26, 1992, with the limitation that he wear corrective lenses for near vision. At the time of the accident, his aviation ratings were airline transport pilot, airplane, multiengine land, DC-6, DC-7, B-707, B-720, B-747, L-1011 and commercial, single-engine land.

The captain had a total flight time of 20,149 hours, including 15,854 hours as a pilot with TWA. He had 2,397 hours in the L-1011, 1,574 of which were as captain. His last annual line check was on July 9, 1992. His last simulator check was on June 4, 1992.

1.5.2 The First Officer

The first officer was born on June 19, 1939. He possessed a Fit Class Aviation Medical Certificate, dated February 5,1992, with the limitation that he wear corrective lenses for near vision. He was employed by TWA on February 17, 1967. His aviation ratings were airline transport pilot, airplane. multiengine land, L-1011; and flight engineer, turbojet-powered airplanes.

He had a total fight time of 15,242 hours, 13,793 of which were with TWA. Included in his time at TWA were 4,842 hours as a first officer, 2,953 of which wen in the L-1011; he also had 2,230 hours as a flight engineer in the L-1011. His last annual line check took place on April 5, 1992.

1.5.3 The Second Officer

The second officer, or flight engineer, was born on July 7, 1958. He was employed by TWA on September 2, 1988. He held a First Class Medical Certificate, with no restrictions, dated January 24.1992. His aviation ratings were airline transport pilot, airplane multiengine land; and flight engineer. turbojet-powered airplanes.

He had a total fight time of 3,922 hours. 2.302 of which were with TWA. He had a total time of 2,266 hours as a flight engineer on the L-1011. His last annual line check was on May 1, 1992. His last simulator check was on September 18.1991. He was rated as a flight engineer, check aman

1.5.4 Other Crewmembers

Both pilots occupying cockpit jumpseats were TWA captains and both were L-1011 qualified. All of the cabin attendants were trained and qualified for their positions.

1.6 Aircraft Information

Based on the airplane records, the accident airplane had a gross weight of 431,773 pounds when it taxied from the gate for takeoff. The maximum allowable taxi weight for this model airplane was 432,000 pounds. With an estimated 2,800 pounds of fuel expended during taxiing for takeoff, the airplane had a takeoff gross weight of about 428,973 pounds. The maximum allowable takeoff weight was 430,000 pounds; the maximum allowable landing weight was 358,000 pounds.

The records showed a center of gravity (CG) of 24.2 percent mean aerodynamic chord (MAC). The allowable operating limits ranged from 12 to 32 percent MAC. The stabilizer trim setting was 4.2 units, nose up. The "V" reference speeds were: V_1 = 140 WAS, V_R = 155 KIAS, V_2 = 164 KIAS. The investigation revealed that the calculated weight and balance and "V speeds were correct for the conditions.

17 Meteorological Information

At the time of the accident, JFK was operating under visual flight rules (VFR) in daylight conditions.

The 1650 National Weather Service report for JFK was as follows:

> 3,500 feet scattered, 5,500 scattered, visibility 11 miles, temperature 76 degrees Fahrenheit (F), dewpoint 62 degrees F, altimeter setting 30.01 inches of mercury.

At the time of the accident, the JFK power controller transmitted to a landing airplane the wind conditions as 150 degrees at 8 knots. The official wind conditions were later determined to be 150 degrees at 10 hots for the actual takeoff of TWA flight 843.

1.8 Aids to Navigation

There were no reported difficulties with aids to navigation.

1.9 Communications

There were no reported difficulties with communications between the airplane and JFK tower or any other controlling agency.

1.10 Aerodrome Information

JFK is in southwestern Long Island, about 15 miles southeast of Manhattan Island. The airport is owned by the City of New York and is located in the Borough of Queens. It is operated by the Port Authority of New York and New Jersey (PNY & NJ).

JFK is served by 5 runways: 4L/22R, 4R/22L, 13L/31R, 13R/31L, and 14/32. At 14,572 feet, runway 13R/31L is the longest runway at JFK. All of the runways were 150 feet wide. The airport's elevation is 13 feet mean sea level. Runway 13R/31L is grooved and composed of asphalt and concrete. A 10-foot high nonfrangible blast fence marked with red and white vertical bars was located approximately 65 feet beyond the departure end of runway 13R. At the time of the accident, landings at JFK were taking place on runway 13L.

1.11 Flight Recorders

An operable CVR and an operable 116-parameter FDR were recovered from the airplane and transported to the Safety Board's laboratories for readout. The rear fuselage sustained substantial fire damage; however, both recorders provided clear information.

1.11.1 Cockpit Voice Recorder

The CVR contained 31 minutes and 46 seconds of recorded conversation. The recording was clear. The CVR recording ended about the time the flightcrew cut off the fuel and electrical power, after the airplane came to a stop.

In postaccident interviews, the pilots described feeling and hearing the stickshaker stall warning, which commenced about the time the airplane lifted off the runway. However, the sound of the stickshaker system has not been identified on the CVR recording.

On August 12, 1992, numerous CVR stickshaker tests were conducted on a TWA L-1011 line airplane at Lambert Field, St. Louis, Missouri, while the airplane was parked at the gate and on a runup pad with the engines running. For each test, the stickshaker was audible on the CVR test tape.

On August 20, 1992, a second series of tests was conducted, using a different TWA L-1011 departing from Lambert Field. On this flight, a V_R of 165 knots was used to simulate the rotation speed of the accident flight; the first officer was at the controls. Rae flaps were set at 10 degrees, and only one air conditioning pack was turned on during takeoff. The stickshaker was artificially activated during acceleration through 140 knots and maintained until after the airplane was airborne.

The airplane was then flown to a safe practice area where three "approaches to stall" were initiated. These tests were conducted at 12,000 feet using 10 degrees of flaps and a V_R of 130 knots. On the third test, both pilots held onto the control wheel in an attempt to dampen the control column response to the stickshaker. The airplane was intentionally operated in the stickshaker regime at 123 to 127 knots for about 10 seconds. The airplane was then flown back to Lambert Field where two touch-and-go landings and one full-stop landing took place. In each takeoff, the stickshaker was artificially activated to record the audio levels. Again, in all circumstances, the stickshaker was audible on the CVR recording. It was noted that when both pilots held onto the control wheel, the sound of the stickshaker was much quieter. In addition, if a map was clipped to the control wheel map holder, it was very difficult to hear the stickshaker on the recording.

A third set of tests was performed on a TWA L-1011 at the company's maintenance facility in Kansas City, Missouri. These tests were performed in a maintenance hangar with no engines running. The stickshaker was activated using the tesr button under varying conditions; first, with a person sitting in the first officer's seat holding onto the control wheel; then the captain; and later both persons held onto the control wheel, These sounds were recorded on the CVR unit, and the tape was returned to the Safety Board's audio laboratory for analysis. As in other tests, the stickshaker was audible, but the audibility varied with the least audible being the test with both crewmembers holding their yokes.

1.11.2 Flight Data Recorder

The FDR provided a clear readout with two synchronization losses; one about the time of the touchdown on the runway, and the other as the airplane was coming to a stop. The readout of the FDR showed, with one exception, normal parameters during startup, taxiing from the gate for takeoff, and acceleration on the runway through rotation and liftoff. The exception to the normal FDR parameters was the right or No. 2 angle-of-attack (AOA) indicator. While the left, or No. 1, AOA indicator showed normal movement throughout the taxi period, and normal values during the airplane's acceleration on the runway and rotation for takeoff, the right indicator showed virtually no movement from startup through takeoff.

The FDR data reveal that at engine start, the left AOA indicator showed a steady 14.4 degrees. It then began and continued to move as the airplane taxied and made the takeoff. However, the right AOA indicator showed a steady 26.3 degrees at engine start and as the airplane began to taxi, changed to 26.1 degrees during the taxi phase and remained at that value through the takeoff and landing. As the airplane was being slowed to a stop, the right AOA indicator moved from the constant value of 26.1 degrees and began to move nearly in concert with the left AQA indicator, until the FDR data ended, after the airplane came to a stop.

During the takeoff, as air speed increased through 158 KIAS, the pitch attitude increased about 2 degrees per second until the airplane's pitch attitude reacher? 12.6 degrees, about 6 seconds after the beginning of rotation. At that time, the airplane was passing through 170 KIAS, and the FDR air/ground (A/G) parameter indicated a transition of the airplane from ground to air.

The FDR showed that the airplane's radio altitude increased from a negative 4 feet indicated to a maximum value of plus 14 feet indicated above ground level (agl). The FDR then showed the airplane's pitch angle steadily decreasing, and the altitude decreasing. until the airplane returned to ground level (indicated as - 4 feet). The maximum air speed indicated was 181 KIAS. This occurred about 6 seconds after the A/G parameter indicated that the airplane had transitioned from ground to air, or within 1 second of the time that the airplane recontacted the runway.

Transfer of control of the flight from the first officer to the captain was not apparent from the FDR data. The peak "G" value recorded for normal acceleration during the landing on the takeoff runway was 2.016. Because normal acceleration values recovered from the FDR were based on a sampling of 4 rimes per second, it is possible that peak Gs of greater magnitude occurred between samples. A data synchronization loss that occurred about the time of touchdown on the mway was most likely the result of the touchdown forces transmitted to the FDR. The peak normal recorded acceleration occurred 0.45 second after the start of data synchronization loss.

1.12 Wreckage and Impact Information

1.12.1 Takeoff Runway

Witness accounts varied abut where the airplane landed on the runway and included descriptions, such as the landing occurred "well down the runway and fast," or "near the intersection with runway 4L/22R."

Initial contact marks found on runway 13R were a pair of tire marks from the left main landing gear, starting about 9,418 feet from the beginning of the takeoff runway. (See figure 5). They started about 39 feet to the left of the runway centerline and ran approximately parallel to the centerline and later angled off the left shoulder of the runway.

A second pair of tire marks, parallel to the first set, began about 9,800 feet from the beginning of runway 13R. The second pair of tire marks tracked about 37 feet to the right of the first pair. The evidence indicated that they came from the wheels on the airplane's right main landing gear. This distance was consistent with the distance between the L-1011's main landing gear. After continuing approximately parallel to the runway centerline and later off the left shoulder of the runway, both pairs of tire marks made furrows in the soft soil to the point where the airplane came to rest.[1]

A third pair of tire marks showed evidence that they came from the nose wheels. These marks began well after the tire marks from the left and right

[1] The airplane performance study (see section 1.16.6.3) found that the right main landing gear touched down first, with 5.419 feet of runway mining, as the airplane landed back on the takeoff runway. The landing occurred with a roll auitude of 1-degree right wing down, with the right main gear touching near the crown of the rutrway. However. tire marks from the right main landing gear were not identified until about 4.772 feet from the departure end of the runway, or 9,800 feet fmm the threshold. Revened rubber on the runway. from previous operations, contributed to the difficulty in identifying the fit tire marks from the right main gear in the landing back on the runway.

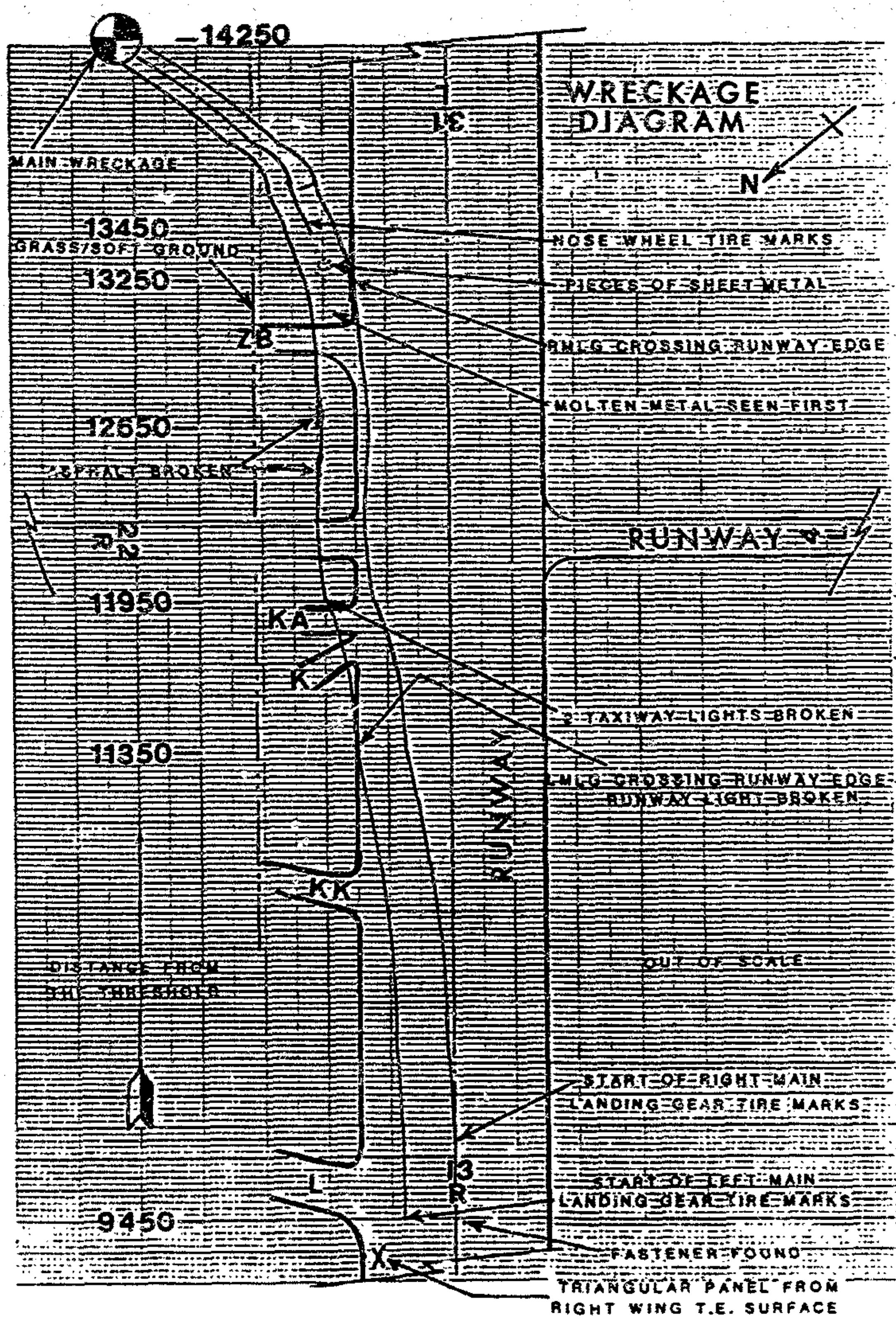

Figure 5.--Wreckage diagram.

main ianding gear, when the airplane was on the asphalt shoulder on the left side of the takeoff runway. They departed the left shoulder of the runway, between the tire marks from the left and right main landing gear.

About 9,500 feet from the beginniig of runway 13R, the strips of tar in the expansion joints between runway sections were more shiny and sticky than normal. There was a strong odor of jet fuel or kerosene but no evidence of burned fuel or fire of any sort at that location.

Although no corresponding runway tire marks were found, the airplane performance study (see section 1.16.6) indicated that the airplane landed in a I-degree right-wing-down attitude, with the right main gear touching first, 9,153 feet from the runway threshold. With the centerline of the airplane about 10 feet to the left of the runway centerline, the right main landing gear touched down about 8 feet to the right of the runway centerline, near the crown or highest point at the centerline of the runway.

A 24- by 10-inch triangular-shaped piece of skin panel was found about 9,350 feet from the beginning of takeoff runway 13R, or about 70 feet prior to the first set of tire marks. The skin panel, which was found about 10 feet to the left of the runway centerfine, was matched to the structure on the bottom inboard side of the right wing of the accident airplane.

A fastener, with an aluminum nut and rubber sealant material atrached, was found at approximately the 9,500-foot mark of the takeoff runway. It was immediately to the right of the mway centerline. The fastener was later matched with the fasteners in the rear spar of the right inboard wing.

A large darkened area on the runway, which progressively widened, was found beginning about 13,250 feet from the threshold of takeoff runway 13R. The right main landing gear skid marks ran through the darkened area. These marks increased in intensity and width until they departed the shoulder on the left side of the runway. The darkened area continued to where the airplane came to rest.

Aluminum splatters were found on the takeoff runway, about 13,000 feet from the threshold and 75 feet to the !eft of runway centerline. Pieces of sheet metal and bits of rubber were found in the blackened area about where the right main landing gear tire marks departed the left side of the runway.

The main gear tire marks departed the asphalt on the Ieft side .of the mway at 13,918 and 14,068 feet, respectively, from the beginning of the runway. The ruts continued to where the airplane came to rest. The main wreckage came to rest, burning, 14,368 feet from the beginning of runway 13R, about 296 feet to the left of the centerline at the departure end of the mway.

1.12.2 The Airplane

1.12.2.1 Fuselage

The airplane was destroyed by fire; however, there was little damage to the fuselage forward of the wing's rear spars. The fire damage was severe in the cabin area, beginning aft of the wing's rear spars.

Intense fire damage existed throughout the empennage. Aft of the forward bulkhead for the coach section, the cabin was substantially burned away. Fuselage skin, frames and stringers were either melted or remained as ash residue, and cabin seats and extensive sections of cabin floor were significantly melted by the fire, leaving a residue of globules of aluminum and ash mixed with the remaining seat and cabin structure. Although the interior of the passenger cabin in the coach class was destroyed, seats forward of the bulkhead between the coach and business class sections were not fire damaged.

There was no heat damage in the cockpit There was fire damage to the left rear of the business class section of the cabin where the fire had broken through the fuselage skin. Otherwise, there was little fire damage to the business class section of the cabin and only smoke damage to the first class section.

After the fii was extinguished, the fuselage remained upright in three large sections. The forward section extended aft to about midway back in the cabin, with this section resting on the wheels of the main landing gear; the second section consisted of the fuselage, from about midway back in the cabin to just before the rear bulkhead; and the third section was comprised of the aft fuselage and empennage, including the rearmost portion of the cabin, as well as the No. 2 engine and engine inlet cowling. The rearmost structure dropped to the ground and rested on the partially burned horizontal stabilizers and underside of the No. 2 engine.

1.12.2.2 Wings

The left wing was mostly unburned. However, there was fire damage where the rear of the left wing joined the fuselage.'

The right wing inboard flap and aileron were destroyed by fire. The upper surface of the right wing exhibited extensive soot deposits that covered the No. 3 engine. The right landing gear was extensively damaged by fire.

The right inboard wing rear spar, which also formed part of the fuel cell wall, was fractured between the right side of the fuselage and the right main landing gear. (See figure.6). M e r the fire was extinguished, fuel continued to drip out of this fracture. The fractures in the right 'wing rear spar were examined in the field by structural engineers and metallurgists; portions of the spar web were brought to the Safety Board's Materials Laboratory in Washington, D.C., for detailed metallurgical examinations.[2]

The detailed examinations of the right wing rear spar revealed no evidence of preexisting fatigue damage. All fractures were found to be caused by overstress forces. There Was no fatigue cracking or progressive failure found in the spar web fracture, or in any other fracture in the structure of the right wing, including stiffeners, upper and lower spar caps, stringers, and skin. Hardness and conductivity measurements of the fractured web material produced results consistent with the specified material.

1.12.3 Engines

The No. 1 engine remained in place attached to its strut beneath the left wing. The engine thrust reversers were fully deployed. There was no fire damage to the engine. All of the fan blades were undamaged. There was no evidence of penetration or other damage to any of the engine rases.

The No. 2 engine sustained severe fire damage and had settled to the ground along with its supporting structure. The fan blades were intact and the thrust reversers were fully deployed. There was no penetration or other damage evident

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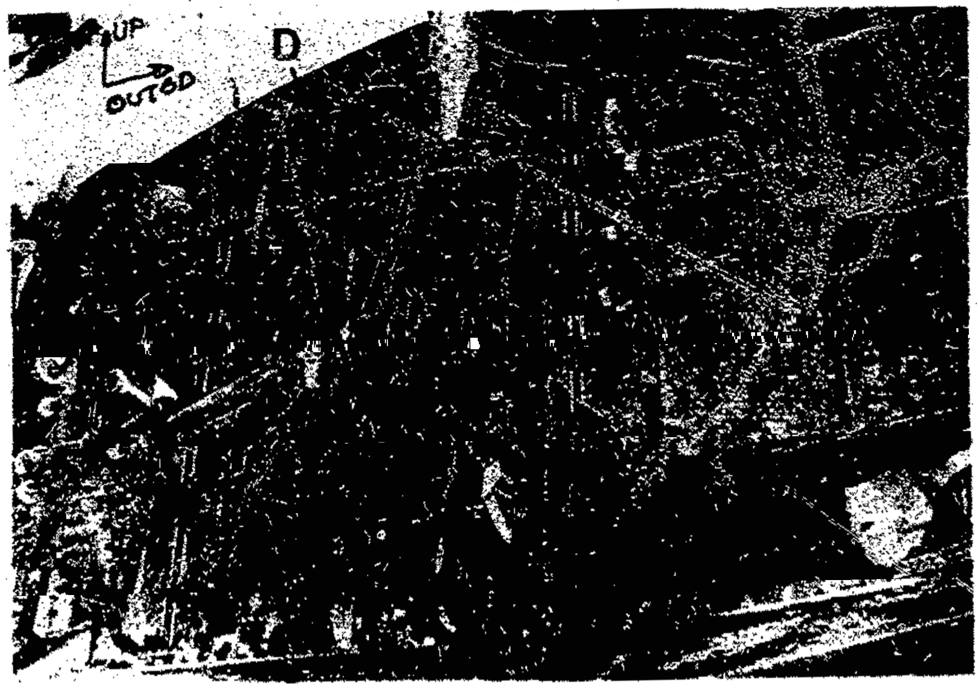
[2]Because of a prior history of fatigue cracks in the wing rear spar web, detailed examinations of this area were conducted to verify that there was no preexisting damage or fatigue that may have been a factor in the accident.



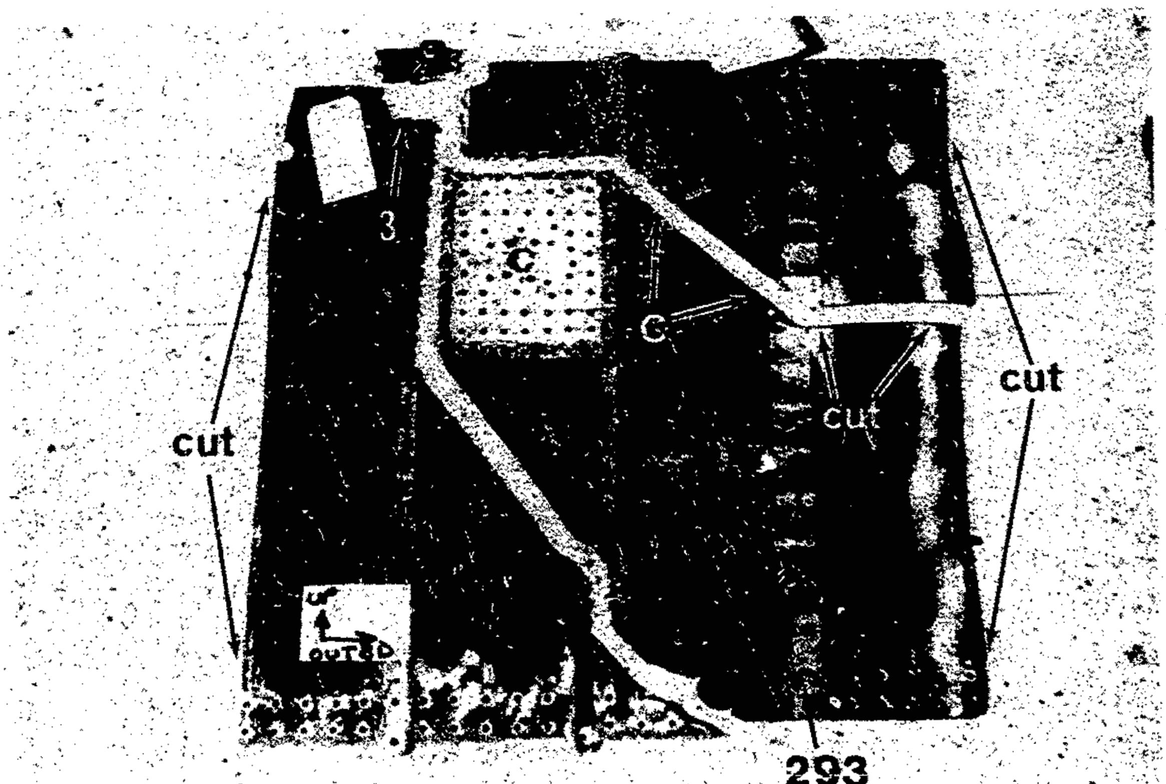


Figure **6.--Right wing spar** damage.

on any of the engine cases. The FDR EPR [engine pressure ratio] values recorded for the No. 2 engine began to show anomalous values as the airplane was decelerating on the runway. These values were followed 17 seconds later by the initiation of the fire warning bell for the No. 2 engine,

The No. 3 engine remained mounted to its strut beneath the right wing. The engine thrust reversers were fully deployed. The leading edges of several fan blades were nicked and torn, outboard of the midspan shrouds; some of the second stage compressor blades also had leading edge damage. The fan rotor could be rotated easily by hand. The last stage of the low pressure turbine was intact and undamaged. There were no penetrations of the engine case.

1.12.4 Aircraft Systems

The cockpit and forward electronics service center system' components were undamaged. Investigators checked the airplane's flight controls and system wiring for continuity. Except where they were damaged by fire, no failures were noted.

The right AOA probe, indicator, and associated stall warning systems hardware were removed from the accident airplane and bench tested under Safety Board supervision at TWA's maintenance facilities in Kansas City, Missouri. (See section 1.16, Tests and Research, for details on the examinations and the maintenance history of the AOA indicators).

1.12.5 Radioactive Cargo

Shortly following the accident, the Safety Board's investigation team received notification that a shipment of radioactive medicine was aboard the accident airplane, stowed in the aft cargo compartment. The Bureau of Radiological Health, New York City Department of Health, was on site when the Safety Board team arrived from Washington, D.C. A Geiger counter examination of the empennage and aft fuselage found no evidence of harmful radiation. With the help of investigators, a representative of the Bureau of Radiological Health found the container of radioactive medicine. The case was not broken, and no harmful radiation was found on a Geiger counter sample of the exterior of the case. The Bureau removed the case and its contents from the site.

1.13 Medical and Pathological Information

All three crewmembers submitted urine samples for besting 'on the morning following the accident. The samples tested negative on a drug screen that.. included barbiturates, benzodiazepine. cocaine, cannabinoids, and opiates.

1.14 Fire

Witnesses observed fuel, mist, or debris escaping from the underside of the airplane or right wing area after the airplane landed on the runway Some of the witnesses described debris coming from the airplane at rotation. However, most witnesses were consistent in stating that the fuel escaped and ignited soon after the airplane touched down on the runway. As the airplane continued down the.runway, the fire was seen traveling along the fuselage. A pilot witness observed that the fire entered the inlet of the No. 2 engine.

The PNY & NJ, which operates JFK, is responsible for police, fire, and rescue functions at the airport. The police incident commander (IC) later stated.that while he was working in his office at the main garage, he heard the crash alarm and the pull-box alarm sound about 1741. He and the ARFF vehicles responded immediately.

The initial response consisted of nine fire fighters and six ARFF vehicles from two fire stations. Two additional reserve trucks responded moments later. Additional police and ARFF officers responded in sector cars from various points around the terminal area. The crew chief of the first ARFF truck to arrive at the crash site reported that the crash alarm and the pull box alarm sounded in the ARFF main garage at airport building 269 about 1741, and that his unit arrived at the crash site 2 to 3 minutes thereafter.

As the vehicles approached the crash site, fii fighters observed thick black smoke and flames rising above the tail of the airplane. Flames were observed beneath the fuselage, especially near the tail, as well as inside the rear cabin. The flames were seen engulfing the No. 2 engine's nacelle.

Fire fighters observed that most of the passengers had already evacuated the airplane. They aimed their turrets and applied aqueous film-forming foam and dry powder chemical agents to protect the remaining three or four occupants who were seen exiting at the L-1 exit. The passengers were gathered on taxiway Zulu, south of the crash site.

As the initial fire fighting vehicles arrived at the site, the fire began to burn through the top of the fuselage. The fire fighters applied extinguishing agent to the fire through the truck turrets and later by means of hand lines. Fire fighting personnel later said that the fire was knocked down within 1 minute after they began to apply the extinguishing agent. However, the fire flared up again and the trucks began to run out of water within about 3 minutes. The trucks began to shuttle to refill their tanks with water from hydrants at taxiway Zulu and at building 269.

The IC stated that water availability was the most critical problem because the nearest hydrant was adjacent to taxiway Zulu, about 3,100 feet from the crash site. He considered pumping sea water from the bay; however, he decided against that because the sea water could clog the pumps. With the help of New York Fire Department personnel and equipment, a hose line was lied to the hydrant adjacent to taxiway Zulu. It is estimated that the hose link was completed about 30 minutes after the first ARFF personnel arrived at the site.

Fire fighters estimated that the fire was substantially out within 5 to 6 minutes. They entered the airplane's cabin, using hand lines, within 20 minutes after arrival. However, the fire continued to smolder and was not totally extinguished until about 40 minutes after the crash.

The IC set up his command post at the intersection of taxiways Zulu and Juliet. Also present at the crash site were representatives from the New York City Fire Department (NYFD), Emergency Medical Service (EMS), and JFK Operations.

1.15 Survival Aspects

All 14 flight attendants (9 duty and 5 off duty or "deadheading") said that the taxi and takeoff roll were unremarkable; however, on rotation and liftoff of the airplane, all of them believed that something was wrong, but they could not specifically relate what it was. Four flight attendants heard an unusual noise prior to landing, and several of them, who were seated in the middle and aft parts of the cabin, heard the engines become quiet. They felt the airplane settle back onto the runway, and they varied in their descriptions of the landing; two of them said that the landing was extremely hard; two stated that the landing was not bad; ana eight had no comment on the severity of the touchdown. Many of them described hearing a "bang," and then they saw fire or an orange glow outside the aft cabin passenger windows. Others saw flames coming through the seals at the bottom and sides of the R-3 door, but they did not recall hearing a bang.

Exits L-1, L-2, and R-1 were used for the evacuation. All of the flight attendants who were seated near the exit doors held passengers back while they assessed the conditions outside their exits. The duty flight attendant at the L-2 door reported that it was "difficult to get a clear picture out the window." She then went to a passenger seat to see if it was clear outside the exit. While doing so, the other flight attendant ("deadheading), who occupied the inboard jumpseat position at L-2, took her place at the L-2 door and said that, "we couldn't see out of the L-2 door window very well." She waited until the other flight attendant told her to open the door. Passengers were jammed at the L-2 door because of the delay in opening. Some of them went forward and used L-1 at the urging of the duty flight attendant.

The R-3 and R-4 doors were not opened during the evacuation because of the fire. The R-4 flight attendant blocked the exit and instructed passengers to go forward. The R-3 flight attendant looked down at the door during the landing roll and saw flames coming in "shooting out like fingers."

The L-3, L-4 and R-2 doors were opened but blocked from use by flight attendants because of fire and smoke.

All of the flight attendants stated that the evacuation was completed in less than 2 minutes. Outside the airplane, the flight attendants gathered passengers together and moved them away from the airplane. All of them stated that rescue personnel were arriving as they evacuated the airplane. None of them saw passengers being injured during the evacuation. However, they did see passengers fall before the airplane came to a complete stop during the landing roll when they attempted to get out of their seats.

Most of the 70 passengers who were interviewed had the same observations as the flight attendants. About 10 passengers, including some with prior experience in L-1011s, stated that when the airplane started to lift off, they had a feeling that it "wasn't going to fly." About nine passengers heard an unusual noise or noises during or just after the airplane left the ground. About five passengers believed that the touchdown was not particularly hard; a few had no comment about the landing; but, most of them said that it was very hard. Many passengers who were in the coach cabin saw an orange glow and fire on the right side outside the cabin windows. After the attendants opened the doors, the evacuation proceeded quickly. All of the passengers stated that the evacuation took 1 to 3 minutes and that rescuers were seen as they were evacuating.

The initial medical response was provided by two PNY & NJ police ambulances, which were stationed at the airport and responded with the ARFF trucks. EMS personnel on those units initiated a triage area adjacent to the IC command post.

The first New York City Health and Hospitals Corporation EMS ambulances were on the scene at 1802. Excess ambulances were staged at the TraveLodge Hotel, adjacent to the airport. They were dispatched as needed to PNY & NJ Headquarters at building No. 269, northeast of runway 14/32, from which they were escorted to the crash site. Twenty EMS personnel were assigned to the triage area, and 15 ambulances were brought to the crash site to transport passengers to area hospitals. An additional 40 to 50 ambulances staged at the TraveLodge were not called for assistance.

Of the 40 persons transported by ambulance to six area hospitals, 34 were passengers, and the rest were rescue personnel. Twenty-five passengers, eight New York City Fire Department personnel, and two ARFF personnel were treated at the scene and released from immediate care. Most of the passengers that sustained minor injuries did so during egress via the airplane's emergency exits and slides.

1.16 Tests and Research

1.16.1 Stall Warning System Operation

The L-1011 airplane has two independent systems to alert the flightcrew that the airplane's AOA has reached a value approaching the AOA at which aerodynamic stall occurs for the given airplane flap/slat configuration. The systems are redundant in that one will activate a stickshaker to vibrate the captain's control column while the other will activate a stickshaker to vibrate the first officer's control column. Since the control columns are mechanically connected, the activation of either stickshaker will be sensed by both pilots. The airplane also has two independent sensors to measure AOA that provide the electrical signals to the stall warning systems, as well as other system that use AOA data in their logic. The signals from both of the AOA sensors are also recorded on the FDR.

One element of the AOA sensor is a tubular probe that protrudes into the airstream. One is located on each side of the fuselage below the cockpit side windows. There are two rows of holes through the wall of the tube that are separated by an angle of about 90 degrees. The dynamic pressure measured by each row is applied to opposite sides of a diaphragm so that the differential pressure acting on the diaphragm is a function of the angular position of the tubular probe relative to the direction of the airstream. (See figures 7 and 8).

When the diaphragm senses a differential pressure, an electrical signal is provided to a servomotor which will rotate the tubular probe until the pressure across the diaphragm is balanced and the electrical signal is nulled. Thus, when functioning properly with the servo loop nulled, the angular position of the tubular probe relative to the fuselage of the airplane is an indication of the direction of the airflow relative to the fuselage, which. in turn, correlates to the airplane's AOA. The angular position of the tubular pmbe is provided to the stall waming system through the Flight Control Electronic System (FCES) computer and other airplane systems as a proportional electrical voltage.

Because the AOA sensor requires the dynamic pressure created by air speed to operate, the angular position of the tubular probe and the corresponding transducer output voltage is meaningless when the airplane is at rest or at the lower speed segments of the landing roll or the beginning of takeoff. Therefore, the activation of the stall warning stickshaker is inhibited until an air-ground switch on the main landing gear strut senses the extension of the strut that occurs at liftoff,

Two switches, (called switchlights, since they illuminate to display system status) located on the cockpit overhead panel, control power to stall warning systems No. 1 and No. 2, respectively. With electrical power on the airplane, the switchlights will illuminate an "OFF" legend that will extinguish when the switches are depressed and power is applied to the stall warning system. The systems have a self-monitoring feature that will cause the "FAIL legend to illuminate in the switchlight under certain conditions. One of these conditions is a failure of the servomotor in the AOA sensor to rotate the tubular probe to null the electrical signal from the pressure diaphragm. The circuitry includes a time delay to prevent nuisance fail indications so that an error signal output from the pressure diaphragm

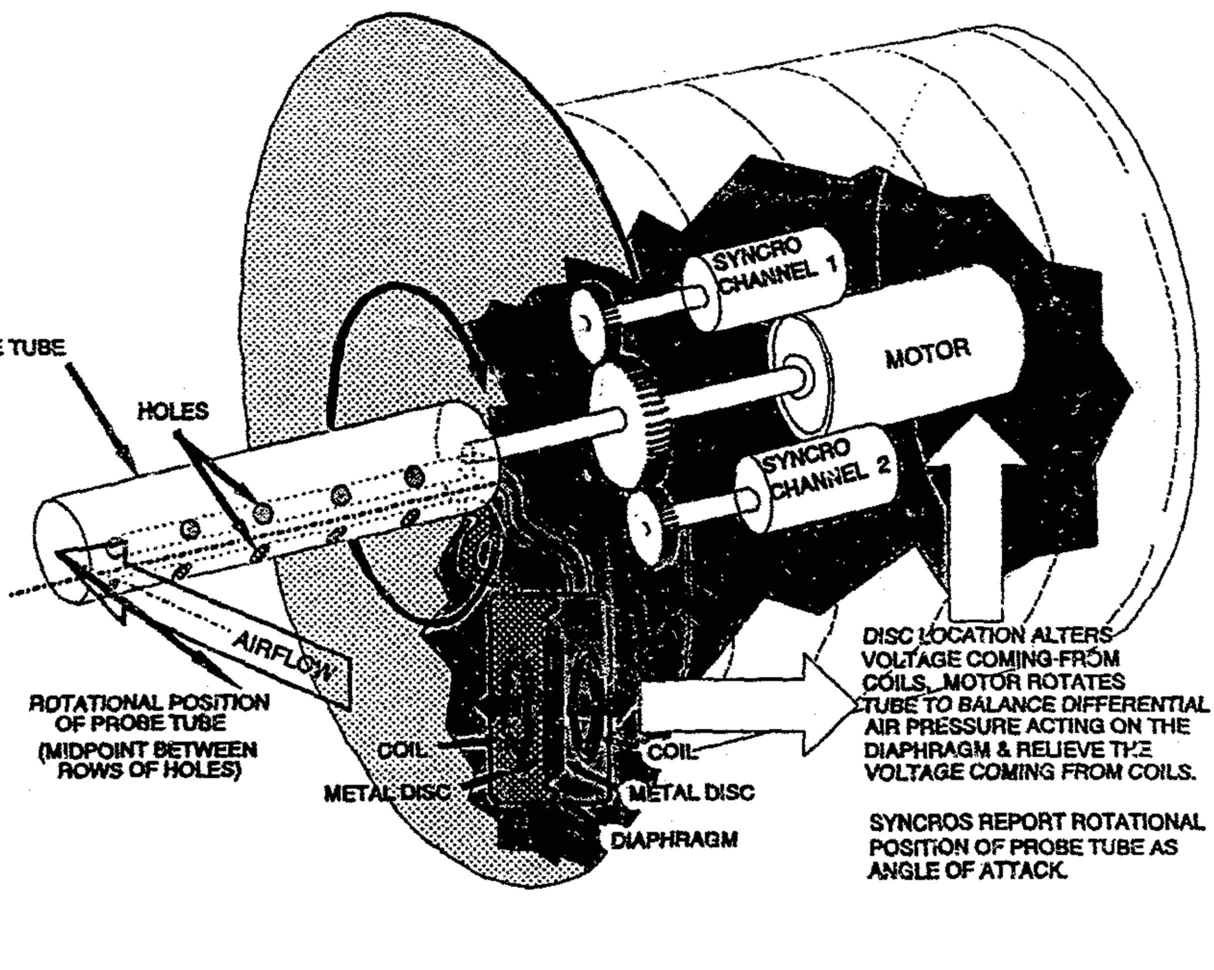


Figure 7.--Angle of attack probe basic components.

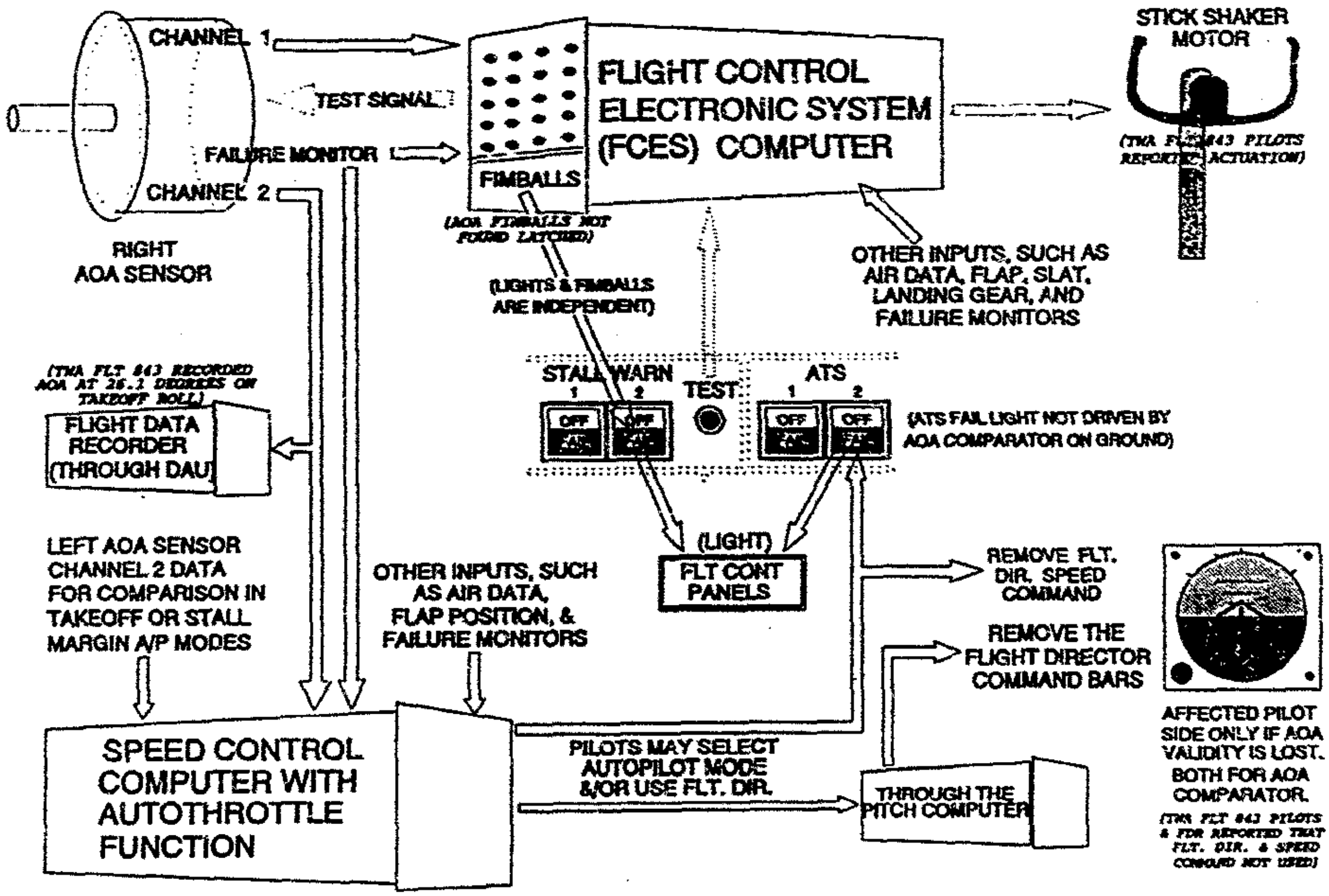


Figure 8.--Stall warning and ATS fail block diagram.

that persists for more than 10 seconds will cause a system fail indication. The illumination of the fail light would also cause an amber light, with the legend FLT CONT PANELS, to illuminate on the lower part of the pilot's center instrument panel. The purpose of this light is to direct the pilot's attention to the overhead panel to ascertain the source of the problem.[3]

The L-1011 stall warning system also incorporates circuitry that provides for a ground test that is routinely accomplished by the flightcrew during preflight checks![4] The crew of flight 843 reported that the test was performed with normal results. An examination of the AOA sensor and stall warning system disclosed that the depression of the ground test button applies an electrical signal directly to the servomotor that drives the tubular probe through its range of rotation with the corresponding changes in AOA signals. The ground test bypasses the air-ground logic switch to simulate the "air" mode, permitting activation of the stickshaker motors when the appropriate AOA signal is received. It was determined that, because the ground test electrical signal is applied to drive the AOA probe servomotor, a failure within the electrical circuitry between the differential pressure diaphragm and the servomotor will not be detected during the preflight ground test. Further, it was determined that a discontinuity or short within the differential pressure diaphragm circuitry that resulted in a loss of the error signal would not be detected by the continuous self-monitoring function. Thus, such a failure would result in an erroneous AOA signal to the stall warning system that would not be detected during the ground test and would not result in illumination of the fail light in flight.

The left and right AOA sensor output signals are also provided to the airplane's speed control computer for use in autopilot, flight director and autothrottle logic functions. Because accurate AOA signals are critical to these functions, the speed control computer incorporates logic to compare the signals from the left and right AOA sensors. Should the speed control computer detect a difference between the left and right sensors of more than 11 degrees, certain functions of the flight director (FD) and autothrottle systems (ATS) are disabled. Since the accuracy of the AOA sensors depends on dynamic pressure at the tubular probe, the comparison circuitry is inhibited when the air-ground logic is in the "ground' mode. In addition, there is a 2-second delay incorporated into the AOA comparison circuitry.

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[3] This check would have come before the announcement "Welcome aboard...." by the captain, which was the first voice on the CVR recording.

[4] The crews reported checking the stall warning and autothrottle systems (ATS) switches when conducting the preflight checks.

Two switchlights, adjacent to the stall warning switchtights on ?he cockpit overhead panel, control power to the airplane's redundant autothrottle systems. These switchlights also illuminate to indicate the QFF or FAIL status of the systems. The switches for the No. 1 and No. 2 autothrottle systems are normally depressed to provide power to the systems during pretakeoff checks. If, upon ?he airplane's leaving the ground, the speed control computer senses a difference of at least 1I degrees between the left and right AOA sensors for up to 2 seconds, the ATS switchlights on the overhead panel should illuminate to indicate FAIL, and the amber FLT CONT PANELS.light on the center instrument panel will illuminate. Further, if the FD is in use in the takeoff mode, both pitch command and fast/slow indications will be removed from the FD display above 90 knots.[5]

The flightcrew of flight 843 did not report observing the illumination of STALL WARNING FAIL, AT§ FAIL, or FLT CONT PANELS lights during the takeoff and landing. These waning lights would not be indicated on the FDR.

In addition to producing FAIL light indications, detection of failures within the AQA system causes either the right or left fault isolation monitor (FIM) ball on the FCES computer in an electronics bay to magnetically latch for the failed system until the next takeoff; the switchlights and FIM balls operate independently.

1.16.2 Stall Warning System Component Examination

1.16.2.1 Angle of Attack Sensor Examination

The stall waning system components were removed from N11002 and tested at the TWA maintenance facility. The right AOA sensor was also tested at Sundstrand Data Control. The left AOA sensor was found lightly sooted. The Pitot-static holes. were clear, and the electrical pins were straight and clean. All bench tests were passed successfully, except the probe range of travel, which was out of tolerance at the extreme limit.

The right AQA sensor was also lightly sooted. All Pitot-static holes were clear, the electrical pins were straight and clean, and there was no evidence of bud strike damage to the right sensor. The probe rotated within maintenance manual tolerances. There was no binding in the probe rotate drive assembly.

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[5]These warning lights and the fault isolation monitor (FIM) ball positions are not recorded on the 116-parameter FDR.

The right sensor was also bench tested. The sensor stopped movement on four different occasions and errors were recorded at four different angles. Although the errors in AOA position were found in two FDR recordings and in two ground tests, the accident flight had the only error sufficient to reach the documented stickshaker limits.

When power was first applied to the right sensor, the AOA signal changed rapidly and a failure was indicated after 10 seconds. Power was then cycled off and on. The sensor again indicated a failure after 10 seconds. When electrical power was cycled again, the probe operated normally without another failure indication, Attempts to induce a failure by gently moving the internal wiring were unsuccessful. The probe successfully passed all tests after the initial failures.

Upon further evaluation at Sundstrand, it was found that tapping on the internal pressure transducer could cause an intermittently false value of AOA. Subsequent taps an this transducer caused the unit to report the correct AOA. The observed failure created a 4-degree error in the reported AOA but not the sticking at 24.1 degrees, as seen in the accident FDR data. The investigation concluded that the "failure was due to intermittencies in coil of pickoff."

1.16.2.2 Flight Control Electronic System Computer Testing

Two FCES computers were bench tested as part of the investigation. The first FCES computer tested (Serial No. 48) was the unit removed from N11002 following the accident. Visual inspection of the FIM balls found that none were latched (no faults). An automated equipment test was performed, and the only failure detected was in a power supply over-voltage protection circuit. Ail other tests of the stall warning system were successfully completed.

The second FCES computer (Serial No. 60) tested was the unit that had been removed from N11002 following a July 8, 1992, incident at JFK (see section 1.16.3). It had not been tested or repaired before the accident occurred. Examination of this unit revealed that the following FIM balls (faults) were latched: COMPUTER FAULT, NORM ACCEL, YAW SAS SERVO 2, and DLC SERVO2 (they were not related to the AOA defect). The checkout by the automated test equipment was successfully passed with no failures indicated.

1.16.3 Maintenance History of Stall Warning System

With the exception of the right AOA indicator and associated components, there were no noteworthy areas found in the maintenance history of the accident airplane. The history of the stall warning/stickshaker system on the accident airplane showed that on July 8, 1992, a pilot-written aircraft maintenance log entry was made on airplane N11002, when the airplane was at JFK. It stated:

> Control column shakes during rotation and in flight for no apparent reason, and ATS fail lights on. Fault isolated to stall warn[ing] sys[tem] 2. By pulling 2F2 CB [circuit breaker] fault was isolated. Unlatching stall warning switches on FCES panel did not stop control column shake. (Reset on approach OK).

The corrective action taken by TWA maintenance was: "Replaced FCES [computer], Ops good."

A maintenance records examination at TWA maintenance headquarters in Kansas City, Missouri, disclosed the following history regarding the No. 2, or right AOA, sensor that was installed on N11002 at the time of the July 8, 1992, incident.

The right AOA sensor (Manufacturer's Part No. 329-9806-010 and TWA Serial No. 544) was obtained by TWA in January 1989 through an exchange program with the American Trans Air Corporation. The sensor arrived at TWA with the following noted:

> Reason for Removai: Stall warn fails test (ATA unit)

> Findings and Repair: Confirmed short in J-2 connector burned out T-1 Xformer. Pickoff bad and four wires to pickoff broken. Replaced wire harness, pickoff & resist assy. and T-1 xformer. Performed [obscured] & calibd.

The maintenance records indicate that the right AOA sensor flew on a TWA L-1011 airplane for 2,640 hours without discrepancy. However, beginning on November 30.1989, it was removed and repaired eight times by TWA maintenance with the following elapsed flight hour intervals between failures: 31, 42, 56, 349, 19, 1, and 24. After each maintenance action, the part was reinstalled on various TWA L-1011s, until it was installed on N11002.

The right AOA sensor had been installed on N11002 for 1,467 flight hours until the accident. These 1,467 flight hours included operation following the July 8,1992, incident and pilot writeup at JFK, after which the FCES computer was replaced.

TWA maintains a record of AOA sensor repair history for individual components. This is independent of the maintenance records for the individual airplanes that the sensor had been installed on. The removals and repairs for AOA sensor, Serial No. 544, were listed on the TWA maintenance data sheet as the following:

> Removal--November 30,1989. # 1 stall warning fail light ON with flaps down - A/C on ground. Reset. No help. Repair--December 6, 1989. Could not confirm. Tested O.K. for four hours.
>
> Removal--February 6, 1990. Inop. Repair--March 6, 1990. Could not confirm. Tested O.K. for 7 hours.
>
> Removal--May 31, 1990. Stall warn fail lite steady ON. Repair--July 26, 1990. Tested O.K. for 3 weeks.
>
> Removal--September 6, 1990. Fail lt [light] ON on test pnl. & Fail bal: on FCES computer. Repair--Confirmed - Burned pin in J-1 connector. Repaired & tested.
>
> Removal--December 8, 1990. NBR 1 stall warning won't test. Repair--December 19, 1990. Could not confirm - Tested O.K.
>
> Removal-42 stall warning illum. on grd and could not ext. Repair--March 12,1991. Tested O.K. for 4 hours.
>
> Removal--September 3, 1991. Fail lt ON. Repair--October 14, 1991. A1Q10 open & pickoff defective. A1Q10 and pickoff.
>
> Removal--December 29, 1991. No tag. Repair--January 4, 1991. Cleaned pin g on J-1 connector as precaution and tested.

1.16.4 TWA AOA Sensor Reliability Control

The TWA Reliability Control **Specification for** the **AOA sensor** *stated* **a policy** by **which** chronic **or** repetitive malfunctions were **to** be identified, and **it specified** the **additional action required before returning the part** *to* service. **The specification did not** allow **for time** spent in storage and *stated* **the following:**

1. Unit removed twice **in <u>60 days</u> €or** same **type** fault **will** require **supervisor** approval **prior** ***to*** **returning** to service.

2. Unit removed three times **in** <u>90 days</u> for **any** type fault that has not been verified will *require* **supervisor** approval **prior** to **returning to** service.

3. Unit removed **four times in** <u>180 days</u> for any reason will **require** engineering approval prior **to returning to** service.

There were **nine** failures of the **40A sensor** installed on the right side **of N11002** between November **30,1989,** and the day **of the** accident. **Eight of** these **failures** occurred **after** relatively short fight hour *time* **spans.** However, **they did not occur** within the <u>calendar day</u> time minima described by the operator's **Reliability** Control **Specification. Therefore,** no additional approval was required to return the part to service **after** each removal.

The timeframe used in **the AOA** Reliability **Control** Specification is **also used** in *the* Reiiability Control Specifications **for other** condition-monitored **avionics** components **used** by TWA. **TWA personnel** reported that similar **specifications** are **used on other** airlines' **airplanes for** which **TWA** provides **maintenance** services. The **TWA** multiple return program was approved by ***the*** **FAA as** a **part of** the TWA **maintenance program.**

1.16.5 Recent L-1011 Stall Warning Incidents

curing the investigation, the Safety Board received **an** undated **Flight** Debrief form[6] with a letter, **dated August** 13, 1992. The Flight Debrief form was **signed by the captain of a** July **16, 1992,** TWA **flight from Los** Angeles to **San** Diego ***to*** **St. Louis. The** letter was signed by the **first** officer of **that** Same **flight.**

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[6] A TWA form intended for flightcrews to describe in detail certain abnormal events

Both documents described two stickshaker stall warnings experienced on successive takeoffs. In each case, the pilots stated that the stickshaker had activated after liftoff and FAIL lights had illuminated. The captain's Flight Debrief stated in part:

> The preflight, taxi and takeoff up through the liftoff were normal; however, after the liftoff the stickshaker activated on a continuous basis. The air speed showed V_2 + 2 or 3 knots, the takeoff/climb attitude was normal, and all center panel engine indications were normal. The aircraft flew normally, and responded to control inputs normally. I instructed the F/O (first officer) and F/E {fright engineer) to deactivate the stickshaker while I flew the aircraft. In all, the stickshaker was activated for approximately 15 seconds. En route, while at cruise altitude, [the F/O and F/E] briefed me that at the time the stickshaker activated, the "flight control panel, and both stall warning, and both ATS "Fail" lights on the pilots overhead panel illuminated, and that the stickshaker stopped when they turned off the # 1 ATS. We restored both stickshaker (stall warning), and both ATS systems and they operated normally for the remainder of the flight. In SAN we discussed the situation with MCI maintenance and were cleared to operate to STL. The SAN-STL leg was piloted by [the F/O] and the stickshaker problem and resolution was virtually a carbon copy of the previous leg.

1.16.6 Airplane Performance Study

1.16.6.1 Accident Conditions

The following airplane and ambient conditions were used in the computer performance study:

1) 10-degree flap setting for takeoff

2) Airplane takeoff gross weight of 428,000 pounds

3) 4.2 units up stabilizer trim

4) Takeoff EPR (engine pressure ratio) of 1.486 (reduced thrust)

5) Calculated V_1 of 140 KIAS, V_R of 155 KIAS, and V_2 of 164 KIAS

6) Winds from 150-degrees magnetic at 10 knots

7) Field elevation of 12 feet mean sea level

8) Altimeter setting of 30.01 inches of mercury

9) Ambient Temperature of 76°F

10) Zero runway gradient

The wind at the time of the accident (reported 150-degrees magnetic at 10 knots) yielded a headwind component of 9.6 knots and a crosswind component of 2.8 knots for takeoff on runway 13R.

1.16.6.2 FDR Data as Used in the Performance Study

The FDR data showed that the airplane was rotated at the calculated or target V_R of 155 KIAS, which was reached at 1741:03. The airplane's pitch attitude began increasing less than 1 second after V_R, with the airplane at approximately 158 KIAS. Liftoff occurred at a pitch attitude near 11 degrees airplane nose up, about 5 1/2 seconds after the start of rotation. The average rotation rate was about 2 degrees per second.

The normal acceleration data is sampled four times per second, and the air-ground switch is sampled once per second. Examination of the normal acceleration data revealed an offset of 0.13 G, and the data were adjusted accordingly.

As would be expected, the normal acceleration increased during liftoff. Correcting for the offset, the normal acceleration rose above 1 G at around 1741:07.5. The air-ground status had switched to "air" at 1741:08.14. However, the normal acceleration values were above 1 G for only about 2 seconds, instead of the 5 to 7 seconds required for transition to climbing flight. The normal acceleration values then decreased to about 0.8 G until ground contact. At 1741:13.23, the normal acceleration started a sharp rise. Loss of recording synchronization occurred at 1741:13.29, and the air-ground switch showed "ground" by 1741:14.14. The peak G load of 2.016 (corrected to about 1.9) was recorded at 1741:13.74, or 0.45 second after the loss of the synchronization. The airplane was airborne for about 6 seconds.

It is unlikely that the peak normal acceleration occurred at one of the sample times, and the accelerometers are not designed to measure impulse-type accelerations. Therefore, the peak recorded value of 2.016 (corrected to about 1.9) is most likely not the peak value experienced by the airplane.

The peak pitch attitude, recorded when the airplane was airborne, was about 12.6 degrees. This value was reached about 1 second after liftoff. The pitch attitude indication on the FDR then decreased at a rate of between 1.5 and 2.0 degrees per second, until touchdown, which occurred at approximately 5-degrees (nose up) pitch. Also, at touchdown, the AOA was about 7.68 degrees. The pitch attitude of 5-degrees nose up and the positive AOA of 7.68 degrees result in a calculated flightpath angle of 2.68 degrees down. Since the air speed was 181 KTAS, the resultant vertical velocity at touchdown was determined to be about 14 feet-per-second down. Radar altitude and pitch data were also used to determine that the average vertical velocity for the final second before touchdown was about 10 feet per second. Both of these values are significantly higher than the design velocity of 6 feet per second specified in 14 CFR Part 25.473.[7]

The FDR shows that the thrust reversers on all three engines deployed about 3 seconds after touchdown. After a momentary decrease, engine EPR values increased to normal reverse thrust levels. The airplane came to rest approximately 33 seconds after touchdown. The average rate of deceleration during the braking phase was approximately 5 knots per second. The FDR data show that the right wing ground spoiler took about 20 seconds to fully deploy after touchdown, compared with the left side spoiler which deployed within 3 seconds after touchdown.

1.16.6.3 Position and Time Calculations

The FDR parameters of air speed, heading, time, winds, and temperature data were integrated by computer to determine the airplane's

[7] 14 CFR Part 25.473, paragraph (1) specifies, in part, "The selected limit load factors at the center of gravity of the airplane may not be less than the values that would be obtained--...(iii) With a limit descent velocity of 6 fps at the design takeoff weight (the maximum weight) for landing conditions at a reduced descent velocity."

position-time history. The plots in Figure 2 are the result of this computer integration.

The start of the takeoff roll was estimated to have been about 300 feet from the beginning of runway 13R. The runway heading, as recorded by the FDR, was approximately 133 degrees magnetic. Indicated air speeds are not considered accurate at low speeds (below 45 KIAS); therefore, a correction was applied that assumed a normal air speed increase during the low speed portion of the ground roll. Ground speeds were determined by correcting true air speeds for the reported winds.

The expected takeoff performance for TWA flight 843 was calculated by the airplane manufacturer, based on the assumed accident conditions and scheduled EPR values for engine thrust. Those results, which were compared to the performance data derived from FDR, CVR, and data from the accident scene, are as follows:

Expected Performance	Actual Performance	Event
140 KCAS	140 KCAS	Brake release to V₁
4,232 Feet	4,304 Feet	
37.4 Sec.	38.4 Sec.	
158 KCAS	158 KCAS	Brake release to rotation
5,761 Feet	5,772 Feet	
44.8 Sec.	44.6 Sec.	
166 KCAS	168 KCAS	Rotation to liftoff
892 Feet	1,390 Feet	
3.4 Sec.	5.3 Sec.	

The actual and expected performance values were similar, except for the time and distance from rotation to liftoff. The manufacturer assumed that a standard 3-degree-per-second pitch rate was executed when, in fact, the pitch rate was about 2 degrees per second. This accounts for the differences in the time and distance from rotation to liftoff.

The airplane position data derived from the FDR indicate that liftoff occurred at 168 KIAS, approximately 7,462 feet from the beginning of the runway. Touchdown occurred at 178 KIAS, approximately 9,153 feet from the beginning of the runway, with 5,419 feet remaining.

1.16.6.4 Comparison of FDR Data

The evaluation of the airplane's performance during the takeoff included the use of an analytical simulation model of the L-1011 by Lockheed. The analytical simulation model was used to evaluate the airplane's performance during the accident takeoff, along with two previous takeoffs, to validate that the computer program accurately predicted the response of the airplane to horizontal stabilizer inputs.

The results of the computer modeling of two previous flights (one with a takeoff weight close to the accident flight) validated the modeling techniques used to predict the response of the airplane to horizontal stabilizer inputs.

Figure 9 depicts the flight control inputs and response of N11002 during the accident takeoff. The control column positions recorded for the captain and first officer agree within approximately 1 degree. The two control column curves track each other and appear normal. The stabilizer movement is consistent with changes in control column position, and the pitch attitude curve responds to changes in stabilizer position. The actual altitude of the main landing gear (derived from FDR radar altitude) indicates that the airplane climbed to a peak altitude of approximately 16 feet. Altitude values then begin to decrease, consistent with the decreasing pitch attitude of the airplane shortly after liftoff.

The Safety Board also made comparisons of the horizontal stabilizer movements and pilots' control column movements for the accident flight and eight previous takeoffs recorded on the FDR.

Figure 10 shows the horizontal stabilizer movement after liftoff for the accident and eight previous takeoffs. This figure shows the change in horizontal stabilizer position with respect to its position at liftoff.

During the first 3 seconds after liftoff, the previous takeoffs show a positive trend (airplane nose up, A.N.U.) of horizontal stabilizer movement during the initial climbout. Stabilizer positions for the accident flight reveal a negative (airplane nose down, A.N.D.) rotation of the horizontal stabilizer during the first 3 second time period.

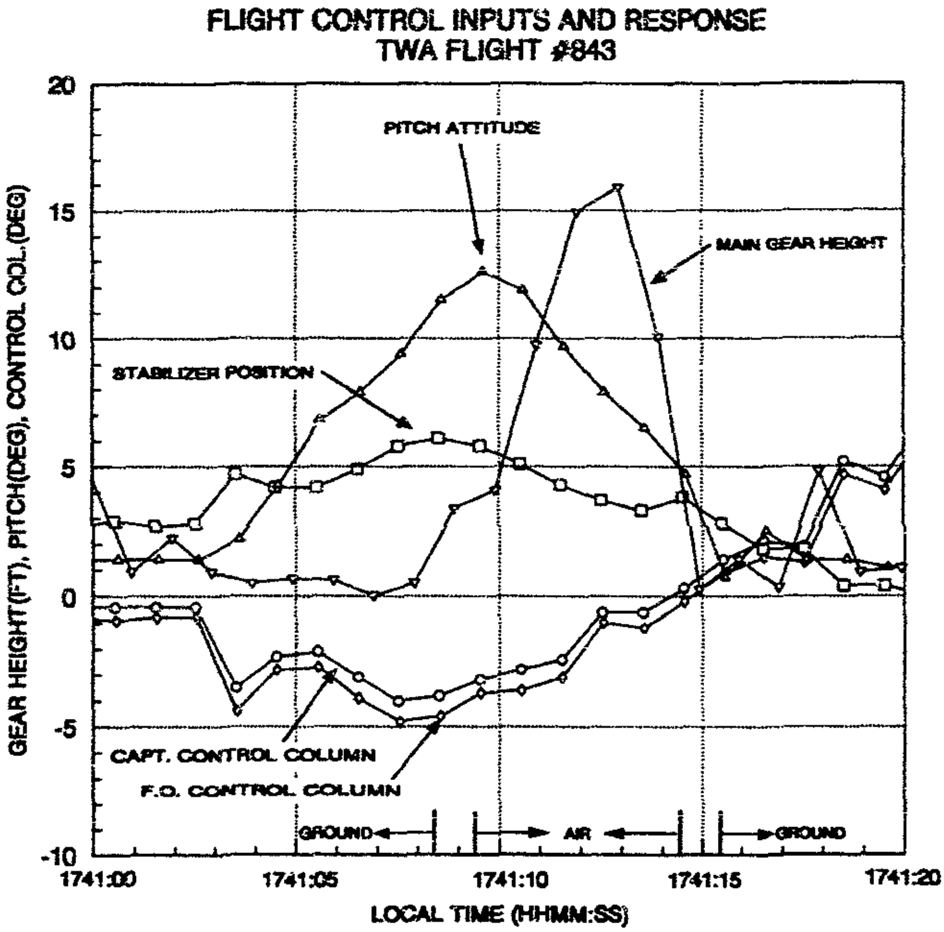

Figure 9.--Flight control inputs and airplane response.

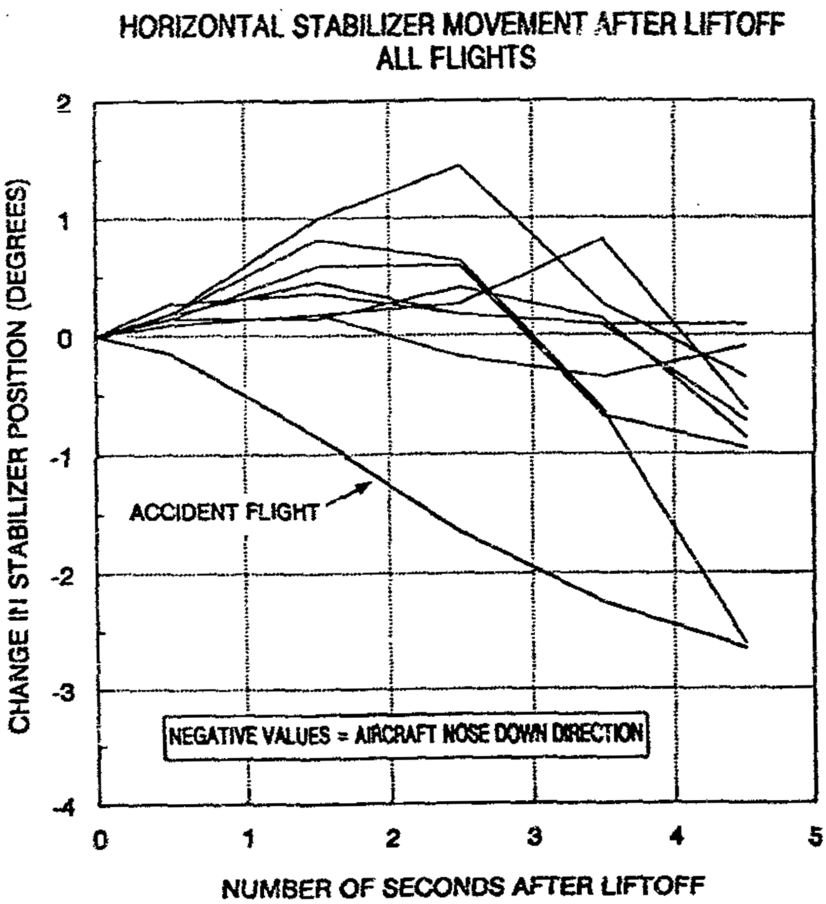

Figure 10.--Horizontal stabilizer movement after liftoff.

Figures 11 and 12 show the pilots' control column movements after liftoff. These plots show the change in control column position with respect to the control column position at liftoff. During the first 2 to 3 seconds after liftoff, the previous takeoffs show a negative, or *aft* control column trend (aft A.N.U.) during the initial climbout. The accident flight control column positions reveal a positive, or forward control column movement (forward A.N.D.) during the first *3* seconds.

The movements of the control columns and horizontal stabilizer after liftoff indicate that a forward movement of the control column occurred earlier on the accident flight than on the previous eight takeoffs. The control column on the accident flight moved forward immediately after liftoff, several seconds earlier than any previous takeoff recorded by the FDR. The forward control column movement occurred at an altitude of only 4 feet, which is inconsistent with FDR data from previous takeoffs. The FDR does not record the control forces used by the pilot; it records only column position. Figure 13 shows the overall flight performance data of the airplane.

1.17 Additional Information

1.17.1 TWA Procedures

The investigation of this accident included interviews and meetings with TWA senior and standardization captains, as well as operational and maintenance managers, to discuss training and procedures for the takeoff sequence. The interviews were supplemented by simulator flights, involving problems and annunciator lights during the takeoff sequence.

It was noted that in the late 1960s, with jet transports established in its fleet, TWA adopted a philosophy that it is better to continue with a takeoff, when nearing V_1, than to reject it. With that philosophy in mind, a senior captain stated that the decision to reject must be made before V_1 and that by V_1 the rejection must be fully in progress, with maximum braking initiated and throttles back to idle.

In flightcrew simulator training sessions, engine failure and other malfunctions are experienced at high speed during takeoff. It was pointed out by the TWA training personnel that this emphasizes *"go"* considerations at high speed. Results from rejected takeoff (RTO) studies indicate a reaction time of *2* seconds for a pilot to identify and initiate the RTO procedure. Assuming an acceleration value of 3 to 6 knots per second, TWA training and checking personnel stated that if

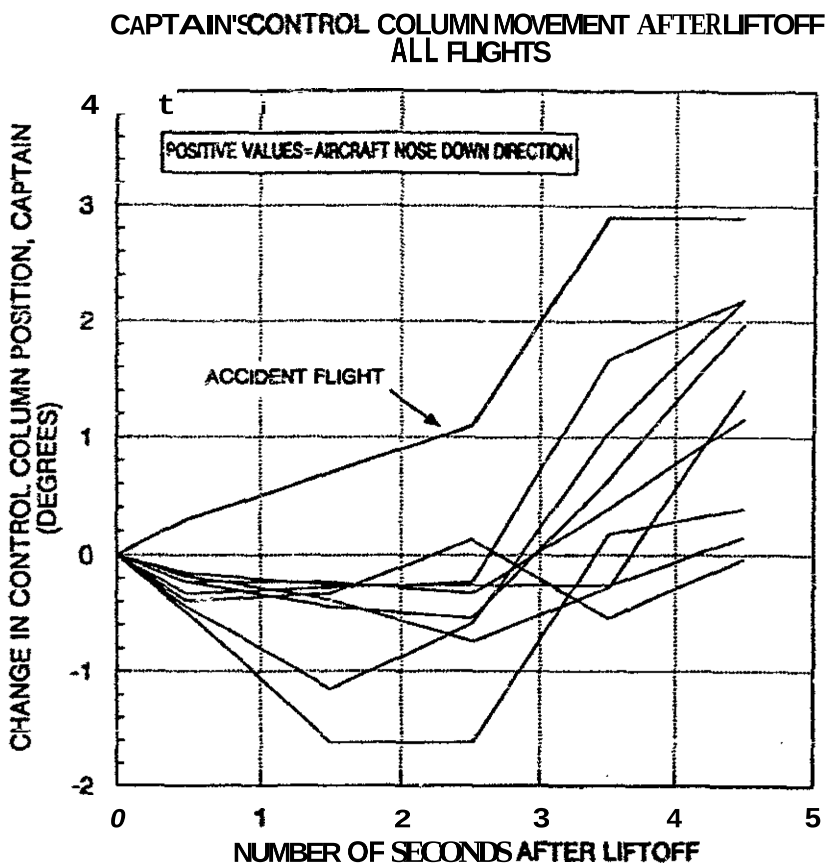

Figure 11.--Captain's control column movement after liftoff.

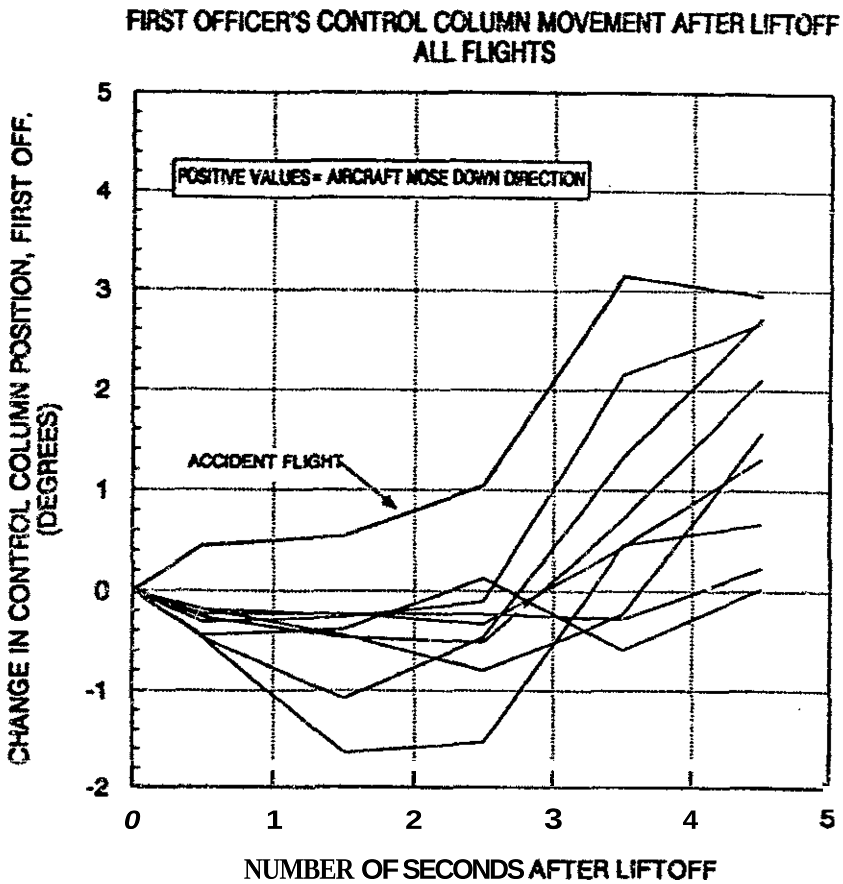

Figure 12.--First officer's control column movement after liftoff.

TWA **FLIGHT** 843

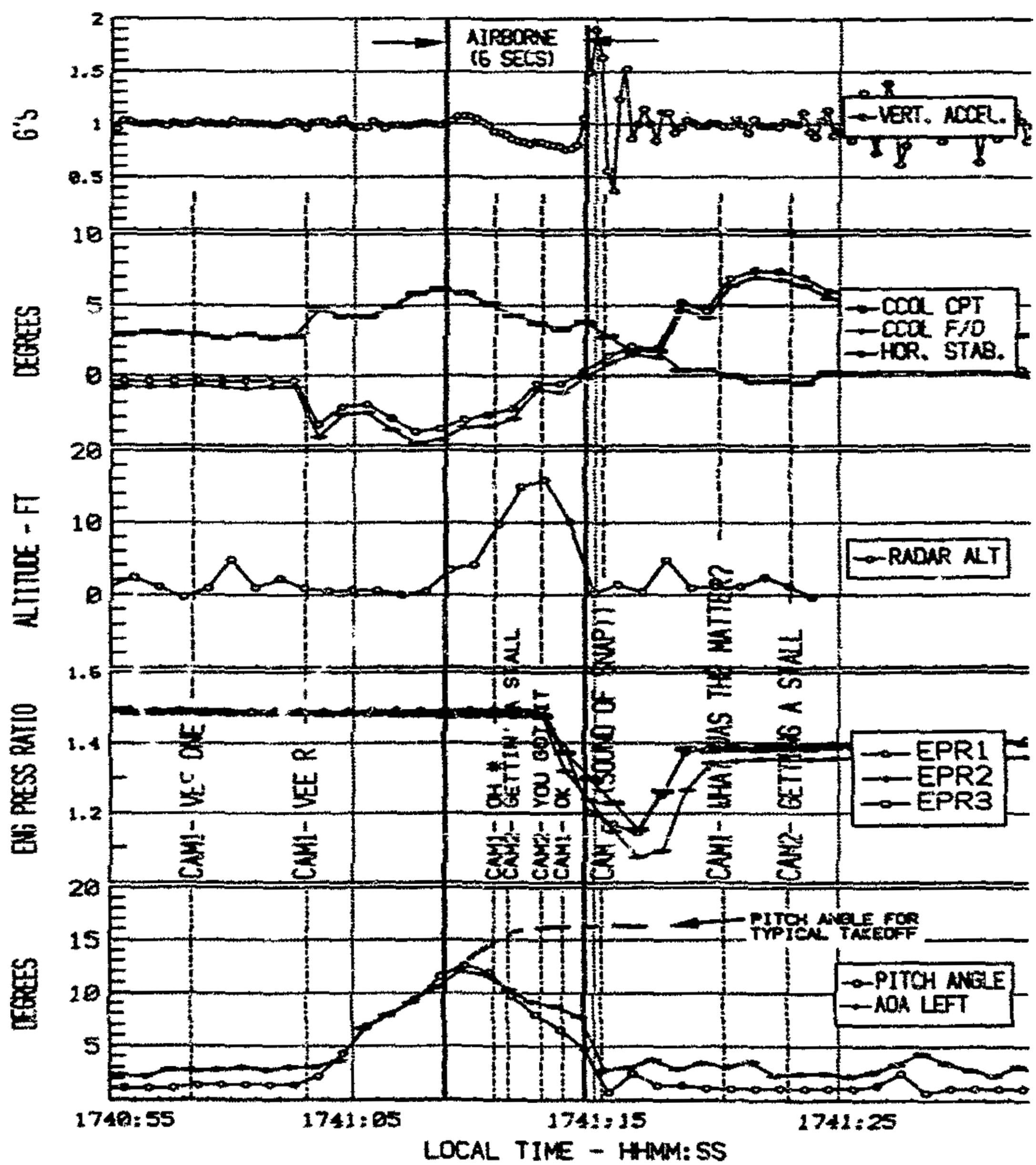

Figure 13.--Flight performance data.

a pilot had an engine failure at V_1 minus 5 knots, it would be considered appropriate to continue with the takeoff.

These concepts and procedures have been emphasized in annual symposia given to TWA check airmen and instructor pilots. Each year, there were flight instructor meetings at each TWA domicile. Lii flightcrews have had the opportunity to meet with flight operation staff at "Let's Talk Safety" meetings.

Interviews and meetings revealed that training and simulation concerning the decision on whether to continue or reject a takeoff were related to an airplane still on the runway. No formal training or procedures specifically addressed the conditions involving abnormal events or false warnings immediately after liftoff from the runway. Further, TWA does not require a verbal pretakeoff briefing regarding the handling of abnormal or emergency events on takeoff.

A review of section 10 sf TWA's Right Operations Policy Manual, dated September 10, 1982, refers to RTQ procedures. It states, in part, the following:

> A. ecision to Reject Takeoff
>
> During the takeoff roll, immediate attention should be given to any abnormal conditions which would indicate the desirability of rejecting the takeoff as a precautionary measure. If at all possible, this decision should be reached before attaining high speed.
>
> Rejecting a takeoff at a high speed is a critical maneuver. Considering a condition of maximum weight for the runway,. a rejected takeoff at V_1 that is perfectly executed will require all of the remaining runway ....
>
> B. Considerations
>
> ...V_1 has been referred to as the "decision speed." It is interesting to note that 2 seconds are allowed for this decision. By definition, V_1 is the speed at which point the pilot is offered two prerogatives, to continue, or to stop. Considering that the aircraft is loaded for the runway, it is only at this point that the aircraft has the capability of doin„ either. Below V_1, the aircraft does not have the Capability

of accelerating to the required liftoff speed and climbing to 35 feet by the end of the runway. Above V_1 the aircraft does not have the capability of stopping on the remaining runway....

V_2: Maximum performance speed. V_2 provides 20 percent protection over stall for takeoff fiap configuration....

The procedure for stall recovery (practiced in the simulator at altitude) is to advance the thrust levers to maximum and to reduce the pitch attitude appropriately. There is no specific training for stall encounters immediately after liftoff from the nmway.

1.17.2 Safety Board Recommendations Subsequent to the Accident

All 292 occupants egressed the airpiane within about 2 minutes. There was only one serious injury reported; a fractured leg occurred during egress. However, there were some issues regarding emergency evacuation cabin safety that were developed during the investigation. They pertain to difficulty in seeing the ground because of grazed or scratched oval-shaped prismatic windows in the eight cabin floor-level doors; the loss of seat structural integrity of the two cockpit observer (jump) seats--both seatpans were found displaced downward and their supporting structures were separated; and the failure of an overhead storage bin door from the accident airplane to pass a postaccident bum test of selected cabin materials.

As a result, on March 8, 1993, the National Transportation Safety Board made the following three recommendations to the FAA:

A-93-16

Require the inspection of windows that are installed in emergency exits to ensure that they are free from damage that would interfere with a clear view and order the replacement of windows that are not airworthy.

A-93-17

Inform operators of L-1011 airplanes of the necessity to adjust seatbelts tightly and to lock both sides of the seatbelts (if locks are installed) that are installed on cockpit observer seats before takeoff, landing, and during turbulence.

A-93-18

Research the effect of aging upon the self-extinguishing ability of cabin interior furnishings and test furnishings that were certified to 14 CFR 25.853(a)(1)(i) to determine if they comply with the self-extinguishing requirements. Interior furnishings that fail to comply with 14 CFR 25.853(a)(1)(i) should be immediately replaced with materials that comply with 14 CFR 25.853, Appendix F.

2 ANALYSIS

2.1 General

Weather and air traffic control were not factors in the accident.

The airplane had been maintained in accordance with an FAA-approved maintenance program. Deficiencies in maintenance troubleshooting of chronic failures of the airplane's stall warning system and the trend analysis (quality assurance) program at TWA, and deficiencies in the design and certification of the L-1011 stall warning system, are addressed later in the analysis.

The flight attendants were properly trained and qualified to perform their duties. The performance of the flight attendants during the emergency evacuation was exceptional and probably contributed to the success of the emergency evacuation.

The pilots had been trained in accordance with the TWA FAA-approved training program. The pilots were properly rested and medically qualified for their duties. There was no evidence of medical conditions that would have affected their performance. Deficiencies in training of the pilots and certain TWA procedures for dealing with abnormal events during critical phases of flight are addressed later in the analysis.

The response and actions by ARFF personnel were timely and adequate; however, they were unable to extinguish the fire before it destroyed a major portion of the airplane. It is most likely that escaping fuel from the right wing area entered the No. 2 engine, causing the FDR EPR anomalous value readings and the fire warning bell. These events are consistent with witness observations of fire in or near the No. 2 engine as the airplane decelerated.

The evidence indicated that the first and most significant factors in this accident were the activation of the airplane's stall warning stickshaker as the airplane lifted off the runway during takeoff and the flightcrew's reaction to the stall warning. Further, the postaccident examination of the FDR AOA data from flight 843 disclosed that one of the two AOA sensors was not functioning properly during the takeoff roll. Analysis of the airplane's systems indicated that the erroneous signal from the malfunctioning sensor would have caused the first officer's stall warning stickshaker to activate when the air-ground logic switch on the main landing gear strut switched to the "air" mode during the takeoff.

Thus, the Safety Board's analysis of this accident focused on the flightcrew's training, TWA's procedures, the performance of the airplane, the airworthiness of the airplane, and the postaccident survival issues.

2.2 The Accident

Flight 843 departed from the gate at an aircraft weight of 431,773 pounds, 227 pounds under the approved maximum taxi gross weight of 432,000 pounds. The airplane was also about 1,000 pounds below its maximum takeoff weight (430,000 pounds) when it began the takeoff. The pretakeoff checklist items were completed uneventfully, and the first officer assumed the duties of the flying pilot.

The airplane was departing runway 13R, which is 14,572 feet long. The calculated "V" speeds for the accident flight were V_1 at 140 KIAS, V_R at 155 KIAS, and V_2 at 164 KIAS. The analysis of the airplane's weight and balance revealed that the V speeds were calculated properly. The CVR and FDR data revealed that the V_1 and V_R speeds were called out correctly by the flightcrew.

The captain advanced the throttles forward, the second officer "trimmed" the throttles, per the captain's command, and then the captain "guarded the throttles" throughout the remainder of the takeoff roll. The captain called V_1 and V_R and monitored the air speed as it accelerated through V_2. Analysis of the FDR data against time revealed that the airplane performed normally during the takeoff roll through the liftoff from the runway. The rotation rate was about 2 degrees per second, well within the nominal value. The rotation was followed by liftoff from the runway and initiation of the climb.

The evidence showed that immediately after the airplane lifted off the ground, the stall warning stickshaker activated[8] and the airplane began to descend back to the runway. The first officer made a statement about the airplane stalling and said to the captain "you got it." The captain assumed control of the airplane and

[8]The sound of the stickshaker was not recorded on the CVR. Nevertheless, based on the variability of the audibility under different test conditions, the statements and reactions of the flightcrew, FDR data, and the evidence of a fault in the AOA probe, the Safety Board concludes that the stickshaker did activate at liftoff from the runway.

made what he described as a "split second" decision to retard the throttles and land back on the remaining mway. The airplane only reached about 16 feet of altitude before descending back to the runway.

The evidence also showed that *the* airplane was performing properly, had accelerated well above V_2 and could have climbed out successfully.

The airplane landed hard, and the right wing sustained a fracture of the rear inboard spar because the airplane touched down with a sink rate of abut 14 feet per second. The airplane's gross weight was about 71,000 pounds over the approved maximum *landing* weight, and the sink rate was well over the certified design limit of 6 feet per second for the structure. The Safety Board concludes that the failure of the right wing inboard rear spar was *caused* by the severe overload stresses imposed at touchdown. Witness observations and the physical evidence confirmed that the airplane lauded very hard. Witnesses saw the wings flex and debris fall from the airplane at touchdown.

The FDR data revealed that the airplane was banked right wing low about 1.1 degrees at touchdown, which occurred with the Centerline of the airplane just to the left of the center crown of the runway. Therefore, the right main landing gear probably touched down before the left main landing gear, and the right wing took the initial violent forces., overloading the structure. The fractures noted in the right wing were consistent with such forces. Further, the forces imposed on the right wing rear spar during rotation for takeoff were calculated to *be* significantly less than those occurring at touchdown. Therefore, the Safety Board concludes that the fracture of the right wing rear spar occurred upon landing.

The first officer perceived that an emergency condition existed when the stall warning stickshaker activated as the airplane lifted off the runway. The Safety Board acknowledges that the activation of a stickshaker immediately after liftoff is an abnormal event that is intended to alert the crew to a potentially dangerous flight condition. The flightcrew should be immediately attentive to the airplane's air speed, flap and leading edge configuration, particularly in the absence of other cues which might confirm that the stickshaker activation is false, a consequence of a fault within the airplane's stall warning system. In this case, it is likely that the flightcrew did not observe any cockpit warning lights that would have prompted them to immediately assess the warning as false. Although certain lights an *the* overhead panel (ATS FAIL) and the lower Center instrument panel (FLT CONT PANEL) may have illuminated, they would not have done so until at least

2 seconds following liftoff. Further, these lights would not have been easily observable by the pilots. and the legends on the lights would not have been readily associated with a stall warning system malfunction.

Nonetheless, the Safety Board does not consider the onset of the stickshaker stall warning as an emergency condition that justifies actions that can place the airplane in jeopardy. The stickshaker activation is a warning indication that the wing is at an AOA approaching a stall condition, but a significant margin of safety is provided before the actual aerodynamic stall angle occurs. Moreover, the captain had called out V_1 and V_R, presumably by reference to the air speed indicator, and the airplane was accelerating through V_2 and beginning to climb. Based on their awareness of air speed and flap configuration, the pilots should have concluded that the stickshaker was a false stall warning.

The feeling that the airplane "didn't seem to want to fly" and the "sinking" feeling described by the cockpit occupants was most likely due either to the first officer's relaxing the control yoke back pressure or his pushing the yoke forward in the "natural" reaction to the stall warning. It is possible that the impression of an aerodynamic stall related by the cockpit occupants was reinforced by the activation of the stall warning stickshaker. That sensory input, coupled with the "sinking" sensation because of the transition from climbing flight to descending flight (reduced load factor), very likely accounts for the impressions of the pilots that the airplane was "not going to fly." The Safety Board was unable to identify any other aerodynamic or mechanical explanation for the pilots' stated belief.

The analyses of the FDR data and modeling of the takeoff verify that the control column moved forward and that the airplane reacted properly to the control inputs when the flightcrew abandoned the climb phase of flight and elected to land the airplane. Comparisons of data from eight previous takeoffs of the airplane with the data from the accident takeoff revealed that the forward movement of the control yoke immediately after takeoff, and the nose-down deflection of the horizontal stabilizer, were unlike any of the eight previous takeoffs. The reactions of the airplane to the control inputs on all nine takeoffs evaluated were consistent and proper.

The results of the airpiane performance analysis showed that the motion of the airplane during the liftoff and Subsequent descent was the result of pilot action--either pushing or allowing the control yoke to move forward. The first officer initiated this control input, which might not have been detectable by the captain.

Inexplicably, the first officer reacted to the stickshaker by immediately deciding that the captain should be flying and abandoning control of the airplane to the captain without warning or proper coordination. This improper and untimely action occurred when the airplane was about 15 feet above the ground and approximately 14 knots above the V_2 speed. The decision and subsequent action of the first officer to "give up" control of the airplane, instead of the captain "taking control" of the airplane, is not consistent with the nearly universal practice m the aviation community regarding transfer of control in two-pilot aircraft. Accordingly, the Safety Board examined TWA's pilot training program and its procedures.

2.3 Flightcrew Training and Procedures

TWA's philosophy regarding flightcrew training and operational procedures, including cockpit resource management, is based on the "quiet cockpit" concept. That is, each pilot is trained in a particular skilled position (captain, first officer, or flight engineer) and that individual is expected to perfom both normal and abnormal procedures, at the appropriate time. Also inherent in this philosophy is the idea that crewmember briefings (takeoffs and approaches) are not necessary because of the expectation that each individual knows his/her duties and that he or she will perform those duties at the appropriate time.

The Safety Board believes that the expectations placed on individual crewmembers under this philosophy could promote a higher probability of confusion and poor crew coordination because the primary information for decisions and actions is not actively disseminated among the individuals during routine flight operations. For example, there are no predeparture briefings concerning such items as a standard instrument procedure, the length of time required to dump fuel in the event that a return to the departure airport is necessary, abnormal procedures for rejected takeoffs (RTOs), possible effects of local environmental conditions, or other abnormal events during critical phases of flight.

The Safety Board believes that, at a minimum, certain information should be briefed during each flight, as it applies to particularly critical phases of operation? For example, the actions to take during an RTO or similar time-critical events should be verbalized to reinforce training and procedures and to serve as a rehearsal in preparation for possible use.

It is an established procedure at many airlines for the captain to maintain a "hands on" position on the throttles during the takeoff phase, regardless of which pilot is flying the airplane. It is also an established procedure that the captain will execute an RTO by first announcing the RTQ and by retarding throttles. At almost all *airlines,* including TWA, fmt officers are not permitted to rake such actions. However, in *this case,* by allowing the control column to move forward, the first officer actually initiated the rejection of the takeoff, when the airplane was barely airborne.

During both initial and recurrent training at TWA, first officers are required to demonstrate their ability to *carry* out an RTQ. as well as other emergency procedures. Therefore, it is possible that a first officer's performance of rejecting a takeoff in the simulator promotes a false sense of command authority *that* is contrary to procedures stated in the TWA Flight Handbook or performed on the line. Specifically, in the event of an RTO during simulation training, the first officer commands and executes the RTO, including manipulating the flight controls and retarding the throttles. This training is contrary to the "real world procedure that the captain will command and execute the RTO, regardless of his flying duties.

The Safety Board is concerned about the prudence of the common practice by many airlines of requiring the captain to initiate rejected takeoffs with his hand on the throttles for all takeoffs, even when the first officer is making the takeoff. *This* "split" control responsibility may not be in the best interest of proper crew coordination during such a critical phase of flight. Therefore, the Safety Board believes that the FAA should study this practice, in cooperation with the National Aeronautics and Space Administration, witk the view toward evaluating and revising. as appropriate, airline procedures and mining. The study should include a comprehensive review and analysis of accident and incident data and simulator or other research, as necessary.

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[9]Reference "Control of the Crew-caused Accident." by L. G. Lautman and P. L. Gallimore, *Airliner.* April-June 1987.

Also, the pilot training syllabus at TWA, as well as at many commercial air carriers, does not include any type of system anomaly training. This type of training is best described as an unusual event, such as a stall warning ai liftoff, overspeed warning, speed brake deploy warning at takeoff, blown tire, or a ground proximity warning system (GPWS) alert during takeoff, that is out of the realm of normal operation or is an expected abnormal condition that the pilots would become familiar with during training. *This* type of training scenario would be of an unannounced nature and would occur at a point in the simulator flight when *the* crew would least expect it.

Additionally, TWA does not address, either in a written procedure or verbally during training, any technique to use in the event of a false warning, including, as in *this* case, the stall warning stickshaker during takeoff. There are written procedures and trainiig for actions the pilot would perform in the event of a stall warning and an actual aerodynamic stall condition in flight; however, these procedures are generic in nature and address situations in different flight regimes and environments. Nevertheless, the typical actions by a properly trained and alert piiot should have ied to the immediate performance of these procedures at the first indication (stickshaker or visual warning) of a stall.

The training provided to both pilots regarding RTOs is intended to instill a "go" attitude after V_1 has been reached. There was no specific *training* in reacting to abnormal events, such as a false stall warning or other "nuisance" warning after V_1 shortly after becoming airborne. However, it is common practice in the airlii industry that in the event of an abnormal occurrence, which would require the captain to assume the flying duties, the first officer would continue flying the airplane until the captain announced that he was physically taking control of it.

A review of flight operations revealed that TWA neither incorporates in its flightcrew training nor practices the principle of the first officer initiating the transfer process by giving up command of the aircraft when performing the duties of the flying pilot. The industry standard is that the captain will take command and control of the aircraft if he or she deems it necessary. The typical and proper method of transferring control of the airplane involves direct verbal interaction and understanding between the pilots.

It is obvious that the first officer's actions occurred in a manner that precluded the captain from gaining an accurate "feel" for the airplane and assessing the nature of the perceived problem. He was placed in a position in which he had to "take control and assess the nature of the anomaly," and make a decision in an inordinately short amount of time on whether to continue the takeoff while the airplane was descending as a result of the first officer's improper actions.

The captain, in the performance of his duties as the nonflying pilot, is responsible for calling the " V speeds during takeoff; thus, he should be well aware of the airplane's speed at all times. When the airplane broke ground, and the stickshaker activated, he should have been aware that the airplane had sufficient flying speed, based on air speed indications, to sustain flight. Also, when the stickshaker activated (indicative of a near-stall condition), all available information (airspeed and engine power) should have been evaluated, and, if necessary, the proper stall recovery procedure of increasing engine *thrust* and making a controlled change in pitch attitude could have avoided this accident. These actions were not taken.

The captain's "split second' decision to land the airplane was most likely based on a false sense that the airplane would not fly, as well as his observation that sufficient runway existed to stop the airplane. It is very likely that if this event had occurred at an airport with a shorter runway, the captain would not have entertained the option to reject the takeoff and attempt to land. The captain's postaccident statements about believing that sufficient runway was available strongly suggest that this condition influenced his decision.

Nevertheless, the decisions made by both pilots regarding the urgency of the situation, and the course of action to take, should not have been influenced by the amount of runway remaining. It is important to note that several other flightcrews had experienced false stall warnings at liftoff, including a flightcrew flying N11002 less than 1 month earlier. In these other cases, the flightcrews flew the airplane successfully.

The Safety Board is aware *that* the subject of RTOs and the decision making involved when pilots are confronted with an abnormal condition or emergency after reaching high speed are complex. The Safety Board is also aware *that* the focus of training for emergencies during the takeoff phase generally involves "go-no-go" decisions while the airplane is on the runway approaching the V_1 speed. While this accident was not a typical RTO, the circumstances that necessitated the split second decision to continue the flight or land the airplane were similar to emergencies at or beyond V_1 requiring rapid decision making. Both situations require proper crew coordination and timely pilot decision making. Thus, the TWA training and procedures, although not specific to this particular situation, were intended to prepare the pilots for the proper decisions and actions. However. the decisions and actions of the flightcrew of flight 843 called into question the adequacy of the training and procedures.

The Safety Board has previously addressed air carrier training with regard to system anomalies on takeoff and recommended that the FAA:

A-90-43

Require that simulator training for flightcrews of 14 CFR 121 operators present, to the extent possible, the cues and cockpit warnings of occurrences other than engine failures that have frequently resulted in high speed rejected takeoffs.

On March 8,1993, the FAA responded that it "agrees with the intent of the recommendation" and has published a Takeoff Safety Training Aid, developed by representatives of the aviation community, to improve the quality of pilot training with respect to RTOs. Although this accident was not specifically an RTO accident, the Safety Board believes that the information contained within the Takeoff Safety Training Aid could have Improved the ability of this flightcrew to recognize and properly respond to the stall warning anomaly they received just after V_2. The Safety Board believes that this accident demonstrates the need for improved training of pilots in recognizing and properly responding to an event that could precipitate an RTO or a similar crew response such as that occurring in this accident. The Safety Board believes that the FAA should require improved RTO-type mining and, as a result, this recommendation is currently classified as "Open--Acceptable Response," awaiting the FAA's requirement for this training.

It has become readily apparent from the considerable studies conducted in the past that proper crew coordination and pilot training, combined with specific procedures, are essential to ensuring proper decision making and actions by pilots during such time-critical events. In this case, the Safety Board believes that the crew coordination was inadequate and training was deficient.

The Safety Board has also previously addressed air carrier training with regard to crew coordination during RTOs, and recommended that the FAA:

A-90-45

Require that simulator training for flightcrews of 14 CFR 121 operators emphasize crew coordination during rejected takeoffs, particularly those rejected takeoffs that require transfer of control from the first officer to the captain.

The FAA responded to this recommendation as it did to Safety Recommendation A-90-43, cited previously. The Safety Board believes that this accident illustrates the need for improved training in crew coordination in response to the transfer of control from one crewmember to the other during an attempt to rapidly reject the takeoff or bring the airplane to a stop on the remaining runway. Therefore, the Safety Board believes that the FAA should require air carriers to improve RTO training and, as a result, this recommendation is currently classified as "Open--Acceptable Response," awaiting the FAA's requirement for this training.

Analysis of evidence derived during the course of the investigation confirmed that this accident was precipitated by improper decisions and actions by the first officer, and improper decisions and reactions by the captain that resulted in a hard landing and damage to the airplane. The Safety Board concludes that the pilots' improper interpretations of information, their false perceptions, and their failure to evaluate all available information were major factors in the cause of this accident.

2.4 Stall Warning System Design

While faulting the pilots' actions, the Safety Board is also concerned that the L-1011's stall waning system was not designed to prevent false warnings that require the pilots to react during critical phases of flight, especially immediately after liftoff from the runway. Therefore, the Safety Board examined the design and certification of the L-1011 stall warning system.

The evidence showed that the right AOA sensor was not functioning properly during the ground operation and takeoff of the airplane. Analysis of the system revealed that the malfunction of the sensor led to an erroneous signal that caused the stall warning stickshaker to activate when the air-ground status switch on the main landing gear strut moved to the "air" status as the airplane lifted off the runway.

During the taxi and takeoff phases of the flight, the right AOA signal remained greater than 26 degrees, which is a much greater value than the stall AOA. The FDR data showed that the signal had reached that value on both AOA sensors at low air speed following the previous landing. The system design accounts for default positions during ground operations and at low air speeds. During the takeoff roll, the left AOA sensor began to decrease during the acceleration for takeoff, reached a normal value consistent with the existing air speed, and continued to function normally through the takeoff and subsequent landing. However, the right AOA sensor did not move to the proper AOA before liftoff, thereby sending a signal that triggered the false stall warning to the pilots.

Disassembly and internal examinations of the right AOA sensor revealed an intermittent discontinuity of the electrical circuit that developed the signal at the pressure diaphragm on the sensor. The discontinuity gave an invalid signal to the stall warning system.

Examination of the design of the stall warning circuitry and the ground preflight test mode for the system revealed that the malfunction of the system on N11002 could not be detected during the preflight test. Specifically, it was determined that the depression of the ground test button eliminates sensing of the "weight-on-gear" or ground status of the air-ground main landing gear switch. It also replaces the pressure diaphragm voltage with an artificial value above that required to activate the stickshaker. The AOA sensing system nulls out the artificial signal by rotating the probe tube. When the probe rotates to a position above the stall warning limits, the stickshaker activates to signal to the flightcrew a successful system test. However, because the ground test signal replaces the pressure diaphragm output, a discontinuity in the output circuit would not be detected by the test.

The L-1011 Operations Manual states that the self-monitoring functions of the stall warning system are intended to illuminate the STALL WARN FAIL light on the panel above the pilots' heads and the FLT CONT PANELS light on the center instrument panel when a failure of an AOA sensor occurs. However, examination of the system design revealed that only an internal power failure or a condition in which the pressure diaphragm voltage could not be nulled out in 10 seconds would trigger an alert to the pilots. Therefore, the defect in the system on the right AOA sensor would not provide the pilots with a warning.

The design of the L-1011 stall warning system incorporates a positive design feature of redundancy to ensure accurate warnings if one system fails. However, because of inadequacies in the system test modes, an undetected fault in only one system could lead to a false warning.

The Safety Board is concerned that the design of the stall warning system on the L-1011 would permit undetected internal failures to exist and would not be detected during manual system tests or by the self-monitoring system. The primary reason for these systems is to alert pilots to either a failure or a discrepancy in the system(s). The single-point failure that occurred in this instance was undetected and led to a false stall warning to which the flightcrew reacted inappropriately.

The ATS system contains the only circuitry capable of comparing AOA values. However. the comparison is inhibited by a weight-on-wheels signal. Therefore, the first indication of failure would have been activation of the stall warning stickshaker, followed by illumination of the ATS FAIL and FLT CONT PANEL lights 2 seconds later.

In addition to the inability to identify failures, the Safety Board is concerned by the poor presentation of failure alerts to the pilots. The pilots of flight 543 reported that they received no failure lights, although previous flights had reportedly received the warnings. The Safety Board believes that the ATS FAIL lights illuminated up to 2 seconds after the airplane was airborne and extinguished on landing seconds later. Referring to the CVR, the flightcrew was responding to the stall warning at the time that the ATS FAIL lights should have illuminated and the FDR showed ihe horizontal stabilizer was moving toward an aircraft nose-down attitude. Even if the piiots had checked the Caution and Warning Panel (CAWP) on the lower center instrument panel at the initiation of the stickshaker, the lights would have been dark until' 2 seconds after takeoff. The location of the FLT CONT PANEL light in the CAWP display made it inconvenient for the pilots to refer to and may have caused rhe pilot's hand or wrist to obscure the flight engineer's view, as well as the view of the pilots riding in the jumpseats.

A master caution/warning annunciation could have alerted the flightcrew to a possible systems failure shown on the C A W display. However, since the FLT CONT PANEL legend on the CAWP refers to flight controls, it detracts from warnings relative to the stall warning and ATS systems. The Safety Board believes that the L-1011 caution/warning system should be altered to clearly alert pilots when discrepancies exist between the AOA outputs or to failures within the stall warning system.

The Safety Board believes that the FAA should determine if there are stall warning system anomalies on transport-category airplanes, including the L-1011, that could be undetected during ground tests and could lead to false stall warnings during takeoff. Based on the review, the FAA should issue appropriate airworthiness directives (ADs) to modify the system designs to prevent this type of false warning. Moreover, the FAA should require the aircraft manufacturers to develop a means to illuminate a caution/warning light on the pilots' instrument panel any time a stall warning system fault exists.

Because of the past history of false stall warnings on N11002 and other L-1011s, some of which also occurred at liftoff from the runway, the Safety Board examined TWA's maintenance and quality assurance programs.

2.5 TWA's Maintenance and Quality Assurance Programs

Although the Safety Board believes that the flightcrew's reactions to the false stall warning were inappropriate, it believes that the malfunction in the AOA sensor that caused the warning should have been detected and repaired by TWA's maintenance and quality assurance programs, thereby eliminating the precipitating event in this accident.

The purpose of trend monitoring in an airline's quality assurance program is to detect chronic problems, such as the right AOA sensor on N11002. It is not uncommon for electronic components on aircraft to have malfunctions that cannot be duplicated or corrected during maintenance troubleshooting. Often, there are intermittent malfunctions that cannot be duplicated and components are returned to service, after bench testing, without corrective actions taken. On many occasions, components are reinstalled in airplanes different from the one that had experienced the earlier malfunction. This is one of the reasons airlines are required by the FAA to establish quality assurance programs to detect repetitive failures in components that have been reinstalled on airplanes after "could not duplicate" maintenance actions.

However, the FAA-approved TWA quality assurance program failed to identify the chronic problem with the stall warning system, specifically within the AOA probe on N11002. There were eight occasions in about a 2-year period that the component had malfunctioned within relatively short flight times between failures. However, there was no indication in any of these eight component malfunctions that the system failed in the absence of an accompanying system failure light. In several of the instances, the malfunction could not be duplicated, and the reason for the failures was not found. The component was then reinstalled on other airplanes.

The failure of TWA's quality assurance program to prevent a defective part from Wig installed on N11002 involves a subtle but critical flaw in TWA's program. Specifically, the chronic part failure trend monitoring system was established on a calendar day basis (rather than a flight hour basis) that only provided an alert to the quality assurance personnel if multiple failures occurred within a specific number of elapsed days. Unfortunately, the manner in which the AOA sensor was processed following each failure prevented the detection of the chronic nature of the problem. Specifically, after each malfunction, the component was inspected by maintenance and subsequently cleared for service: however, the sensor was returned to supply as a spare part before being reinstalled on another airplane. Therefore, many calendar clays elapsed before the part was reinstalled on another airplane and placed in a situation in which it could fail again. Had TWA's trend monitoring system also been based on a number of hours of flight service of the part, the chronic mature of the problem would more likely have been detected.

The Safety Board believes that the failure of TWA's maintenance department to detect the faulty AOA sensor by means of its quality assurance trend monitoring program was an important factor in the causal chain that led to this accident. If TWA's trend analysis program had functioned as intended, the accident would have been prevented. Therefore, the Safety Board concludes that the inadequacy of this program was causal to the accident, as were the pilots' reactions to that false warning.

The Safety Board was unable to determine how such an apparently simple oversight of using a calendar day basis for trend monitoring, instead of flight-hour based monitoring, was not remedied before this accident occurred. Because of the findings in this case, the Safety Board believes that the FAA should examine TWA's and other airlines' quality assurance programs for detecting repetitive and unsafe trends in component failures, in order to prevent a recurrence of the circumstances that led to this accident. The Safety Board also believes that the FAA should make the circumstances of this accident known to all FAA Principal Operations and Maintenance Inspectors, and to the appropriate officials at U.S.

airlines for the benefit of their pilot training, maintenance, and quality assurance programs.

2.6 Blast Fence Beyond Departure End of Runway 13R

The captain stated that following recontact with the runway, he steered the airplane to the left, off the runway and onto the soil, in order to avoid the blast fence that was beyond the end of runway 13R. After the decision was made to land back onto the takeoff m w a y and. as the captain stated, the airplane did not respond to braking as quickly as expected, steering away from the blast fence was prudent.

The FAA and the PNY & NJ were unable to recover documentation. explaining why the blast fence was built about 20 years ago. PNY & NJ personnel stated that they believed the fence was constructed to provide protection from the jet blast of airplanes taking off on runway 31L for airplanes operating on runway 4R. Noise abatement was also stated as a reason for the fence.

The Safety Board believes that the FAA and PNY & NJ should find alternatives to the blast fence, regarding its construction and location, or at least consider removing the fence.

2.7 Emergency Evacuation and Rescue and Fire Fighting Services

2.7.1 Timeliness of the Evacuation

The evacuation of the airplane occurred within 2 minutes. The speed in evacuating 292 passengers and crew from the airplane was complemented by the following: TWA's requirement (in accordance with TWA's normal operating procedures) for nine flight attendants, which was three more than the FAA minimum; and the fact that the nine flight attendants were assisted by five TWA nonrevenue (off-duty) flight attendants and two off-duty TWA captains who were occupying the cockpit jumpseats.

TWA flight attendants undergo recurrent training on the operation of all airplane cabin doors every 12 months. This is twice as often as the every 24-month requirement of the FAA. The flight attendants reponed no problems operating the exits, and the Safety Board believes that the training they received helped in this regard.

Without any instruction, the five off-duty flight attendants remained at their positions and assisted in the evacuation by yelling commands to passengers to move forward. They also assisted the other flight attendants at their exits. One of the five extra flight attendants stationed herself at the L-2 exit because the assigned flight attendant could not see clearly out the exit door's prismatic window and had moved to a passenger window to assess conditions outside. The extra attendant then yelled commands for passengers to move forward to the L-1 exit, in order to relieve congestion at L-2 exit. The Safety Board believes that if there had not been an extra flight attendant near the L-2 exit, that exit might not have been opened and the evacuation might have been delayed. In addition, the timeliness of the evacuation was augmented by the fact that the extra flight attendants were in areas of the cabin other than at exit doors, where they assisted in keeping passengers moving to and through available exits:

The emergency evacuation of the airplane was accomplished in an exemplary manner, resulting in only one serious injury and several minor injuries, despite the rapidly spreading fire that quickly destroyed the airplane. Although certain deficiencies were noted in the cabin furnishings that require corrective actions (See section 4 for safety recommendations), the performance of the flight attendants and the pilots in leading the emergency evacuation prevented significant loss of life.

2.7.2 Rescue and Fire Fighting Services

ARFF personnel responded in a timely manner; however, they were unable to extinguish the fire before it consumed major portions of the fuselage ana aft cabin area. The firefighters were able to "knock down" the fire in the first 2 minutes of arrival at the scene; however, it took several minutes before the fire was totally under control and extinguished.

The Safety Board notes that the New York City EMS's use of the mobile lounge vehicle to hold passengers for additional triage was prudent and efficient.

3. CONCLUSIONS

3.1 Findings

1. Weather was not a factor in the accident.

2. Air traffic control services were not a factor in the accident.

3. The flightcrew and flight attendants were properly qualified to conduct their duties.

4. The pilots were trained in accordance with the applicable TWA and FAA requirements; however, training in crew coordination €or transfer of control of the airplane between rhe pilots was inadequate.

5. The TWA procedure that allows the flightcrews to initiate takeoffs without a predeparture briefing does not adequately prepare the flightcrews for coordination sf potential abnormal circumstances during takeoff.

6. Other than engine failures, the flightcrews were not adequately trained to evaluate and react to unexpected anomalies, such as false stall warnings and overspeed warning, during the takeoff phase.

7. The airplane was about 1,000 pounds under its maximum weight for takeoff; the center of gravity was within limits.

8. The performance of the airpiane during the takeoff roll and the rotation and liftoff from the runway was proper. The airplane was rotated at the proper V_R speed, and the airplane lifted off and accelerated to above V_2 before the takeoff was abandoned.

9. A false stall warning stickshaker occurred as the airpiane lifted off from the runway.

10. The first officer, who was the flying pilot for the takeoff, incorrectly perceived that the airplane was stalling and gave

control of the airplane to the captain without proper coordination of the transfer of control.

11. The first officer either pushed the control column forward or allowed the control column to move forward in reaction to the false stall warning.

12. The captain made a "split second" decision to reject the takeoff by reducing the engine thrust. His decision was very likely based, in part, on the perception of available runway to stop the airplane.

13. The airplane landed extremely hard at a vertical descent rate of about 14 feet-per-second, considerably over the maximum structural design limit of 6.0 feet-per-second, and at a weight of about 71,000 pounds over the design maximum landing weight.

14. The airplane was in a slight right-wing-low attitude when the right main landing gear touched down first, near the runway centerline crown. The right main] landing gear touched down at a force exceeding the structural design limits, resulting in overload fractures in the right wing rear spar; nc evidence of fatigue was found in the fractures.

15. The intermittent malfunction of the right AOA Sensor was not detectable during preflight system tests by the piiots, and it did not trigger 2 fault light as part of the system's automatic monitoring system. These deficiencies in the system design permitted the malfunctioning sensor to cause a false warning when the air-ground sensor on the landing gear went to the air status on takeoff.

16. The right AOA sensor bad experienced nine previous malfunctions (eight times before being installed on N11002) and was inspected and returned to service without a determination on the reason for the intermittent malfunction. The repetitive malfunctions were not detected by the TWA quality assurance trend monitoring program because the program used a calendar day, rather than flight hour, basis to detect trends.

17. The emergency evacuation was performed in a timely, efficient, and exemplary manner that was the ,direct result of TWA's training program. Both the flight .attendants and the flight crewmembers, as well as the off-duty crewmembers, performed exceptionally well in the evacuation.

18. Following the landing, the captain's performance in stopping the airplane and moving it off the runway was excellent.

19. The airport rescue and fire fighting services responded in a timely and efficient manner.

32 Probable Cause

The National Transportation Safety Board determines that the probable causes of this accident were design deficiencies in the stall warning system that permitted a defect to go undetected, the failure of TWA's maintenance program to correct a repetitive malfunction of the stall warning system, and inadequate crew coordination between the captain and first officer that resulted in their inappropriate response to a false stall warning.

4. RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board makes the following recommendations:

--to the Federal Aviation Administration:

issue an air carrier operations bulletin directing Principal Operations Inspectors for 14 CFR 121 and 14 CFR 135 airlines to include in the training and procedures a requirement for crew coordination briefings on actions to take in the event of abnormal situations during the takeoff and initial climb phase of flight, and the proper techniques for the transfer of control of the airplane, especially during time-critical phases of flight. (Class II, Priority Action) (A-93-49)

Issue an air carrier maintenance bulletin directing the Principal Maintenance and Avionics Inspectors for 14 CFR 121 and 14 CFR 135 airlines to review the airlines' maintenance and quality assurance programs and take appropriate actions to verify that the trend monitoring programs are structured to detect repetitive malfunctions by means of flight-hour monitoring, as well as calendar-day monitoring. (Class II, Priority Action) (A-93-50)

Issue an airworthiness directive to require that a caution or warning light Illuminates on the pilots' caution-warning panel in the event of a failure within the circuitry of L-1011 stall waming systems during ground or flight operations. (Class II, Priority Action) (A-93-51)

Require that the redundant stall waming systems installed on transport-category airplanes have ground test features and self-monitoring systems to alert the pilots to malfunctions in the stall warning systems. (Class II, Priority Action) (A-93-52)

Issue air carrier bulletins directing the Principal Inspectors for 14 CFR 121 and 14 CFR 135 airlines to review the circumstances of the accident involving TWA flight 843 on July 30, 1992, and to make the facts, conditions, and circumstances of the accident known to the appropriate airline operations, training, and maintenance personnel. (Class II, Priority Action) **(A-93-53)**

Conduct a human factors study, in cooperation with the National Aeronautics and Space Administration, of the practice by many airlines of requiring the captain to initiate and execute a rejected takeoff, even when the first officer is making the takeoff. The study should include a thorough examination of the practice of having the captain keep his hand on the power levers when the first officer is making the takeoff. The study should also include a comprehensive review and analysis of accident and incident data and simulator or other research, as necessary. The results of the study should be widely disseminated to the airline industry for use in evaluating and revising, if appropriate, rejected takeoff procedures and training. (Class II, Priority Action) **(A-93-54)**

—to the Port Authority of New York and New Jersey:

Remove the blast fence located near the approach end of runway 31L at John F. Kennedy International Airport, and implement alternative methods to protect airplane operations from jet blast on runway 4R/22L. (Class II, Priority Action) **(A-93-69)**

Also, as a result of the investigation of this accident, on March 8, 1993, the Safety Board made the following recommendations to the Federal Aviation Administration:

A-93-16

Require the inspection of windows that are installed in emergency exits to ensure that they are free from damage that would interfere with a clear view and order the replacement of windows that are not airworthy.

A-93-17

Inform operators of L-1011 airplanes of the necessity to adjust seatbelts tightly and to lock both sides of the seatbelts (if locks are installed) that are installed on cockpit observer seats before takeoff, landing, and during turbulence.

A-93-18

Research the effect of aging upon the self-extinguishing ability of cabin interior furnishings and test furnishings that were certified to 14 CFR 25.853(a)(1)(i) to determine if they comply with the self-extinguishing requirements. Interior furnishings that fail to comply with 14 CFR 25.853(a)(1)(i) should be immediately replaced with materials that comply with 14 CFR 25.853, Appendix F.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

Carl W. Vogt
Chairman

Susan Coughlin
Vice Chairman

John K. Lauber
Member

John Hammerschmidt
Member

Christopher A. Hart
Member

March d1, 1993

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident about 1820 on July 30, 1992. An investigation team was launched from Washington, D.C., departing National Airport about 2130 on an FAA airplane. Investigators from the Safety Board's Northeast Regional Office, Parsippany, New Jersey, departed immediately to the crash site. Two of the Northeast Regional investigators served as Group Chairmen during the investigation.

On-scene investigation groups consisted of airport rescue and fire fighting, metallurgy, airplane structures, airplane systems, operations, witnesses, and survival factors. A human performance specialist participated in the operations group work. In addition, a maintenance records group was formed at the TWA facility in Kansas City, Missouri. The CVR and FDR were recovered from the airplane and were immediately taken to the Safety Boards laboratories in Washington, D.C., for readout.

2. Public Hearing

The following organizations were parties to the investigation: Federal Aviation Administration; Air Line Pilots Association: Collins Commercial Avionics; Independent Federation of Flight Attendants; Lockheed Aeronautical System Company; Port Authority of New York and New Jersey; Rolls-Royce, Incorporated; Sundstrand Data Control; and Trans World Airlines, Incorporated.

There was no public hearing or depositions taken in connection with this investigation.

APPENDIX B

PERSONNEL INFORMATION

The Captain

The captain. William Shelby Kinkead, was born on May 2, 1938. He was employed by TWA on May 24, 1965. He was hired as a first officer and remained in that position until March 1989.' Prior to becoming a captain on the L-1011, he served as a first officer on both the L-1011 and B-747.

The captain possessed a First Class Aviation Medical Certificate, dated March 26, 1992, with corrective lenses required for near vision.. At the time of the accident, his aviation ratings were airline transport pilot, airplane, multiengine land, DC-6, DC-7, B-707, B-720, B-747, L-1011; and commercial, single-engine land.

The captain had a total flight time of 20,149 hours,. including 15,854 hours as a pilot with TWA. He had 2,397 hours in the L-1011, of which 1,574 hours were as captain. His last annual line check was on July 9, 1992. His last simulator check was on June 4,1992.

The captain was.based at JFK International Airport. He lived in the Virgin Islands. He came to New York, off duty, on a flight the day before the accident. He rested overnight prior .tothe late afternoon flight on July 30, 1992.

The First Officer

The first officer, Dennis William Hergert, was born on June 19, 1939. He was employed by TWA on February 17, 1967.

His aviation ratings were airlii transport pilot, airplane, multiengine land, L-1011; and flight engineer, turbojet-powered airplanes.

The first officer possesse I a First Class Aviation Medical Certificate, dated February 5, 1992, with c..rrective lenses required for near vision.

He had a total flight time of 15,242 hours, of which 13,793 hours were with TWA. Included in his time ai TWA in the L-1011 were 4,842 hours as a first officer, of which 2,953 hours were in the L-1011. He also had 2,230 hours as a flight engineer in the L-1011.

His last annual line check took place on April 5,1992.

The first officer was based at JFK International Airport, and he drove from home to the airport.

The Second Officer

The second officer, Charles Edward Long, was born on July 7, 1958. He was employed by TWA on September 2, 1988, after leaving active duty in the U.S. Air Force, where he had been a B-52 first officer. He had just checked out as a 3-5.2 captain prior to his release from active duty. He joined TWA as a student Right engineer. On April 1989, he was assigned to the position of L-1011 check airman.

The second officer held a First Class Medical Certificate, with no restrictions, dated January 24, 1992. His aviation ratings were airline transport pilot, airplane multiengine, land; and flight engineer, turbojet-powered airplanes.

He had a total fight time 3,922 hours, of which 2,302 were with TWA. His total time as a Right engineer, all of which was in the L-1011, was 2,266 hours. His last annual line check was on May 1, 1992. His last simulator check was on September 18,1991. He was rated as a flight engineer, check airman.

b

APPENDIX C

AIRPLANE INFORMATION

N11002, a Lockheed L-1011-385-1, Serial Number 193B1014, was operated by Trans World Airlines, Incorporated. The airplane was registered to Interface Group - Nevada, Incorporated, and the registration was issued by the FAA on August 15, 1990.

At the time of the July 30, 1992, accident, the airplane had flown a total of 49,662 flight hours, ... 19,659 cycles on the airframe.

The airplane was powered by three Rolls-Royce RB211-22B-02 *engines.* At the time of the accident, the historicai data of the engines was as follows:

Position	Serial No.	Total T i e	Total Cycle
1	10430	42,842.4	13,944
2	10293	43,677.5	15,181
3	10322	41,260.4	14,031

APPENDIX D

COCKPIT VOICE RECORDER TRANSCRIPT

Transcript of a Fairchild A-100 cockpit voice recorder, s/n 1723, TWA L-1011, which was involved in an accident at John F. Kennedy International Airport on July 30, 1992.

LEGEND

CAY	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
PA	Voice from aircraft public address system
INT	Interphone conversations between ground crew and Captain
FIC	Radio Transmissions from TWA Flight Information Center
GNV	JFK Ground Controller
TWR	JFK Tower Controller
UHK	Unknown
ACM	Aditional Crew Member as a passenger in the cockpit.
-1	Voice identified as Captain
-2	Voice identified as First Officer
-a	Voice identified as Flight Engineer
-4	Voice identified as female ground agent
-5	Voice identified as forward ACM
-6	Voice identified as aft ACM
-7	Voice identified as female flight attendant
-8	Voice identified as ground crewman
-9	Voice identified as male service manager
-?	Voice unidentified
	Unintelligible word
#	Non pertinent word

%	Break in continuity
( )	Questionable insertion
(( ))	Editorial insertion
- - -	Pause

Note: All times are expressed in eastern daylight savings time (EDT).

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT

START OF RECORDING

START OF TRANSCRIPT

1711:07
PA-1 welcome aboard ladies and gentleman, this is your pilot. we're obviously still loading passengers. once we're under way, flight time today is five hours and thirty minutes to San Francisco at a cruising altitude of thirty-one thousand feet. the weather in San Francisco is ah is partly cloudy skies, temperature * six degrees. our route of flight is ah arround Indianapolis west ** -

1711:41
CAM-2 I guess we'll -

1711:53
CAM-3 you almost got it on. there's a person In the seat.

1711:58
CAM-4 thanks * you have your our personal log book?

1711:59
CAM-3 yes we do.

1711:69
CAM-4 there's somthin' right here. bye.

1711:59
CAM-3 bye.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1712:07 CAM-3	okay.		
1712:10 CAM.?	there still might be something back there **		
1712:11 CAM-5	Idon't know .		
1712:13 CAM-6	I don't think so.		
1712:14 CAM-1	yeah you guys are senior to all but one of those xcaps.		
1712:19 CAM-6	one of them. well that's true. they're all on jump seats now.		
1712:25 CAM-?	are they?		
1712:26 CAM-1	have her scour around and give us a go.		
1712:29 CAM-2	go through one by one you know * if there's.		
1712:29 CAM4	I'll see.		
1713:29 CAM-6	yeah she confirmed they're full - so.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1713:29 CAM-3	you still bring your b* along with ya.		
1713:36 CAM-6	that's a different one.		
1713:46 CAM-3	oh it's a new one?		
1713:47 CAM-6	yeah that's.		
1713:53 CAM-6	here try it.		
1713:54 CAM-3	is that a Zenith or somethin'?		
1713:55 CAM-6	it's a Mytech ah it's much smaller and a lot more ah powerful.		
1713:59 CAM4	you still write in Foxbase.		
1713:59 CAM-6	yeah.		
1714:09 CAM-3	Foxpro it's the same Foxpro.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOMRCE**	**CONTENT**
1714:12 CAM-6	just en advanced.		
1714:13 CAM-3	yeah, I never did buy the upgrade. ((sounds similar passenger door closing))		
1714:28 CAM-6	you wan! to si! up in the front?		
1714:29 CAM-7	okay we can go.		
1714:37 I WT-8	and a ground to cockpit we're ready when you are .		
1714:38 INT-1	let me check if everybody's down.		
1714:39 INT-8	roger.		
1714:42 CAM-I	could you see if everybody's down.		
1714:42 CAM-3	everybody down?		
1714:43 CAM-3	everybody down ?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1714:44 CAM-6	everybody down?		
1715:22 INT-1	ah no* we got some people still standing.		
1715:23 INT-8	okay you can release the brakes if you'd like.		
1715:23 INT-1	brakes released.		
1715:24 INT-8	roger.		
1715:25 CAM-1	ell *door* lights are out, right?		
1715:27 CAM-3	yes sir, all door lights are out.		
1715:29 PA-1	ah ladies and gentleman we are eh ready to depart, however we do need everyone in their seats with their seat belts fastened before we can push out from the gate.		
1715:50 CAM-9	okay everybody down gentleman.		
1715:52 CAM-3	everybody's down.		

INTRA-COCKPIT COMMUNICATION TIME & SOURCE	CONTENT	AIR-GROUND COMMUNICATION TIME & SOURCE	CONTENT
1715:54 CAM-1	thank you.		
1715:55 CAM-1	give FIC a call.		
1715:59 CAM-2	roger.		
		1716:09 RDO-2	FIC eight forty three to push out of gate two.
		1716:12 FIC-	eight four three push back approved.
		1716:14 RDO-2	*.
1716:15 INT-1	okay, we're cleared to push.		
1716:16 INT-8	okay here go.		
1716:18 CAM-?	*.		
1717:29 CAM-6	interesting the loads that you can carry cheap to LA in the middle of the week.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME a SOURCE	CONTEWT	TIME & SOURCE	CONTENT
1717:42 CAM-3	yeah especially with United runnin' a non-stop out there American runnin' a non-stop.		
1717:44 CAM-6	and have full flights.		
1717:47 CAM-3	carry good loads all month long on this thing.		
3719:46 INT-8	okay you're cleared to turn one, three, and two.		
1719:48 INT-1	okay we're turnin' num- one.		
1719:50 INT-8	roger,		
1719:50 CAM-3	loads reduced, air to one.		
1719:51 CAM-2	yeah.		
1719:52 CAM-3	one.		
1720:17 CAM-3	eight percent.		
1720:18 CAM-2	thank you.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1720:29 INT-8	okay, you can park the brakes.		
1720:29 INT-1	brakes parked.		
1720:29 INT-8	roger		
1721:54 INT-2	is three clear?		
1721:55 INT-8	clear number three.		
1721:56 CAM-3	sir to three.		
1721:57 INT-2	turning.		
1721:58 INT-8	roger.		
1722:19 CAM 4	eight percent.		
1722:20 CAM-2	thank you.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1722:59 CAM-2	and two.		
1722:59 CAM-3	air to two.		
1723:20 INT-2	luming two.		
1723:20 INT-8	clear number two.		
1723:21 CAM	((sound of knock))		
1723:22 CAM-9	everybody got a paper here.		
1723:24 CAY.?	oh thank you .		
1723:29 CAM-3	eight percent.		
1723:29 CAM-	((sound similar to cockpit door closing))		
		1723:43 UNK-	is this the municipal dump over here by ah thirteen left with all the stuff up between the ah taxi way to the runway .

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		1723:52 GND-	well the whole airport's built on a landfill.
1723:52 CAM-	((sound of laugh))		
1723:56 UNK-	naw, just down there by there- between the Bravo and Delta taxiways. there's just so much stuff on the grass that it's unbelievable.		
1723:59 GND	ah roger.		
172368 CAM-6	the whole airport's still a dump.		
1724:11 CAM-3	no #.		
1724:11 CAM-6	Mount Canarsie is gunna be ah * we're gunna be extending the runways over to Mount Canarsie.		
1724:38 CAM-3	it hasn't gone up yet.		
1724:44 CAM-3	engine's not going to.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1724:44 CAM-2	I don't think it's going to.		
1724:47 INT-1	OK, we've got three good starts. pull you're headset, and I'll take hand signals.		
1724:50 INT-8	roger, we'll see you. have a good one.		
1724:52 INT-1	so long.		
1724:55 CAM-2	idling pretty low.		
1724:56 CAM-3	how about the ground idle circuit breaker. you want me to pull it and reset it real quick?		
1724:59 CAM-1	yeah, go ahead.		
1724:59 CAM-5	what's happening?		
1725:07 CAM-1	okay, reset it.		
1725:12 CAM-2	okay, it's running cooler.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1725:13 CAM-1	another crisis avoided.		
1725:14 CAM-2	yeah.		
1725:19 CAM-2	after start please.		
1725:19 CAM-3	after starting engine checklist. start switches?		
CAM-2	they're off.		
CAM-3	beacon lights?		
CAM-2	an.		
CAM-3	brake pressures?		
CAM-2	checked.		
1725:19 CAM-3	after starting engine checklist complete.		
1725:19 RDO-2	TWA ah-.		
1725:19 CAM-1	eight forty three.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME 6 SOURCE	CONTENT
		1725:19 RDO-2	eight forty three heavy coming out Bravo.
		1725:37 GND-	TWA eight forty three heavy, Kennedy ground . runway one three right, taxi left outer ,hold short of November.
		1725:43 RDO-2	eight forty three heavy roger.
1725:45 CAM-2	thank you. I had an absolute mental blank out I couldn't remember the flight.		
1725:48 CAM	((sound of laugh and background conversation))		
1725:49 CAM-2	clear right.		
1726:19 CAM-1	left at the outer and short of November.		
1726:19 CAM-2	okay.		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
172636 CAM-3	TWA eight forty three has a full *load.* two ACMs, three in the cabin, two eight In the front, two four seven In back, take-off fuel, one niner decimal three, take-off weight is four two eight, nine seven three, trim four decimal two, no GSIs, • one one one, be off at four *five.*
1727:16 CAM-2	nine hundred's here on time.
1727:18 CAM-2	okay on the flaps?
1727:19 CAM-1	sure.
1727:19 CAM-2	wanna stop about right here?
1727:19 CAM-1	they just *cut* the grass and there was a bunch of paper in there, so they chopped up all the paper.
1727:38 CAM-2	((sound of laughter))
1727:41 CAM-1	it does look like there's a whole lot of # in there.
1728:15 CAM-3	take off data for one three right.
1728:19 CAM-2	thank you.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT

a.

INTRA-COCKPIT COMMUNICATION

AIRSROUND COMMUNICATION

TIME & SOURCE	CONTENT	TIME & BOURCE	CONTENT
172819 CAM-3	I'm sure you guys have guessed this already but we have a full boat.		
1728:19 CAM-2	yeah.		
1728:19 CAM-1	say again.		
1728:19 CAM-3	I'm sure you've guessed this already but we have a full boat.		
1728:19 CAM-1	yeah.		
1729:19 CAM-3	never spilled a drop.		
1729:19 CAM-2	never spilled a drop.		
1729:36 CAM-?	probably doing that now.		
1729:39 CAM-?	((unintelligible background conversation starts))		
1729:49 CAM-1	last time we flew together I guess you had you're wife with you?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1729:56 CAM-2	pardon?		
1729:57 CAM-1	you had your wife with you last time we flew together.		
1729:58 CAM-2	I don't know.		
1730:00 CAM-1	we went to San Francisco I guess. you went out with some friends from LA.		
1730:02 CAM-2	oh, that's right. yea we had about twenty hour layover there.		
1730:05 CAM-3	yea, that's true.		
1730:22 CAM-6	I just think about the fallout. uh what if they keep moving it away,. there's no second guessing ***.		
1730:26 CAM-?	((end of background conversation))		
1730:59 CAM-1	where does Tower Air fly all these seven forty sevens to?		
1730:59 CAM-2	I don't know.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1731:07 CAM-2	someplace where we don't. obviously.		
1731:10 CAM-3	places we never heard of.		
1731:11 CAM-2	right.		
1731:17 CAM-1	well, there's no money in cargo I've heard so I don't know where they go.		
1731:19 CAM-?	*.		
		1731:36 GND-	TWA eight forty three heavy, right November Papa follow the business express Saab. monitor tower one one niner point one. good day.
		1731:46 RDO-2	eight four three, so long. ((several clicks. and then sound of lower conversation))
1731:47 CAM-1	gonna wait till we stop. you knew he was going to do that.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1731:48 CAM-2	yeah.		
1731:51 CAM-1	follow the Biz-Ex Saab.		
1731:53 CAM-2	that's a Saab over there, there.		
1731:56 CAM-1	yeah, I think so. I don't know. by process of elimination.		
1731:59 CAM-2	that's not a Saab.		
1731:59 CAM-1	that is definitely not a Saab nor is that one down there. so that one must be.		
1732:06 CAM-3	vary good.		
1732:14 CAM-1	nobody out here *yet*. that's a *good* sign.		
1732:18 CAM-	((unintelligible background conversation))		
1732:40 CAM-1	ninety four off to San Juan.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1732:59 CAM-5	note the number one relief run.		
1733:11 CAM-1	he could taxi a little faster speed if he wanted to though.		
1733:18 CAM-?	((unintelligible background conversation))		
1733:27 CAM-	((knock at the door))		
1733:29 CAM-9	how much longer?		
1733:29 CAM-6	not very much longer.		
1733:29 CAM-?	we're next.		
1733:36 CAM-9	the flight attendants working in the galley. I'm going to send them up.		
1733:37 CAM-3	we're number two, yeah.		
1733:39 CAM-9	OK. ((sound of door closing))		
1733:48 CAM-?	((unintelligible low level background conversation between ACMs))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1735:18 CAM-1	taxi check list, please.		
1735:19 CAM-3	taxi check list. flaps?		
1735:22 CAM-1	ten, green light, one three right is at Kennedy.		
1735:27 CAM-3	ten degrees, fourteen green lights. engine anti-ice?		
1735:29 CAM-1	that's off.		
1735:29 CAM-3	pitot, alpha and window heat?		
1735:29 CAM-1	on.		
1735:29 CAM-3	flight controls?		
1735:29 CAM-I	they're checked.		
1735:29 CAM-3	stabilizer trim?		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
1735:36 CAM4	I don't think I have checked the rudders, actually.
1735:39 CAM-1	now they're checked. stabilizer trim four point two, which is set.
1735:42 CAM-3	take-off data, EPR and airspeed bugs?
1735:47 CAM-1	one forty, one fifty five, one sixty lour on the bug.
1735:53 CAM-3	OK, seat belt shoulder harness?
1735:55 CAM-1	on the left.
1735:55 CAM-2	same.
1735:55 CAM-3	taxi checklist complete.
1736:08 CAM-1	both of those guys are taxiing about as slow as they can. I don't know what the, American is number one.
1736:14 CAM-2	look at this. do you think this is some sheik's gold coming and going someplace?

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1736:18 CAM-1	I don't know.		
1736:19 CAM-6	not on this ** probably some TWA pilot's files.		
1736:19 CAM-1	that's tight. Carl Icahn is taking it up.		
1736:19 CAM-5	B fund, B tund going to Carl's **.		
1736:19 CAM-1	Going up to Mount Kisco, they've got a helicopter waiting for him.		
1736:39 CAM-?	must be serious then.		
1736:42 CAM-1	looks like Swiss Air.		
1736:43 CAM-2	yeah, Swiss Air.		
1736:45 CAM-6	he's going to Zurich man.		
1736:47 CAM-?	into a Swiss bank account.		
1737:04 CAM-1	come on Biz-Ex, for # sake,		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1737:19 CAM-2	this Saab really need the full length on uh thirteen right?		
1737:38 CAM-1	I wouldn't have thought so.		
1737:42 CAM-2	he's probably going west, so he must.		
1737:44 CAM-1	yeah, he's got a full load.		
1737:47 CAM-1	taxi check list is completed isn't it?		
1737:48 CAM-3	yes sir, complete.		
		1737:56 TWR-	TWA eight forty three heavy, Kennedy Tower, runway one three right, taxi into position and hold.
		1738:00 RDO-1	position and hold, one three right, TWA eight forty three.
1738:04 PA-3	ladies and gentlemen, we're next for take-off. flight attendants please be seated.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	OONTENT	TIME & SOURCE	CONTENT
1738:06 CAW?	((descending whistle sound))		
1738:06 CAM-2	dive.		
1738:17 CAM-1	I thought you were going to keep going Biz-Ex.		
173818 CAM-2	Delta Connection, we can't understand.		
1738:19 CAM-1	we're learning to fly and it shows.		
1738:36 CAM-2	before take-off please.		
1738:37 CAM-3	before take-off check list, cabin alert?		
1738:38 CAM-2	checked.		
1738:39 CAM4	transponder?		
1738:40 CAM-2	checked.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1738:43 CAM-3	caution and warning panel?		
1738:44 CAM-2	checked.		
1738:45 CAM-3	strobe lights?		
1738:45 CAM-2	on.		
1738:46 CAY4	ignition?		
1739:47 CAM-2	on.		
1738:48 CAM-3	temp probe heat?		
1738:49 CAM-2	on.		
1738:50 CAM-3	before taxi-, before take-off checklist complete.		
1738:51 CAM-I	thank you, one forty, one fifty five, one ten initial heading.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1738:52 CAM-2	one ten new heeding, right-oh		
1739:19 CAM-1	you got the directions sir?		
1739:19 CAM-2	yes.		
1739:19 DAM-1	brakes and all that?		
1739:19 CAM-1	got the brakes?		
1739:19 CAM-2	yeah.		
1739:47 CAM-2	holding us for the prop wash.		
1739:48 CAM-1	wake turbulence, departing Saab.		
1739:49 CAM-6	you guys must be holding two minutes?		
1739:59 CAM-3	prop wash can be vicious on a day like today.		

INTRA-COCKPIT COMMUNICATION TIME & SOURCE	CONTENT	AIR-GROUND COMMUNICATION TIME & SOURCE	CONTENT
1740:01 CAM-?	that's true.		
1740:03 CAM-2	right oh.		
		1740:05.0 TWR-	TWA eight forty three heavy, maintain four thousand, runway one three right, cleared for take-off.
		1740:10.9 RDO-1	eight forty three cleared for take-off one three right, maintain four.
1740:15.0 CAM-	((sound [illegible] engines starting to accelerate))		
1740:15.0 CAM-1	four thousand, clocks are running.		
1740:15.8 CAM-2	O K.		
1740:16.0 CAM-?	*.		
1740:17.0 CAM-?	g o.		
1740:26.5 CAM-1	looks like they're all running.		
1740:27.7 CAM-1	trim throttles.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1740:28.0 CAM-3	set throttles.		
1740:28.9 CAM-2	seventy.		
1740:35.7 CAM-3	throttles trimmed.		
174060.3 CAM-1	V one.		
1741:03.1 CAM-1	V r.		
1741:10.8 CAM-1	oh #.		
1741:11.4 CAM-2	gettin' a stall.		
1741:12.8 CAM-2	you got it.		
1741:13.7 CAM-1	OK.		
1741:15.3 CAM-	((sound of snap))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1741:15.4 CAM-1	oh Jes**.		
1741:15.7 CAM-2	abort, get it on.		
1741:16.3 CAM-3	get it off.		
1741:17.5 CAM-2	get it on.		
1741:18.0 CAM-3	get it off.		
1741:18.6 CAM-1	#.		
1741:20.3 CAM-1	what was the matter?		
1741:22.9 CAM-2	getting a stall.		
1741:32.0 CAM-1	stay with it.		
1741:33.7 CAM-2	stay on the brakes. stay on the brakes.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1741:35.3 CAM-?	((fire warning bell))		
1741:36.8 CAM-3	fire warning.		
1741:36.8 CAM-	((starts rattling sound))		
		1741:38.2 TWR-	TWA eight forty three heavy, numerous flames.
1741:41.0 CAM-?	oh #. there it goes.		
1741:41.5 CAM-	((sound of several bud bangs))		
1741:45.0 CAM-1	OK, hit the evacuate.		
1741:45.0 CAM-?	evacuate (overlaps)		
1741:45.3 CAM-2	evac alarm. ((sound of fire bell))		
		1741:50.0 TWR-	redbird seven forty six, go around, climb and maintain.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1741:50.0 CAM-3	evac alarm.		
1741:50.1 CAM-1	OK evac alarm.		
1742:52.9 CAM-1	cancel it out.		

END OF RECORDING

NATIONAL TRANSPORTATION SAFETY BOARD
Engineering Services Division
Washington, D.C. 20594

ADDENDUM

SPECIALIST'S FACTUAL REPORT OF INVESTIGATION
Cockpit Voice Recorder
DCA 92 MA 044

November 20,7992

The following corrections to the original transcript have been approved by the CVR Group:

1. Add statement at time 1734:48;

   TWR- TWA eight forty three heavy, Kennedy Tower.

2. Add statement at time 1734:50;

   RDO-2 eight forty three, go ahead.

3. Add statement at time 1734:54;

   TWR- TWA eight forty three heavy, initial heading will be one one zero, departure frequency, one three two point four.

4. Add statement at time 1734:59;

   RDO-2 one one zero one three two four roger.

Albert G. Reitan
Transportation Safety Specialist

As part of the Safety Board's accident investigation process, the Captain, First Officer, and Second Officer were invited to review the CVR group's transcript and provide suggested corrections or additions. Also in attendance at this review, was one of the two ACMs present on the accident flight. The second ACM stated he was sleeping during the take-off and initial part of the runway excursion. This review was conducted on August 6, 1992 and suggested the following changes:

1. Statement at 'he 1738:00, change to: RDO-2
2. After statement at time 1738:48, add statement: CAM-3 . one pack for take-off.
3. Statement at time 1738:51, change to: CAM-2
4. Statement at time 1738:52, change to: CAM-1
5. Statement at time 1739:49, change to: CAM-5
6. Statement at time 1739:59, change to: CAM-?
7. Statement at time 1740:03, change to: CAM-1
8. Statement at time 1740:10.9, change lo: RDO-2
9. Statement at time 1740:27.7, change to: CAM-1 trim throttles, please.
10. Statement i time 1740:28.0, change to: CAM-3 trim throttles.
11. Statement at time 1740:28.9, (eliminate thb statement)
12. After statement at time 1741:03.1, (crew stated the cockpit stick shaker activated four seconds after V r, but they could not hear it on the CVR tape)
13. Sound at time 1741:15.3, (new stated this was sound of throttles coming back)

14. Statement at time 1741:32.0, change to: **CAM-5** stay with it. you're doing good.

15. Sound at time 1741:41.5, (crew states this was the sound of the nose gear collapse and ACM seat collapse)

16. Statement at time 1740:50.0, change to: **CAM-1**

17. Statement at time 1740:50.1, change to: **CAM-3**

Albert G. Reitan
Transportation Safety Specialist

Attachment: