Landed short, Eastern Air Lines, Inc., Boeing 727-225, N8845E, John F. Kennedy International Airport, Jamaica, New York, June 24, 1975

Micro-summary: This Boeing 727-225 collided with approach lighting when landing in a thunderstorm.

Event Date: 1975-06-24 at 1605 EDT

Investigative Body: National Transportation Safety Board (NTSB), USA

Investigative Body's Web Site: http://www.ntsb.gov/

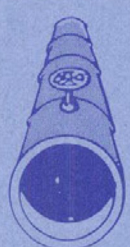
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

EASTERN AIR LINES, INC.
BOEING 727-225, N8845E

JOHN F. KENNEDY INTERNATIONAL AIRPORT



JAMAICA, NEW YORK

JUNE 24, 1975

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UNITED STATES GOVERNMENT

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Adopted: March 12, 1976

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SYNOPSIS

About 1605 e.d.t. on June 24, 1975, Eastern Air Lines Flight 66, a Boeing 727-225, crashed into the approach lights to runway 22L at the John F. Kennedy International Airport, Jamaica, New York. The aircraft was on an ILS approach to the runway through a very strong thunderstorm that was located astride the ILS localizer course. Of the 124 persons aboard, 113 died of injuries received in the crash. The aircraft was destroyed by impact and fire.

The National Transportation Safety Board determines that the probable cause of this accident was the aircraft's encounter with adverse winds associated with a very strong thunderstorm located astride the ILS localizer course, which resulted in a high descent rate into the non-frangible approach light towers. The flightcrew's delayed recognition and correction of the high descent rate were probably associated with their reliance upon visual cues rather than on flight instrument references. However, the adverse winds might have been too severe for a successful approach and landing even had they relied upon and responded rapidly to the indications of the flight instruments.

Contributing to the accident was the continued use of runway 22L when it should have become evident to both air traffic control personnel and the flightcrew that a severe weather hazard existed along the approach path.

1. INVESTIGATION

1.1 History of the Flight

On June 24, 1975, Eastern Air Lines Flight 66, a Boeing 727-225, N8845E, operated as a scheduled passenger flight from New Orleans, Louisiana, to New York, New York. The flight departed New Orleans about 1319 e.d.t. 1/ with 116 passengers and 8 crewmembers aboard. It proceeded to the John F. Kennedy International Airport, Jamaica, New York, on an instrument flight rules (IFR) flight plan.

Eastern 66 arrived in the New York City terminal area without reported difficulty, and, beginning at 1535:11, Kennedy approach control (Southgate arrival controller) provided radar vectors to sequence the flight with other traffic and to position it for an instrument landing system (ILS) approach to runway 22L at the Kennedy airport. The flight had received a broadcast on the automatic terminal information service (ATIS), which gave in part the 1251 Kennedy weather observation and other data as follows: "Kennedy weather, VFR, sky partially obscured, estimated ceiling 4,000 broken, 5 miles with haze...wind 210° at 10, altimeter 30.15. Expect vectors to an ILS runway 22L, landing runway 22L, departures are off 22R...."

At 1551:54, the Southgate arrival controller broadcast to all aircraft on his frequency, "...we're VFR with a 5-mile, light, very light rain shower with haze, altimeter check 30.13....It's ILS 22L, also." At 1552:43, the controller transmitted, "All aircraft this frequency, we just went IFR with 2 miles very light rain showers and haze. The runway visual range is---not available, and Eastern 66 descend and maintain four thousand, Kennedy radar one three two four." Eastern 66 acknowledged the transmission.

Eastern 66 was one of a number of aircraft that were being vectored to intercept the ILS localizer course for runway 22L. At 1553:22, the flight contacted the Kennedy final vector controller, who continued to provide radar vectors around thunderstorms in the area, to sequence the flight with other traffic, and to position the flight on the localizer course. About 1557:21, the flightcrew discussed the problems associated with carrying minimum fuel loads when confronted with delays in terminal areas. One of the crewmembers stated that he was going to check the weather at the alternate airport, which was LaGuardia Airport, Flushing, New York. Less than a minute later, one of the crewmembers remarked, "... one more hour and we'd come down whether we wanted to or not." At 1559:19, the final vector controller transmitted a message to all aircraft on his frequency that "a severe wind shift" had been reported on the final approach and that he would report more information shortly.

1/ All times herein are eastern daylight based on a 24-hour clock.

Eastern Air Lines Flight 902, a Lockheed 1011, had abandoned its approach to runway 22L at 1557:30. At 1559:40, Eastern 902 re-established radio communications with the Kennedy final vector controller, and the flightcrew reported, "...we had...a pretty good shear pulling us to the right and...down and visibility was nil, nil out over the marker...correction...at 200 feet it was...nothing." The final vector controller responded, "Okay, the shear you say pulled you right and down?" Eastern 902 replied, "Yeah, we were on course and down to about 250 feet. The airspeed dropped to about 10 kn below the bug and our rate of descent was up to 1,500 feet a minute, so we put takeoff power on and we went around at a hundred feet."

Eastern 902's wind shear report to the final vector controller was recorded on Eastern 66's cockpit voice recorder (CVR). While Eastern 902 was making this report, the captain of Eastern 66, at 1600:33, said, "You know this is asinine." An unidentified crewmember responded, "I wonder if they're covering for themselves."

The final vector controller asked Eastern 66 if they had heard Eastern 902's report. Eastern 66 replied, "...affirmative." The controller then established the flight's position as being 5 miles from the outer marker (OM) and cleared the flight for an ILS approach to runway 22L. Eastern 66 acknowledged the clearance at 1600:54.5, "Okay, we'll let you know about the conditions." At 1601:49.5, the first officer, who was flying the aircraft, called for completion of the final checklist. While the final checklist items were being completed, the captain stated that the radar was, "Up and off...standby." At 1602:20, the captain said, "...I have the radar on standby in case I need it, I can get it off later."

At 1602:42, the final vector controller asked Eastern 902, "...would you classify that as severe wind shift, correction, shear?" The flight responded, "Affirmative."

At 1602:50.5, the first officer of Eastern 66 said, "Gonna keep a pretty healthy margin on this one." An unidentified crewmember said, "I...would suggest that you do;" the first officer responded, "In case he's right."

At 1602:58.7, Eastern 66 reported over the OM, and the final vector controller cleared the flight to contact the Kennedy tower. At 1603:12.4, the flight established communications with Kennedy tower local controller and reported that they were, "outer marker, inbound." At 1603:44, the Kennedy tower local controller cleared Eastern 66 to land. The captain acknowledged the clearance and asked, "Got any reports on braking action...?" The local controller did not respond until the query was repeated. At 1604:14.1, the local controller replied, "No, none, approach end of runway is wet...but I'd say about the first half is wet--we've had no adverse reports.

At 1604:45.8, National Air Lines Flight 1004 reported to Kennedy tower, "By the outer marker" and asked the local controller, "...everyone else...having a good ride through?" At 1604:58.0, the local controller responded, "Eastern 66 and National 1004, the only adverse reports we've had about the approach is a wind shear on short final...." National 1004 acknowledged that transmission--Eastern 66 did not.

Both flight attendants who were seated in the aft portion of the passenger cabin, described Eastern 66's approach as normal--there was little or no turbulence. According to one of the attendants, the aircraft rolled to the left, and she heard engine power increase significantly. The aircraft then rolled upright and rocked back and forth. She was thrown forward and then upright; several seconds later she saw the cabin emergency lights illuminate and oxygen masks drop from their retainers. Her next recollection was her escape from the wreckage.

Witnesses near the middle marker (MM) for runway 22L saw the aircraft at a low altitude and in heavy rain. It first struck an approach light tower which was located about 1,200 feet southwest of the MM; it then struck several more towers, caught fire, and came to rest on Rockaway Boulevard. Initial impact was recorded on the CVR at 1605:11.4. The accident occurred during daylight hours at 40° 39' N. latitude and 73° 45' W. longitude.

Five witnesses located along the localizer course, from about 1.6 miles from the threshold of runway 22L to near the MM, described the weather conditions when Eastern 66 passed overhead as follows: Heavy rain was falling and there was lightning and thunder; the wind was blowing hard from directions ranging from north through east.

Persons driving on Rockaway Boulevard stated that a driving rainstorm was in progress when they saw the aircraft hit the approach light towers and skid to a stop on the Boulevard. Persons located about 0.6 miles south of the accident site stated that no rain was falling at their location when they saw the crash. They stated that the visibility to the northeast was good, but that visibility to the north was reduced. Persons who were in the north and northwest areas of the airport between 1555 and 1600 stated that heavy rain was falling; one stated that a violent wind was blowing from the northwest.

Flying Tiger Line Flight 161, a DC-8, had preceded Eastern 902 on the approach and had landed on runway 22L about 1556:15. After clearing the runway, at 1557:30, the captain reported to the local controller: "I just highly recommend that you change the runways and... land northwest, you have such a tremendous wind shear down near... the ground on final." The local controller responded, "Okay, we're indicating wind right down the runway at 15 kn when you landed." At 1557:50, the captain of Flight 161 said, "I don't care what you're indicating; I'm just telling you that there's such a wind shear on the final on that runway you should change it to the northwest." The local controller did not respond. At 1557:55, he transmitted missed approach directions to Eastern 902 and asked "...was wind a problem?" Eastern 902 answered, "Affirmative."

The captain of Flying Tiger 161 stated that during his approach to runway 22L he entered precipitation at about 1,000 feet 2/, and he experienced severe changes of wind direction, turbulence, and downdrafts between the OM and the airport. He observed airspeed fluctuations of 15 to 30 kn and at 300 feet he had to apply almost maximum thrust to arrest his descent and to strive to maintain 140 kn on his inertial navigation system groundspeed indicator. The aircraft began to drift rapidly to the left, and he eventually had to apply 25° to 30° of heading correction to overcome the drift. He believed that the conditions were so severe that the would not have been able to abandon the approach after he had applied near maximum thrust, and therefore he landed.

The captain of Eastern 902 stated that on his approach to runway 22L he flew into heavy rain near 400 feet. The indicated airspeed dropped from about 150 kn to 120 kn in seconds and his rate of descent increased significantly. The aircraft moved to the right of the localizer course, and he abandoned the approach. He was unable to arrest the aircraft's descent until he had established a high noseup attitude and had applied near maximum thrust. He thought the aircraft had descended to about 100 feet before it began to climb.

Two aircraft, Finnair Flight 105, a DC-8, and N240V, a Beechcraft Baron, followed Eastern 902 on the approach. Their pilots stated that they also experienced significant airspeed losses and increased rates of descent. However, they were able to cope with the problem because they had been warned of the wind shear condition and had

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2/ All altitudes herein are mean sea level.

increased their airspeeds substantially to account for the condition. Neither pilot reported the wind shear conditions; one pilot stated that he did not report the wind shear because it had already been reported and he believed that the controllers were aware of the situation.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	6	106	0
Nonfatal	2	10 3/	0
None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Six approach light towers were destroyed and four were damaged. A street light stanchion and a section of chain link fence which bordered the airport were destroyed.

1.5 Crew Information

The crewmembers were qualified and certificated for the flight. The four flight crewmembers had been on duty about 8 hours 20 minutes on the day of the accident. One crewmember, a flight check engineer, was giving an annual line check to the flight engineer. The flightcrew had been off duty the required time before they reported for duty on June 24, 1975. (See Appendix B.)

1.6 Aircraft Information

N8845E was owned and operated by Eastern Air Lines, Inc. It was certificated and maintained in accordance with Federal Aviation Administration (FAA) regulations and requirements. (See Appendix C.)

3/ One of the passengers who is listed as having nonfatal injuries died 9 days after the accident. Since 49 CFR 830.2 defines "fatal injury" as one that results in death within 7 days of the accident, this passenger's injuries are listed as nonfatal.

N8845E departed New Orleans with 38,000 lbs. of Jet-A fuel on board. The fuel consumed during the flight was estimated at 26,700 lbs., and N8845E's estimated landing weight was 141,042 lbs. At that weight the aircraft's approach reference speed with 30° of flaps extended was about 130 kn. The aircraft's center of gravity and weight were within prescribed limits both for takeoff and for landing.

1.7 Meteorological Information

The weather in the New York City area at the time of the accident included scattered thunderstorm activity. Weather radar observations established that the thunderstorms near the Kennedy Airport were very strong with associated heavy precipitation.

The surface weather observations at the Kennedy Airport were:

1251 - Sky partially obscured, estimated ceiling 4,000 broken, 5 miles with haze, wind--210° at 10 kn., altimeter setting--30.15 in.

1550 - 3,000 feet scattered, estimated 6,000 feet broken, visibility--5 miles in light rain showers and haze, temperature--77°F, dewpoint--71°F, wind--300° at 6 kn., altimeter setting--30.13 in., visibility north--2 miles, towering cumulus north, rain began at 1515.

1602 - Special, 3,000 feet scattered, estimated 5,000 broken, visibility--2 miles, thunderstorm, light rain showers, haze, wind--210° at 7 kn., altimeter setting--30.13 in., thunderstorm began at 1601, thunderstorm overhead moving northeast, occasional lightning cloud to cloud, visibility south--5 miles.

1606 - Special, similar conditions to those reported at 1602 except: A thunderstorm was north moving northeast, visibility--4 miles, and wind--100° at 4 kn.

The anemometer, which provides the official wind information on the Kennedy Airport, is located about midway between runways 22L and 22R and about a mile from the threshold of runway 22L. Remote indicating equipment is located in the control tower and the NWS office on the airport.

At 1526, the National Weather Service Forecast Office (NWS), located in midtown Manhattan, issued a strong wind warning which was valid from 1600 to 2000. The warning called for gusty surface winds to 50 kn from the west in thunderstorms in the New York City terminal area. The NWS distributed the warning to various facilities in the area, including the Kennedy control tower and approach control and Eastern Air Lines operations at the Kennedy Airport. There was no evidence that the warning was disseminated to flightcrews operating in the area.

The NWS had WSR-57 weather radar equipment located atop the RCA building in midtown Manhattan. The radar returns from the New York City area were unusable for aviation purposes because of ground clutter.

About 8 minutes before the accident, the NWS weather radar located at Atlantic City, New Jersey, showed that an area of thunderstorm activity was centered along the northern edge of Kennedy Airport. The area was oriented west-northwest to east-southeast and was 30 to 35 miles long and about 15 miles wide. Several groups of thunderstorm cells in the area had tops which exceeded 50,000 feet. The tropopause was reported at 46,500 feet. About the time of the accident, the largest group of cells, moving east-southeast at a speed of 30 to 35 kn, merged with a smaller group of cells, moving east-northeast at a speed of about 20 to 25 kn; the cells merged over the approach course to runway 22L. There is no evidence that this information was available to either air traffic control (ATC) agencies or flightcrews who were operating in the New York City terminal area.

The NWS terminal forecast for Kennedy Airport, which was valid before Eastern 66 departed New Orleans, called for thunderstorms and moderate rain showers after 1800. The forecast was amended at 1430 to include thunderstorms and moderate rain showers after 1515. At 1545, the forecast was further amended to call for thunderstorms, heavy rain showers with visibilities as low as 1/2 mile, and winds from 270° at 30 kn with gusts to 50 kn after 1615. There was no evidence that the flightcrew of Eastern 66 received any of these forecasts.

At the time of the accident, there was no SIGMET in effect for the New York City terminal area.

The Eastern Air Lines forecast, which was issued at 1208 and which was valid from 1215 to 2000, predicted widely scattered thunderstorms with tops from 30,000 to 40,000 feet in New York and eastern

New Jersey. The terminal forecast for New York City predicted scattered clouds until 2000; thereafter, thunderstorms were possible with light rain showers. The flightcrew of Eastern 66 received this forecast before departing New Orleans.

1.8 Aids to Navigation

Kennedy Airport is equipped with approach control radar and numerous VOR and ILS approach aids. Runway 22L is equipped with a Category I ILS approach; the glideslope is unusable below 200 feet.

About 1 1/2 hours after the accident, the FAA flight-checked the ILS for runway 22L. All components except the approach light system operated within prescribed tolerances. The approach lights had been put out of service by the crash.

1.9 Communications

ATC air-to-ground radio equipment in the Kennedy Airport terminal area, was operating satisfactorily; however, the frequencies in use were congested because of heavy traffic.

1.10 Aerodrome and Ground Facilities

Kennedy Airport, located in Queens County, New York, is about 12 miles southeast of midtown Manhattan, about 9 miles south-southeast of LaGuardia Airport, and about 18 miles east-southeast of Newark International Airport in New Jersey. Two sets of parallel runways are available--4-22 and 13-31, left and right. These runways are equipped with ILS facilities; however, under IFR weather conditions, only one runway at a time can be used for instrument approaches. A short runway, 14-32, is available for general aviation and short takeoff-and-land aircraft. Airport elevation is 12 feet.

Runway 22L is 8,400 feet long and 150 feet wide. The elevation at the touchdown zone is 12 feet. The runway is equipped with high intensity runway lights and a high intensity approach lighting system with sequence flashing lights. There were no visual approach slope indicators (VASI) on runway 22L. According to the local controller, the runway and approach lights were on when Eastern 66 crashed, and they were set one step below maximum intensity.

The approach light towers struck by the aircraft were spaced 100 feet apart and constructed of nonfrangible material.

1.11 Flight Recorders

N8845E was equipped with a Sundstrand Model FA-542 flight data recorder (FDR), serial No. 2556, and a Fairchild Model A-100 CVR, serial No. 3303. Both recorders were recovered intact; all FDR traces and CVR channels were recorded clearly. The final 10 minutes of the FDR traces were read out; the final 5 minutes were plotted. (See Appendix E.) The full CVR tape was transcribed.

Pertinent CVR sounds were correlated with the FDR airspeed and altitude traces for the 5-minute period before impact. They were correlated by matching the time of impact and the times of air-to-ground radio transmissions, which were indicated on both recordings. These events were correlated further to local time by comparing them with the time signals on the ATC tapes.

The Kennedy approach control automated radar terminal system (ARTS) 1A radar equipment and the New York air route traffic control center's (NYARTCC) national airspace system (NAS) Stage-A radar equipment each recorded N8845E's approach to Kennedy Airport. Characteristics of the radar-processing equipment limited these data to flight above 2,000 feet for the ARTS 1A and above about 750 feet for the NAS Stage-A. Available data were correlated with the CVR and FDR data to locate the aircraft's position relative to the ground. From this correlation, the Safety Board determined N8845E's position relative to the ILS glideslope during the first part of the approach. (See Appendix F.)

The correlation of CVR, FDR, and radar data shows that N8845E intercepted the glideslope at an altitude of about 3,000 feet at 1601:20. At that time, the captain commented, "Just fly the localizer and glideslope," and the first officer replied, "Yeah, you save noise that way and get a little more stability." The flaps were extended to 15° and the landing gear were lowered. The flightcrew was engaged in final checklist duties for the next 30 seconds, and the aircraft was bracketing the glideslope. The airspeed varied between 160 and 170 kn.

At 1603:05.5, the first officer requested 30° of flaps. The aircraft continued to bracket the glideslope and the airspeed oscillated between 140 and 145 kn. At 1603:57.7, the flight engineer called, "1,000 feet," and at 1604:25, the sound of rain was recorded.

At 1604:38.3, N8845E was nearly centered on the glideslope when the flight engineer called, "500 feet." The airspeed was oscillating between 140 and 148 kn. The sound of heavy rain could be heard as the aircraft descended below 500 feet, and the windshield wipers were switched to high speed.

At 1604:40.5, the captain said, "Stay on the gauges." The first officer responded, "Oh, yes. I'm right with it." At 1604:48.0, the flight engineer said, "Three greens, 30 degrees, final checklist," and the captain responded, "Right."

At 1604:52.6, the captain said, "I have approach lights," and the first officer said, "Okay." At 1604:54.7, the captain again said, "Stay on the gauges," and the first officer replied, "I'm with it." N8845E then was passing through 400 feet, and its rate of descent increased from an average of about 675 feet per minute (fpm) to 1,500 fpm. The aircraft rapidly began to deviate below the glideslope, and 4 seconds later, the airspeed decreased from 138 kn to 123 kn in 2.5 seconds.

N8845E continued to deviate further below the glideslope, and at 1605:06.2, when the aircraft was at 150 feet, the captain said, "runway in sight." Less than a second later, the first officer said, "I got it." The captain replied, "got it?" and a second later, at 1605:10.2, an unintelligible exclamation was recorded, and the first officer commanded, "Takeoff thrust." The sound of impact was recorded at 1605:11.4.

Because of the landing problems reported by the pilots of Flying Tiger 161 and Eastern 902, the Safety Board obtained their FDR's and examined them. Also, the FDR from Finnair 105 was examined. The NAS Stage-A radar data provided a basis for determining the time intervals between the flights. Flying Tiger 161, Eastern 902, and Finnair 105 preceded Eastern 66 on the approach by 8 minutes 59 seconds, 7 minutes 28 seconds, and 6 minutes 45 seconds, respectively.

Flying Tiger 161 was equipped with a Sundstrand Model FA-542 FDR, serial No. 1453A. The recorder traces showed that after the flight had descended through 500 feet, its airspeed decreased from 154 to 137 kn within 10 seconds. During the same period, the aircraft's rate of descent increased from 750 fpm to 1,650 fpm.

Eastern 902, a Lockheed 1011, was equipped with a Lockheed Model 209-E, digital flight data recorder (DFDR), serial No. 104. The DFDR recorded 63 parameters of flight on magnetic tape. The data showed altitude and airspeed deviations similar to those encountered by Eastern 66.

After Eastern 902 had descended below 400 feet, its rate of descent increased from 750 fpm to 1,215 fpm, and its airspeed decreased from 145 to 121 kn in 10 seconds. When the airspeed reached 121 kn, the engine pressure ratios increased from 1.1 to 1.5. The airspeed remained at 121 kn for about 6 seconds and then began to increase. The aircraft continued to deviate below the glideslope, however, until it reached 75 feet. At that time, Eastern 902 was about 120 feet below the ILS glideslope, and a positive rate of climb was established to execute the missed approach procedure.

Finnair 105 was equipped with a Fairchild Model 5424 FDR. The traces showed that the flight was maintaining about 160 kn while it descended to 750 feet. Between 750 and 500 feet, the airspeed oscillated between 148 and 154 kn. After Finnair 105 descended through 500 feet, the airspeed began to decrease to 122 kn within the following 20-second period. The rate of descent increased momentarily; however, it decreased when the aircraft descended through 250 feet. The airspeed increased slightly and continued to oscillate until touchdown.

1.12 Wreckage

Eastern 66 first contacted the top of the No. 7 approach light tower at an elevation of 27 feet above the mean low-water level and 2,400 feet from the threshold of runway 22L. The aft end of the jackscrew fairing for the left, outboard trailing edge flap lodged in the tower. The aircraft continued and struck towers 8 and 9. The aircraft's left wing was damaged severely by impact with these towers--the outboard section was severed. The aircraft then rolled into a steep left bank (well in excess of 90°) between towers 9 and 10, where it first contacted the ground. Its descent angle between the No. 7 tower and the beginning of the ground mark was 4.5°. It missed towers 10, 11, and 12; a gouge in the earth, about 340 feet long, paralleled the approach light towers on the northwest side from near tower No. 10 to tower No. 13. Three large outboard sections of the left wing were located near the beginning of the gouge.

Near the No. 13 tower, the aircraft's direction of travel changed from a magnetic heading of 220° to 205°; the fuselage struck towers 13, 14, 15, 16, and 17. The aircraft then continued to Rockaway Boulevard, where it came to rest. The approach light towers and large boulders along the latter portion of the path caused the fuselage to collapse and disintegrate. (See Appendix G.)

There was no evidence of preexisting structural damage or control malfunction, nor was there any evidence of an in-flight fire, bird strike, explosion, or lightning strike.

The stabilizer trim setting was 8.25 units airplane noseup. The wing leading edge devices were extended fully and the trailing edge flaps were extended 30°. The landing gears were fully extended.

Parts of the No. 1 engine were located near tower No. 12; the engine was damaged severely. The No. 2 engine was found beside the tail section, and the No. 3 engine remained attached to the tail section.

The fan and compressor blades in all three engines were bent or broken in a direction opposite that of normal fan and compressor rotation. The rotating components of the front and rear compressor sections had been damaged by foreign objects.

There was no evidence that any of the engines had experienced overtemperatures. The main oil screens and fuel filters on all three engines were uncontaminated.

The recovered engine components associated with engine acceleration were tested functionally; they operated within prescribed limits. The eighth-stage compressor bleed air systems of the Nos. 2 and 3 engines contained debris. The thirteenth-stage bleed air systems of these two engines were clear. The compressor bleed air systems of the No. 1 engine were damaged too severely to detect debris.

Under the atmospheric conditions that existed at the time of the accident and at nominal thrust levels of 3,000 lbs., the thirteenth-stage bleed air valve would be closed and the eighth-stage bleed air system would be supplying engine demands. Corresponding values of engine pressure ratio, N_1 compressor speed, and N_2 compressor speed would be 1.20, 62 percent, and 78 percent, respectively.

1.13 Medical and Pathological Information

The flightcrew died from multiple extreme impact injuries. Post-mortem examinations and toxicological analyses disclosed no preexisting pathological conditions or other findings which would have affected their performances.

Two flight attendants died of multiple extreme impact injuries. The two flight attendants who survived sustained one or more fractures and multiple contusions and abrasions. The latter injuries were most notable over the pelvic areas where their seatbelts had restrained them.

Most of the passengers died from severe multiple impact injuries. Some of them also suffered varying degrees of burns. Each of the surviving passengers sustained burns which varied from first to third degree over 30 to 70 percent of the body. Some of these passengers also received impact injuries and fractures.

1.14 Fire

Fire erupted after the left wing failed and released fuel as the aircraft skidded through the approach light towers. There were numerous ignition sources--hot engine components, electrical wiring in the aircraft, the approach light system, and the street light system--and many friction sources. Destruction of the fuselage caused more fuel to be released, and the fire continued to burn after the aircraft came to rest.

The assistant chief of the Kennedy tower activated the fire alarm about 1606 and the Port Authority of New York and New Jersey's fire department, which is located at Kennedy Airport, responded immediately. The first firetruck arrived at the scene about 2 minutes later. The New York City Fire Department was notified about 1609, and its first units arrived about 4 minutes later.

The main fire was under control in about 2 minutes and was extinguished about 3 minutes later. The firemen extinguished a number of small fires with portable fire extinguishers.

The Port Authority fire department used 900 pounds of dry chemical, 1,430 gallons of foam concentrate, and 24,000 gallons of foam and water mix to extinguish the fires.

The fire department's rapid response prevented fatal burns to the 9 passengers who ultimately survived; some were found lying in pools of fuel and fire-extinguisher foam.

1.15 Survival Aspects

The accident generally was not survivable because of the near complete destruction of the aircraft's fuselage. The cockpit seats, the forward flight attendants' seats, and the passengers' seats were torn from their supporting structures. The seats were mangled and twisted and were scattered throughout the area along the last 500 to 600 feet that the aircraft traveled. Only the aft flight attendants' seats remained attached to their supporting structure. Almost all passenger seatbelts remained attached to their seat structures and remained fastened.

When the fuselage disintegrated and the cabin floors and seat anchors failed, the aircraft's occupants became unrestrained and unconfined. They collided with each other and their surroundings, causing multiple extreme impact injuries.

The 14 survivors were seated in the inverted rear portion of the passenger cabin. Although their seat support structures (except the aft flight attendants') also failed, they were less severely injured because the rear portion of the passenger cabin and the empennage section remained relatively intact. The aft flight attendants were able to escape unaided because their restraint systems did not fail, and they were protected from flying debris.

Personnel from the Port Authority Medical Clinic arrived at the scene promptly, and they administered first aid to the survivors. Only one ambulance was available and it was used to transport six survivors to the Jamaica Hospital. Firemen transported the remaining survivors to the hospital in a firetruck.

Two of the 14 survirors died shortly after they arrived at the hospital. Two passengers died within 5 days after the accident and one passenger died 9 days after the accident.

1.16 Tests and Research

1.16.1 Aircraft Performance Analyses

Aircraft performance analyses were conducted to determine the extent to which Eastern 66, Flying Tiger 161, and Eastern 902 were affected by the winds they encountered during their approaches to runway 22L. The Boeing Company, the Lockheed California Company, the Douglas Aircraft Company, and the National Aeronautics and Space Administration's Ames Research Center participated in the analyses.

During the analyses, the movements of the airplanes through space, as determined from the FDR parameters and the NAS Stage A radar data, were compared with the theoretical performance capability of the aerodynamic model of each airplane.

The airplane's theoretical performance capability for a given set of conditions (including weight, configuration, thrust, airspeed, and altitude), was established by a specific plot of vertical speeds versus longitudinal accelerations. When the values for the airplane's rate-of-altitude change and rate-of-airspeed change at a given instant were not compatible with the calculated theoretical performance capability, the differences were attributed to external forces on the airplane which were produced by changes in the vertical and horizontal components of the wind.

For the B-727 and DC-8 aircraft, certain thrust settings and airplane configurations were assumed as a function of time. The assumptions made for the DC-8 were based on comments from its pilots. The analysis of Eastern 66's data was based on cockpit conversations, other sounds recorded on the CVR, and standard operating procedures for Eastern's pilots.

Although the total effect of the wind could be determined by these analyses, the exact combinations of vertical and horizontal wind components which would reproduce the actual flightpaths could not be determined precisely. However, the additional parameters measured by the DFDR from Eastern 902 provided the information for a more comprehensive analysis of the winds encountered by that aircraft.

For Eastern 902, known DFDR values were used for aircraft configuration and thurst. Additionally, through use of DFDR values for the airplane's pitch attitude and angle of attack, the airplane's instantaneous vertical speed relative to the air mass in which it was moving was determined. The aircraft's vertical speed was compared with the derivative of the measured altitude to find the vertical component of the wind velocity. The remaining effect of wind on aircraft performance, therefore, was attributed to the rate of change in the longitudinal component of the wind velocity.

By the above process, a wind model, defined by the vertical and horizontal components of the wind, was established as a function of Eastern 902's altitude and its flight-recorder time base. The total performance degradation caused by this wind model was nearly identical to the calculated performance degradation attributed to wind in the analysis of Eastern 66's flightpath. The wind model was related to the aircraft's position over the ground by correlating DFDR and radar data. It appeared that Eastern 66 and Eastern 902 encountered similar wind environments, except that Eastern 66 encountered the conditions closer to the runway threshold.

The results of these analyses showed that Eastern 66 probably encountered an increasing headwind as it descended on the ILS glideslope. The wind changed from about a 10-kn headwind at 600 feet to an approximate 25-kn headwind at 500 feet. About the time the aircraft descended through 500 feet, it encountered a downdraft with peak speeds of about 16 feet per second (fps). The headwind diminished to about 20 kn as the aircraft descended to 400 feet, where the speed of the downdraft abruptly increased to about 21 fps, and the headwind suddenly decreased from 20 kn to 5 kn over a 4-second period. During this encounter, the aircraft deviated rapidly below the glideslope. As the aircraft continued to descend toward the ground, the downdraft diminished and the longitudinal wind component continued to decrease.

The wind model was considered to be consistent with the downdraft and outflow activity that has been measured in the vicinity of strong thunderstorms. Close examination of the wind model disclosed transient periods in which the combination of downdraft speed and the rate-of-airpseed change (caused by the abrupt decrease in the longitudinal wind component along Eastern 66's flightpath) might have exceeded the aircraft's static performance capability. That is, during these transient periods, the aircraft could have lost airspeed or altitude, or both, even with maximum thrust and regardless of compensatory flight control inputs.

It was hoped that, as a result of these analyses, the effect on the aircraft's performance while it traversed the changing wind conditions during the transient periods could be measured in terms of minimum altitude lost. However, the problem is dynamic, complex, and dependent on many variables, among which are the aircraft's entry airspeed and the rapidity with which compensatory thrust and flight control changes are applied. Therefore, the only valid method by which the total effect of the environment on aircraft control and performance could be assessed was through the introduction of pilot responses.

1.16.2 Simulator Tests

A Boeing Company flight simulator, programmed with the dynamic winds and the flight characteristics of N8845E, was used to assess the influence of pilot responses on aircraft control and performance. The fixed-base simulator was equipped with a black and white TV-image visual system. The visual system was adjusted to produce a low-visibility condition. The approach environment, including the approach light system and ILS glideslope and localizer geometry, was modeled for the runway 22L approach to Kennedy Airport. The simulator cockpit, including the instrument panel and flight director displays, was similar to the cockpits of Eastern Air Lines' B-727's. The simulator was instrumented to record pertinent flight parameters.

The simulator was modified to accept wind models consisting of changing vertical and horizontal wind components as a function of the aircraft's altitude and its distance from the runway threshold. Four wind models were developed, each of which was designed to produce a combination of vertical and horizontal wind changes similar to those deduced from the foregoing performance analyses.

Since data were not available to determine the exact winds which existed in the areas above and below the analytical flight track, it was necessary to make assumptions about the wind in these areas in order to provide a model of the entire three-dimensional environment. The assumptions used for each of the models differed slightly. The wind models represented the downdraft and outflow activity associated with a strong thunderstorm located astride the localizer course.

The objectives of the simulator tests were: (1) To examine the flight conditions which probably confronted the flightcrew of Eastern 66, and (2) to observe the difficulties that a pilot has in recognizing the development of an unsafe condition and in responding with appropriate corrective action.

Fourteen pilots participated in the tests; nine pilots were either currently or formerly qualified in B-727 aircraft. Each pilot flew several approaches, beginning at the OM, through one or more of the wind models. The pilots were told to attempt to maintain an airspeed of 140 to 145 kn, which was 10 to 15 kn above reference speed. They were given the option of attempting to land or executing a missed-approach, but in any event, they were to try to avoid landing short of the runway threshold.

Fifty-four approaches were flown; on 18 of the approaches, the simulator reached an altitude which corresponded to an impact with the approach lights. Thirty-one missed-approaches were flown successfully. Only five approaches were flown successfully (placing the simulator over the runway threshold in a position from which a landing could be attempted).

None of the pilots had problems bracketing the glideslope while the simulator descended to 500 feet. At 400 feet, the simulator deviated rapidly below the glideslope. The deviation was exhibited by the upward movement of the flight director command bars and the almost immediate and full-scale deflection of the glideslope deviation indicator. The 20-kn decrease in airspeed also was displayed. The pilots were prepared for these cues and most responded immediately with thrust increases and noseup control movement.

Although the pilots were told to attempt to "go visual" on some approaches, any attempt to simulate surprise was futile. The pilots hesitated to switch from instrument to visual cues, partially because the simulator lacked peripheral imagery.

The pilots who flew approaches which terminated in impact with the approach lights were reluctant, when adding thrust, to interrupt their instrument scan to verify the engine thrust settings. Consequently, most of the pilots actually added less thrust than they thought they had added. Also, on several of the approaches the pilots did not rotate the aircraft to the pitch attitude commanded by the flight director or to the pitch attitude needed to stop the rate of descent; the attitude change required was about 9° noseup.

Several pilots noted that the back pressure needed on the control column to rotate the simulator 9° noseup was more than they had anticipated. Boeing engineers believed that the simulated control force was realistic but that the force was greater than that normally required because of the variation in longitudinal trim induced by the rapid loss of airspeed. The loss of airspeed was caused by the abrupt change in the headwind component.

On most approaches, as the simulator descended through 400 feet, the airspeed was higher than N8845E's airspeed at that altitude. The average speed was about 150 kn. On those approaches that ended with a short landing, the airspeed at 400 feet was usually about 145 kn. When plotted as a function of distance from the runway, several of the airspeed and altitude traces recorded during the simulated approaches resembled the traces on N8845E's FDR.

Following the simulator tests, comments were solicited from the pilots. Seven of the 10 pilots who commented believed that their recognition of the effects produced by the wind would have been delayed had they disrupted their instrument flying to "go visual" during the descent through 400 feet. Eight of the 10 pilots believed that they might have crashed during actual flight.

1.17 Other Information

1.17.1 Eastern Air Lines Altitude Awareness Procedures

Eastern's altitude awareness procedures required that the pilot not flying the aircraft call out the following information during an instrument approach:

(1) 1,000 feet above field elevation, airspeed, rate of descent, and the results of a flight instrument flag scan;

(2) 500 feet above field elevation, airspeed, rate of descent, and the results of a flight instrument flag scan; thereafter, any significant deviations from the desired performance;

(3) 100 feet above decision height or minimum descent altitude; and

(4) decision height or minimum descent altitude.

1.17.2 Eastern Air Lines Administrative Bulletins

During the year preceding the accident, Eastern issued a number of bulletins on low-level wind shear associated with both thunderstorms and frontal-zone weather. Although the bulletins were informative and contained many suggestions on how to anticipate and detect low-level wind shear, they did not provide specific flying techniques to overcome the effects of low-level wind shear. The bulletins implied that higher approach speeds should be used when shear is anticipated, but cautioned that when runways are wet excessive landing speeds should be avoided because of hydroplaning.

1.17.3 New York Terminal Control Area

The New York City area is enclosed by a Group I terminal control area (TCA). Special airborne-equipment requirements and air traffic control procedures apply to all operators who enter or depart the TCA. Three major commercial airports, Kennedy, LaGuardia, and Newark, are included in the TCA. Other airports in the TCA also accommodate significant volumes of traffic--Teterboro, Westchester County, Republic, and Morristown; the TCA also contains many smaller general aviation airports.

The New York Common IFR Room (CIFRR) which is located on Kennedy Airport, controls all air traffic operating under IFR procedures in the New York TCA. The three major approach control services, Kennedy, LaGuardia, and Newark, are located in this facility.

Since 14 CFR 93 (K) designates the Kennedy and LaGuardia Airports as high density traffic airports, the number of takeoffs and landings at these airports is limited during periods when traffic demands are high. At Kennedy, these operations are limited from 1500 to 2000, and at LaGuardia they are limited from 0600 to 2400. The operator of an aircraft must obtain a reservation from ATC to land at or depart from the Kennedy and LaGuardia Airports during these hours.

1.17.4 Runway Use at Kennedy

The Chief of the Air Traffic Division in the FAA's Eastern Region established the procedures for runway use at Kennedy, LaGuardia, Newark, and Teterboro Airports. The tower supervisors were responsible for selecting runways in accordance with their respective runway-use programs; the following considerations were paramount: (1) Safety, (2) aircraft noise abatement, and (3) operational advantages. The tower supervisors then coordinated with the assistant chief of the CIFRR before making the runway assignments. The latter was responsible for determining that the selected runways created the least adverse impact on the traffic flow to all of the airports, and he was the final authority for determining the runway configurations to be used.

The runway-use program at Kennedy Airport provided for a computer to assist the tower supervisor in making runway selections. The objective of the program was to optimize noise abatement throughout the airport community without derogating the safe, orderly, and expeditious flow of traffic.

The program applied to all turbojet aircraft when the wind speed was 15 kn or less and when there was no ice, slush, water, or any other condition which would render the selected runway unsuitable for the intended operation. If the wind changed from one direction/ quadrant or velocity category to another or if a runway combination had been in use for 6 hours, a new runway configuration would be selected. Runways could be used with crosswinds up to 15 kn. The computer's first selection of runways could be rejected and another runway configuration could be selected if: (1) The computer's selection would have an unacceptable impact on adjacent airports, and (2) one set of parallel runways was closed and traffic delays of 30 minutes or more were likely.

In the event of computer failure, criteria were established to alter runway use providing the surface winds did not exceed 15 kn. Runways could be selected for use even though crosswinds of 15 kn existed. If the surface winds exceeded 15 kn, the runway use program was not to be used.

On June 24, 1975, runways 31L/R at Kennedy Airport had been in use from 0718 to 1347. At 1347, operations were changed to runways 22L/R. From 1500 to 1900 was a peak traffic period and shortly after 1500, inbound traffic was being delayed. According to the approach control logs, about 1510 the watch supervisor of the CIFRR requested that the Kennedy tower permit some of the arriving traffic to use runway 13L. The control tower advised that a flight check was in progress on runway 31R (reciprocal runway) and that they would accept traffic spaced 10 miles apart. At 1539, the tower advised that they could not allow any landing traffic on runway 13L because the visibility was too low.

About 1543, Kennedy approach control began to hold inbound traffic at Southgate. 4/ Five minutes later, all low-level traffic inbound from Philadelphia was suspended. About 1550, Kennedy departure control began to delay all traffic departing Kennedy via the Oakwood 5/ departure routes. About 1554, Kennedy approach control began to hold all inbound traffic, and at 1602 Kennedy approach control anticipated arrival delays of 15 minutes at Southgate and 12 minutes at Bohemia. 6/ The reason for the delays was the thunderstorm activity in the area.

At the Safety Board's public hearing, the assistant chief of the Kennedy tower, who was in charge of the control tower cab personnel, testified that the 1500-to-2300 duty period generally was very busy. Shortly after 1500, he observed thunderstorms to the northwest of Kennedy on the tower radar. Thereafter, he was busy coordinating various activities and did not notice the rain and lightning northeast of the airport. He was aware that Eastern 902 had abandoned its approach to runway 22L but did not know why; the local controller was too busy to be interrupted for an explanation. Also, he did not know that Flying Tiger 161 had reported the wind shear and had recommended that the runway be changed. He stated, however, that had he known of Flight 161's report, he would not have changed the runway because the surface wind was most nearly aligned with runway 22L.

The local controller testified that he was aware of thunderstorms to the north of Kennedy about 15 minutes before the accident, but he considered them to be weak. He was very busy with his duties and did not have time to pass either Flying Tiger 161's report or Eastern 902's report to the assistant chief. He stated that he did not consider a change of runway either before Flight 161's and 902's problems or in response to Flight 161's recommendation because the

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4/ A navigation fix about 30 miles south of the Kennedy airport defined by the intersection of the 131° radial of the Colts Neck VOR and the 221° radial of the Deer Park VOR.

5/ Routes toward the northwest to the Huguenot VOR.

6/ A navigation fix about 32 miles east-northeast of the Kennedy Airport defined by the intersection of the 083° radial of the Deer Park VOR and the 191° radial of the Bridgeport VOR.

official wind instrument was indicating that the surface wind was most nearly aligned with runway 22L. He further stated that it would take anywhere from a few minutes to 30 minutes to change the runway.

The local control coordinator testified that shortly after 1500 he saw dark clouds to the west and northwest of Kennedy. On radar, he confirmed that there was a large thunderstorm to the west and that it was moving east. He was concerned about the weather situation and he expected it to deteriorate. About 1551, he observed the official prevailing visibility to be 2 miles. He stated that a thunderstorm with considerable lightning activity was north of the airport and that during the 10 to 15 minutes before the accident there was heavy rain just off the approach end of runway 22L. He described the rain as forming a solid wall beyond which he could not see. He said that throughout this period both he and the local controller were very busy controlling the inbound and outbound traffic.

The Kennedy approach control final vector controller stated that on his radar screen he saw a small thunderstorm cell centered on the localizer course about the time he cleared Eastern 66 for the ILS approach. The cell was located about midway between the OM and the airport. He said that he was very busy with his duties, and that he had received no report that wind shear had affected Flying Tiger 161. The only report he had received was from Eastern 902.

A number of airline pilots stated that when they conduct instrument approaches to airports affected by weather hazards they rely substantially on the experiences of pilots who precede them when they decide whether to make the approach themselves or to choose a different course of action.

The manager of B-727 flight training for Eastern testified that under IFR weather conditions at high density traffic airports such as Kennedy, Miami, and others, a pilot could expect substantial delays (about 30 minutes) if he chose to land on a runway other than the one which ATC had established as the runway for instrument approaches. These delays could be anticipated because ATC could not provide simultaneous instrument approaches to different runways. Therefore, the pilot would have to wait for ATC to resequence the traffic and provide separation from the normal flow. Most pilots are familiar with these delays, and their fuel supply becomes a significant factor in their decisions whether to accept the delays, to continue in the flow of traffic that ATC has established, or to proceed to their alternate airport.

1.17.5 Development of Wind Shear Detection Equipment

The Wave Propagation Laboratory of the National Oceanic and Atmospheric Administration experimented with an acoustical doppler system to measure wind shear at a large commercial airport in Colorado. According to the project manager, the experiments have proved that the system can detect and measure wind shear. However, because of problems with the system, additional experimentation and testing are needed before it can be used. Other wind shear detection systems, such as lasers and doppler radar, are being considered; however, much research and development are required to determine their feasibility and practicability.

1.17.6 Installation of Frangible Approach Light Towers

The nonfrangible approach light towers were responsible for much of the severe destruction of the aircraft. The need for frangible approach light towers on the approach paths to runways has been recognized. On April 5, 1975, the FAA issued Order No. 6850.9 on revised approach lighting criteria. Among other things, the order provided that frangible structures would be used for the full length of all future approach light installations. Additionally, a retrofit program would be considered if funds were available.

The Chief, NAVAID/Radar Facility Branch, Airway Facility Service, FAA, testified that funding for part of the retrofit program was expected in the fiscal year 1977 budget. He stated that the towers currently being installed were designed to fracture at impact speeds of 80 kn or higher and that the towers would probably fracture at speeds well below 80 kn, depending on the type of aircraft involved.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The aircraft was certificated, equipped, and maintained in accordance with regulations and approved procedures. There was no evidence of a malfunction or failure of the aircraft or its components that would have affected its performance.

All three engines were operating normally until impact. The presence of debris within the eighth-stage compressor bleed air systems and the absence of debris within the thirteenth-stage bleed air systems indicates that the Nos. 2 and 3 engines were operating at engine pressure ratios of about 1.20 or more at the time the debris was ingested into the engines. The damage to the fan blades and compressor section on the No. 1 engine was consistent with a high-power setting at impact.

The flightcrew was certificated properly and each crewmember had received the training and off-duty time prescribed by regulations. There was no evidence of medical or physiological problems that might have affected their performances.

It is clear from surface weather reports, weather radar data, and witness and pilot statements that a large area of very strong thunderstorms accompanied by strong, variable, and gusty surface winds was moving rapidly along the northern perimeter of Kennedy Airport between 1540 and 1620. The storm area was moving east-southeasterly, and about 1550 it began to seriously affect safe approach operations to runway 22L. Although the weather along the final approach course to that runway deteriorated rapidly from about 1550 to the time of the accident, the approach paths to the northwest runways remained relatively unaffected by the storms. Significant clues (both visual and radar) were available to air traffic controllers and flightcrews alike to indicate the existence of these conditions on and near Kennedy Airport.

Given the above circumstances, two causal aspects of this accident require discussion and analysis: (1) The weather hazards that existed along the approach path to runway 22L and how they affected Eastern 66, and (2) the reason or reasons why approach operations to runway 22L were continued even though the thunderstorms along the final approach course were evident and hazardous wind conditions had been reported.

How Thunderstorms Affected Eastern 66

Air flow is disturbed significantly within a mature thunderstorm cell and in the air mass surrounding the cell. These disturbances are dominated generally by vertical drafts, both up and down, which are created when the relatively cold and more dense air formed at higher altitudes displaces the warmer and less dense air near the surface. The downdrafts, which are frequently accompanied by heavy rain, can reach vertical speeds exceeding 30 fps. The interaction between the descending air and the earth's surface causes the flow to change from the vertical direction to the horizontal direction and creates a horizontal outflow of air in all directions beneath the cell and near the surface. The speeds of the vertical drafts and horizontal outflows depend on the severity of the storm. An aircraft passing through, below, or near a thunderstorm cell at low altitude may encounter these rapidly changing vertical and horizontal winds.

To analyze the effects of these rapidly changing winds on the flightpath of an airplane, forces which act on the airplane must be considered. These forces are lift, drag, weight, and thrust. In a dynamic situation, changes in the lift and drag are most significant because they depend at any instant on the airplane's relative wind vector; that is, the direction and speed of the impinging air stream relative to the airplane's control axes. The airplane's weight can be considered a constant since it varies only as fuel is consumed. Thrust is related primarily to throttle position and only to a small extent to the properties of the engine inlet air.

The analysis is simplfied by resolving the components of these forces along the aircraft's vertical and longitudinal axes. As long as the components of the forces are balanced, the airplane will remain in unaccelerated flight. However, if the forces are unbalanced, by the pilot's manipulation of the throttles or flight controls or by a change in the environment surrounding the airplane, the airplane will accelerate or decelerate until a new flightpath is established and the forces are again balanced.

When the airplane flies into a vertical wind, the transient change in the direction of the total wind vector, relative to the airplane's entry path, causes a change in both lift and drag. If the vertical wind's direction is downward, the lift and drag will decrease and the airplane will accelerate downward. The basic stability of the airplane will cause it to pitch nose up initially; however, the ultimate effect on the airplane's flightpath will be an increase in the descent rate relative to the ground. If the flight controls remain fixed, the aircraft will restabilize and descend with the descending air mass. Thus, the change in the airplane's rate of descent relative to the ground will equal the vertical speed of the wind and, if longitudinal wind does not change, the airspeed will remain approximately constant. The pilot can compensate for this condition by increasing the airplane's pitch attitude and by adding thrust to establish a climb relative to the descending air mass. He will thereby maintain the desired flightpath.

When an airplane flies into an area where the direction of the horizontal wind changes abruptly, the indicated airspeed will change. The change is equivalent to the abrupt change in the relative wind. Both lift and drag will also change abruptly and thus produce an imbalance in the forces acting along the airplane's longitudinal and vertical axes.

If the airplane flies into an increasing headwind or a decreasing tailwind, the speed of the relative wind will increase. The indicated airspeed, lift, and drag will increase; the nose of the airplane will pitch up; and the vertical speed will change in the positive direction. If the wind speed continues to change, the airplane will appear to have a positive increase in its performance. When the wind speed stabilizes, if thrust has not been changed, the longitudinal forces will be unbalanced because of the increased drag. The airplane will decelerate and eventually will return to equilibrium at its original airspeed. The pilot might react to the initial airspeed increase by reducing thrust. If he does, the thrust must be reset to prevent the airplane for decelerating to an airspeed lower than the original airspeed. When equilibrium is regained, however, the airplane's speed relative to the ground will have been changed by the amount of the change in the longitudinal wind component.

If the airplane flies into a decreasing headwind or an increasing tailwind, the effect will be opposite. The indicated airspeed will decrease, lift will decrease, the airplane's nose will pitch down, and the vertical speed will change in the negative direction.

An airplane that is approaching to land is generally operated in a high-drag configuration but at an airspeed near that at which minimum drag for that configuration is produced. Therefore, an abrupt decrease in airspeed may not cause a significant reduction in drag, and drag may even increase. Under such conditions, the only imbalance in the longitudinal forces which will cause the airplane to return to equilibrium is that change in the longitudinal component of weight produced by the change in the airplane's pitch attitude. Consequently, the increased descent rate which is developed will continue until the airplane responds to positive actions from the pilot.

The pilot must exert back pressure on the control column to bring the nose of the airplane up, and he must increase thrust. These actions will increase lift to decrease the descent rate and simultaneously produce the longitudinal force needed to accelerate the airplane to a safe flying speed.

The severity of the effects produced by an encounter with a decreasing headwind will depend on the magnitude of the change in wind speed and the abruptness with which the change occurs. Obviously, the higher the speed change and the shorter the time interval involved, the greater the effect on the airplane's flightpath.

Other significant factors include the airplane's entry airspeed, its configuration, and its flight characteristics under such conditions. For example, a jet transport which encounters the wind change at an indicated airspeed of 155 kn will experience less loss of lift and will develop a lower initial descent rate than the same airplane which encounters the condition at 140 kn. Also, a smaller aircraft, with a lower wing loading, and operating with a higher relative airspeed margin between approach and stall speeds, will likely be less affected than the large transport. Therefore, the pilot of a jet transport who flies at a higher-than-normal approach speed and the pilot of a small airplane who flies at a normal approach speed may be able to stop the rate of descent imposed on their aircraft quicker, with lower control forces, and with less thrust addition than the pilot of a jet transport who flies at normal approach speed.

As illustrated above, passage through either a downdraft or a decreasing headwind can singularly be hazardous; however, when combined, the two conditions produce an even more critical situation. A mature thunderstorm cell contains both. As the airplane approaches the storm, it encounters the influence of the horizontal outflow in the opposite direction of flight as an increasing headwind; as the flight continues, it passes below the storm and through the peak downdraft. Almost immediately, the change in direction of the horizontal outflow will affect the aircraft as an abrupt decrease or loss of headwind. The sequence of the wind change can be particularly dangerous since the pilot might reduce power when he senses the positive performance effect caused by the initially increasing headwind. Therefore, the airplane may already be power deficient when it encounters the downdraft and loss of headwind; thus, their negative effect on the airplane's performance is compounded.

The Safety Board concludes from the evidence that Eastern 66 and at least four of the flights which preceded it encountered abrupt changes in the vertical and horizontal winds on the approach path to runway 22L.

When Eastern 66 was tracking the glideslope near the OM, the airplane was affected by a slight headwind and little or no vertical winds. While the airplane descended and approached the strongest cells of the thunderstorm, it was influenced by the vertical winds and the horizontal outflow. The increase in headwind of about 15 kn and possibly an updraft produced a reduction in the rate of descent and the airplane moved slightly above the glidepath as it descended between 600 feet and 500 feet. When the flight descended through 500 feet, about 8,000 feet from the runway threshold, the airplane was passing into the most severe part of the storm. The vertical draft changed to a downdraft of about 16 fps and the headwind diminished about 5 kn. As the airplane descended through 400 feet, the downdraft velocity increased to about 21 fps and the airplane began to descend rapidly below the glideslope. Almost simultaneously, the change in the direction of the horizontal outflow produced a 15-kn decrease in the airplane's headwind component, which caused the airplane to lose more lift and to pitch nose down. Consequently, the descent rate increased.

The wind conditions encountered by Flying Tiger 161, Eastern 902, Finnair 105, and N240V were similar but possibly less severe than those encountered by Eastern 66. All of these flights managed to negotiate the conditions without mishap, but not without difficulty. The captain of Flying Tiger 161 stated that after he recognized the shear he needed near maximum thrust to keep his aircraft from losing altitude. At that point, he was not sure of his aircraft's missed-approach capability and he had to continue to a landing.

The pilot of Eastern 902 had no forward visibility when he penetrated the area of the most severe wind changes. Therefore, he was flying his aircraft solely by reference to flight instruments. It is obvious from the DFDR traces that he immediately recognized the downward acceleration of his aircraft and responded with the addition of thrust and noseup pitch changes. Nevertheless, the aircraft descended about 120 feet below the glideslope and within about 70 feet of the elevation of the approach lights.

The pilot of Finnair 105 anticipated the adverse wind conditions and added 20 to 25 kn to his normal approach reference airspeed. Although he too experienced an increase in the rate of descent as a result of the downdraft and horizontal wind changes, the total effect and control corrections required to decrease the rate of descent were probably lessened by the higher airspeed. The pilot apparently detected the effect of the wind and responded rapidly to maintain flightpath control.

Likewise, the pilot of N240V, a Beechcraft Baron, was able to limit the altitude loss caused by the wind conditions with less difficulty because of the different flight characteristics of his smaller aircraft and because he was flying it at a higher-than-normal approach speed.

The flightcrew of Eastern 66 was made aware of the adverse wind conditions by Eastern 902's report on wind shear, and they, too, added 10 to 15 kn to their normal approach reference speed. Both theory and simulator test results indicate that increasing final approach airspeed is advantageous when an aircraft is flying through dynamic wind conditions. However, too much airspeed can lead to a potentially hazardous situation for landing, particularly when the runway is wet. Since the captain of Eastern 66 inquired about the braking conditions, he was concerned about stopping the aircraft after landing. Therefore, after considering all of the approach conditions, the Safety Board believes that the addition of a 10- to 15-kn airspeed margin was reasonable. Simulator tests showed that even with this airspeed margin, the pilot must recognize immediately the aircraft's descent below the glideslope. He then must make rapid and pronounced pitch attitude and thrust changes to stop the aircraft's descent and prevent impact short of the runway.

There were no voice comments or sounds, until shortly before impact, which indicated that the flightcrew was either aware of or concerned about the increased rate of descent. Throughout the time period, the captain probably was looking outside, because about 6 seconds before the rate of descent began to increase he called "I have approach lights" and about 7 seconds after the rate began to increase he called "runway in sight." At the time of the latter call, the airplane was descending rapidly through 150 feet and was about 80 feet below the glideslope--twice the distance that would have produced a full-scale "fly up" indication on the related flight instruments if the glideslope signal was reliable. The Safety Board believes that the first officer's immediate response, "I got it," to the captain's identification of the runway indicates that the first officer also had probably been looking outside or was alternating his scan between the flight instruments and the approach lights. Although the aircraft was in heavy rain, the absence of significant turbulence might have caused him to underestimate the severity of the winds' effects.

Even though the first officer might have detected some of the glideslope, airspeed, and rate of descent excursions, simulator tests suggested that he probably reacted with insufficient thrust and pitch corrections to alter the excursions before he switched to visual references. These tests showed that large pitch and thrust changes were needed to stop the descent, and that the pilots often applied less sufficient changes than were needed because of the control forces involved and their reluctance to alter their instrument scan to verify the thrust settings.

Because of the low visibility, the flightcrew probably realized too late how rapidly they were descending and the magnitude of the corrections which were needed to stop the descent. By the time the first officer called for takeoff thrust, impact was inevitable.

The Safety Board recognizes the tendency of the pilot who is flying the aircraft to transfer at the earliest opportunity from instruments to visual references. In fact, this tendency is probably greater on approaches to runways like runway 22L at the Kennedy Airport because the ILS glideslope is designated as unusable below 200 feet. However, the Safety Board continues to believe that the visual references available to a pilot under conditions of rain and reduced visibility are often inadequate to provide timely recognition of flightpath deviations, such as those which can occur when traversing adverse wind conditions. This accident and others like it emphasize the need for air carriers to educate their flightcrews on the effect of a wind shear encounter, and to review instrument approach procedures which are related to flightcrew duties. The Safety Board believes that these procedures should stress that at least one pilot must scan the instruments until sufficient exterior references are visible to provide vertical guidance. Also, the Safety Board believes that research must be continued to develop a better method to transition from instrument flight to visual flight. High intensity VASI's on all runways served by instrument approaches, the "heads-up" displays, and the monitoring of flight instruments until touchdown as practiced by some air carriers are three concepts that appear promising.

Even with these landing aids, an approach which places an airplane in or near a thunderstorm at low altitude is hazardous. The wind conditions which might exist can place the airplane is a position from which recovery is impossible--even if both the pilot and the airplane perform perfectly. The number of recent approach and landing accidents which have been caused by the airplane's passage through or near localized thunderstorm cells indicates that many pilots and air traffic controllers do not have the proper appreciation for the hazards involved.

Approach Operations to Runway 22L

Since the thunderstorm astride the localizer course to runway 22L was obvious and since there was a relatively clear approach path to at least one of the northwest runways (31L), the Safety Board sought to determine why approach operations to runway 22L were continued, particularly after both pilots and controllers had been warned that severe wind shear conditions existed along the final approach to the runway.

According to the Kennedy tower local controller, he did not consider a runway change, either before or after he received the recommendation from Flying Tiger 161, because the surface winds were most nearly aligned with runway 22L. He further stated that he was too busy to pass the recommendation to the assistant tower chief who was responsible for initiating runway changes. Although the runway-use program did not require that runway selection be based on alignment with the wind, the criteria did require that, if conditions permitted, another set of runways be used for noise abatement because runways 31L/R had been in use for more than 6 hours. Therefore, because noise abatement favored the use of runways 22L/R, which were most nearly aligned with the wind, the control tower personnel apparently believed that they were operating with the best runway configuration.

However, the Safety Board concludes that had the thunderstorm activity been evaluated properly, it should have been apparent that the approach to runway 22L was unsafe and that approaches to that runway should have been discontinued. The Safety Board believes that ATC did not consider a runway change either before or after the Flying Tiger captain's recommendation because a change of runways would have further increased traffic delays and would have increased the already heavy workload.

When operating at capacity, the air traffic system in a high density terminal area tends to resist changes that disrupt or further delay the orderly flow of traffic. Delays have a compounding effect unless they can be absorbed at departure terminals or within the en route system. Consequently, controllers and pilots tend to keep the traffic moving, particularly the arrival traffic because delays involve the consumption of fuel and tardy or missed connections with other flights, which could lead to further complications. As weather conditions worsen, the system becomes even less flexible.

Although ATC has major responsibilities in the safe conduct of air operations, under current regulations and procedures, the pilot-in-command is the final authority on whether he will pursue a certain course of action, including whether he will conduct an instrument approach through a thunderstorm or other adverse conditions.

In view of the above, the Safety Board sought to determine why the captain of Eastern 66 continued his approach to runway 22L. The captain had received only one report of adverse conditions--the report from Eastern 902. This report apparently disturbed the captain ("...this is asinine"), but it also apparently was quickly rationalized to some degree ("I wonder if they're covering for themselves"). Had the captain known that two flights had reported adverse conditions, rationalization probably would have been more difficult. However, had he decided to make his approach to a different runway, he probably would have been delayed up to an additional 30 minutes because simultaneous instrument approach operations could not be conducted to two different runways. A 30-minute delay would have reduced substantially his fuel reserve of about 1 hour. Considering the thunderstorm activity affecting the New York City area, including his alternate airport, LaGuardia, his fuel reserve would have been minimal.

It is uncertain when the captain of Eastern 66 made his final decision to continue the approach. He apparently had not made a final determination when the flight was 5 miles from the OM and was cleared for the approach because he told the final vector controller, "...we'll let you know about conditions." Also, about a minute later, he explained to the first officer, "I have the radar on standby in case I need it...", which suggests he was thinking about the possibility of either not making the approach or having to abandon it. However, because pilots commonly rely on the degree of successes achieved by pilots of preceding flights when they are confronted with common hazards, it is likely that he continued the approach pending receipt of information on the progress of the two flights which were immediately ahead of him. By the time the second of these two flights had landed without reported difficulty, the captain of Eastern 66 was apparently committed to the approach, which discloses the hazards of a reliance on the success of pilots of preceding flights when dynamic and severe weather conditions exist. Within minutes, flight conditions can change drastically in or near mature thunderstorms. Moreover, pilot and controller workloads, and communication frequency congestion, can lead to omissions and assumptions, and confusion about who is aware of what.

In summary, the accident involving Eastern 66 and the near-accidents involving Flying Tiger 161 and Eastern 902 were the results of an underestimation of the significance of relatively severe and dynamic weather conditions in a high density terminal area by all parties involved in the movement of air traffic in the airspace system. The Safety Board, therefore, believes that no useful purpose would be served by dwelling critically on individual actions or judgments within the system, but that the actions and judgments required to correct and improve the system should be reviewed. All parts of the system must recognize the serious hazards that are associated with thunderstorms in terminal areas. A better means of providing pilots with more timely weather information must be designed.

Air traffic controllers and their supervisors must closely follow the development and movement of severe weather conditions by gathering, assimilating, and disseminating information from all sources--radar, visual, pilot reports, and weather reports--so that appropriate action can be planned before air safety is threatened. ATC must recognize that thunderstorms and other dynamic weather conditions which develop within, or move into, terminal areas may seriously disrupt the safe flow of traffic. When these conditions appear likely, ATC must be capable of adjusting the flow of traffic into terminal areas so that timely actions and rational judgments in the interest of air safety are primary to moving the traffic.

Pilots must exercise more independent judgments when they are confronted with severe weather conditions in the terminal areas. They must recognize that the conditions within, under, or near rapidly developing and maturing thunderstorms are dynamic and can change significantly within a short distance or within a short time, or both. In particular, they must recognize and avoid low-altitude hazards associated with thunderstorms along or near the approach path.

Air carrier and NWS forecasters must emphasize the accurate and timely forecasting and reporting of severe weather conditions. The NWS must emphasize the determination of thunderstorm severity and must accurately project thunderstorm development and movement, particularly in or near high density terminal areas. The NWS must provide this information and other weather radar information to the air traffic control system in a timely manner. As a corollary, the improved location of weather radar equipment is needed, particularly in high density terminal areas.

The Safety Board stresses the continuing need for air carrier operations managers and dispatchers, in conjunction with captains of flights destined for high density terminal areas, to plan their operations to take into account the extensive delays that might become necessary when severe weather conditions exist or are forecasted in the areas. These delays must be predicted conservatively and procedures developed to cope with them, particularly if it is likely that the captain might have to choose a nonroutine course of action to avoid penetration of thunderstorms.

Finally, reliable wind shear detection equipment is needed at commercial airports. However, several years of research may be needed before a reliable system can be developed and made operational. In the meantime, flightcrews must be trained to recognize meteorological conditions conducive to wind shear and flight techniques to overcome wind shear should be emphasized. Similarly, ATC supervisors and controllers must learn that low-altitude wind shear is a serious hazard to all aircraft particularly to large jet transports, and that air traffic operations should be conducted to avoid the phenomenon whenever possible.

During the past 7 years, the Safety Board has made a number of recommendations in the preceding areas.[7] Although the development of wind shear detection equipment has been emphasized, limited operational progress has been made. Additionally, little progress has been made in the areas of: (1) The dissemination of radar-detected severe weather information to the air traffic control system, (2) the formal training of flightcrews in the recognition of wind shear and the techniques for coping with wind shear, and (3) timely and accurate forecasts of wind shear.

7/ Report Nos. NTSB-AAR-74-5, Ozark Air Lines, Inc., Fairchild Hiller FH-227B, N4215, near the Lambert-St. Louis International Airport, St. Louis, Mo., July 23, 1973; and NTSB-AAR-74-14, Iberia Lineas Aereas De Espana, (Iberian Airlines) McDonnell Douglas DC-10-30, EC CBN, Logan International Airport, Boston, Mass., December 17, 1973.

2.2 Conclusions

(a) Findings

1. There was no evidence of a malfunction or failure of the aircraft's structure, flight instruments, flight controls, or powerplants before impact with the approach light towers.

2. Eastern 66 was conducting an ILS approach to runway 22L at the Kennedy Airport; the first officer was flying the aircraft.

3. When Eastern 66 approached the airport, a very strong thunderstorm was located along the localizer course near the MM.

4. The pilots of Flying Tiger 161 and Eastern 902 reported that hazardous wind shear conditions existed on the final approach to runway 22L.

5. Eastern 66 received Eastern 902's report on the wind shear but did not receive Flying Tiger 161's report.

6. While penetrating the thunderstorm between 600 and 500 feet, Eastern 66 encountered an increased headwind of about 15 kn; about 500 feet, it encountered a downdraft of about 16 fps. Between 500 feet and 400 feet, the headwind diminished about 5 kn; at 400 feet, the downdraft increased to about 21 fps, and the headwind decreased about 15 kn within 4 seconds.

7. At 400 feet the aircraft began to descend rapidly below the glideslope because of the downdraft and decreased headwind.

8. About 400 feet, the captain stated that he had the approach lights in sight, and he directed the first officer to remain on instrument references.

9. In response to the captain's direction, the first officer replied that he was remaining on instruments; however, he probably began transitioning to the visual references he would need to complete the approach.

10. Although the first officer might have applied pitch and thrust changes to correct for the aircraft's deviation below the glideslope, any changes made were insufficient to alter significantly the aircraft's high rate of descent and reduced airspeed.

11. The flightcrew probably did not recognize the deviation below the normal approach path until a high descent rate had developed because of their reliance on visual references which were obscured by heavy rain and low visibility.

12. By the time the flightcrew recognized the aircraft's dangerously low altitude, impact with the approach light towers was inevitable because of the aircraft's high rate of descent.

13. Simulator tests showed that approximately 9° of noseup pitch change was needed to stop the aircraft's high rate of descent; also, tests showed that pilots applied less pitch change than was needed and were hesitant to divert their instrument scan to verify that sufficient thrust had been added to compensate for the airspeed loss.

14. The simulator tests were inconclusive as to whether the flightcrew could have avoided the accident had they relied on and responded rapidly to the flightpath deviations which were probably evident on their flight instruments.

15. The flightcrew of Eastern 66 and the air traffic controllers were aware of the thunderstorm activity on the localizer course to runway 22L.

16. The terminal air traffic system at Kennedy Airport was operating at capacity for at least 30 minutes before the accident, and the air traffic controllers were very busy.

17. After 1551, only one runway could be used for landing because IFR weather conditions prevailed.

18. At least one of the northwest runways (31L) was relatively unexposed to the influences of the thunderstorms.

19. Even though thunderstorm hazards were visible on the approach path, neither the pilots of inbound flights nor air traffic control took action to discontinue the initiation of approaches to runway 22L or to change the landing runway.

20. The accident was not survivable because the fuselage almost completely disintegrated and the occupant restraint systems failed. The unrestrained occupants collided with numerous objects and received multiple extreme impact injuries.

21. The fire department's rapid response and application of fire extinguishing agents prevented fatal burns to nine of the passengers who ultimately survived.

22. The nonfrangible approach light towers caused extensive damage to the aircraft.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the aircraft's encounter with adverse winds associated with a very strong thunderstorm located astride the ILS localizer course, which resulted in a high descent rate into the nonfrangible approach light towers. The flightcrew's delayed recognition and correction of the high descent rate were probably associated with their reliance upon visual cues rather than on flight instrument references. However, the adverse winds might have been too severe for a successful approach and landing even had they relied upon and responded rapidly to the indications of the flight instruments.

Contributing to the accident was the continued use of runway 22L when it should have become evident to both air traffic control personnel and the flightcrew that a severe weather hazard existed along the approach path.

3. RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board has issued the following recommendations to the Administrator, Federal Aviation Administration:

"1. Conduct a research program to define and classify the level of flight hazard of thunderstorms using specific criteria for the severity of a thunderstorm and the magnitude of change of the wind speed components measured as a function of distance along an airplane's departure or approach flight track and establish operational limitations based upon these criteria.

"2. Expedite the program to develop and install equipment which would facilitate the detection and classification, by severity, of thunderstorms within 5 nmi of the departure of threshold ends of active runways at airports having precision instrument approaches.

"3. Install equipment capable of detecting variations in the speed of the longitudinal, lateral, and vertical components of the winds as they exist along the projected takeoff and approach flightpaths within 1 nmi of the ends of active runways which serve air carrier aircraft.

"4. Require inclusion of the wind shear penetration capability of an airplane as an operational limitation in the airplane's operations manual, and require that pilots apply this limitation as a criterion for the initiation of a takeoff from, or an approach to, an airport where equipment is available to measure the severity of a thunderstorm or the magnitude of change in wind velocity.

"5. As an interim action, install equipment capable of measuring and transmitting to tower operators the speed and direction of the surface wind in the immediate vicinity of all runway ends and install lighted windsocks near to the side of the runway, approximately 1,000 feet from the ends, at airports serving air carrier operations.

"6. Develop and institute procedures whereby approach controllers, tower controllers, and pilots are provided timely information regarding the existence of thunderstorm activity near to departure or approach flightpaths.

"7. Revise appropriate air traffic control procedures to specifiy that the location and severity of thunderstorms be considered in the criteria for selecting active runways.

"8. Modify or expand air traffic controller training programs to include information concerning the effect that winds produced by thunderstorms can have on an airplane's flightpath control.

"9. Modify initial and recurrent pilot training programs and tests to require that pilots demonstrate their knowledge of the low-level wind conditions associated with mature thunderstorms and of the potential effects these winds might have on an airplane's performance.

"10. Expedite the program to develop, in cooperation with appropriate Government agencies and industry, typical models of environmental winds associated with mature thunderstorms which can be used for demonstration purposes in pilot training simulators.

"11. Place greater emphasis on the hazards of low-level flight through thunderstorms and on the effects of wind shear encounter in the Accident Prevention Program for the benefit of general aviation pilots.

"12. Expedite the research to develop equipment and procedures which would permit a pilot to transition from instrument to visual references without degradation of vertical guidance during the final segment of an instrument approach.

"13. Expedite the research to develop an airborne detection device which will alert a pilot to the need for rapid corrective measures as an airplane encounters a wind shear condition.

"14. Expedite the development of a program leading to the production of accurate and timely forecasts of wind shear in the terminal area."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

March 12, 1976

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident about 1630 on June 24, 1975. The Safety Board immediately dispatched an investigative team to the scene. Investigative groups were established for operations, air traffic control, witnesses, weather, human factors, structures, powerplants, systems, flight data recorder, maintenance records, cockpit voice recorder, and aircraft performance.

Parties to the investigation were: The Federal Aviation Administration, Eastern Air Lines, Inc., The Boeing Company, Air Line Pilots Association, Pratt and Whitney Division of United Aircraft Corporation, Transport Workers Union, International Association of Machinists and Aerospace Workers, Professional Air Traffic Controllers Organization, and Airline Dispatchers Association. Special observers to the investigation were: The Federal Bureau of Investigation, the Port Authority of New York and New Jersey, and American Association of Airport Executives.

2. Hearing

A public hearing was held in the Roosevelt Hotel, New York, New York, on September 8 through 12, 1975. Parties to the hearing were: The Federal Aviation Administration, Air Line Pilots Association, Professional Air Traffic Controllers Organization, Eastern Air Lines, Inc., and the National Weather Service.

APPENDIX B

CREW INFORMATION

Captain John W. Kleven

Captain Kleven, 54, was employed as a mechanic by Eastern Air Lines on July 1, 1940. From February 1942 to October 1945, he served in the armed forces, and he returned to Eastern on October 13, 1945. He assumed duties as a pilot on December 4, 1953, and he became a captain on B-727 aircraft on July 10, 1968.

Captain Kleven held Airline Transport Pilot Certificate No. 308477 with type ratings in L-188, Martin 202/404, B-727 and DC-8 aircraft. He had commercial privileges with airplane single-engine and multiengine landing ratings. He held Mechanics Certificate No. 123502. He held a first-class medical certificate dated December 15, 1974, with the limitation that he wear reading glasses while flying.

Captain Kleven had accumulated about 17,381 flight-hours, 2,813 of which were in the B-727. He passed a proficiency check on April 10, 1975, and a line check on April 3, 1975. In the 30-, 60-, and 90-day periods preceding the accident he flew 66:57, 133:37, and 201:32 hours, respectively, in the B-727.

First Officer William Eberhart

First Officer Eberhart, 34, was employed by Eastern Air Lines on July 5, 1966. He held Airline Transport Pilot Certificate No. 1581111 and commercial privileges in airplane single-engine and multiengine land ratings. He held Flight Engineer Certificate No. 1716000 for turbojet aircraft, and a first-class medical certificate which was issued with no limitations on August 30, 1974. He passed a proficiency check on February 21, 1975, and a line check on March 19, 1975.

First Officer Eberhart had accumulated about 5,063 flight-hours, 4,327 of which were in the B-727. During the 30-, 60-, and 90-day periods preceding the accident he flew 68:07, 132:35, and 212:41 hours, respectively, in the B-727.

APPENDIX B

Second Officer Gary M. Geurin

Second Officer Geurin, 31, was employed by Eastern Air Lines on January 8, 1968. He held Commercial Pilot Certificate No. 1751173 with airplane single engine land and instrument ratings. He held Flight Engineer Certificate No. 1837806 with turboprop and turbojet ratings. His first-class medical certificate was issued with no limitations on January 31, 1975.

Second Officer Geurin passed a proficiency check on May 28, 1975, and he was taking a line check on the day of the accident. During the 30-, 60-, and 90-day periods preceding the accident, he flew 34:25, 84:57, and 132:41 hours, respectively. He had a total of 3,910 flight-hours, 3,123 of which were in the B-727.

Second Officer Peter J. McCullough

Second Officer McCullough, 33, was employed by Eastern Air Lines on November 16, 1970. He held Commercial Pilot Certificate No. 1709782 with airplane multiengine land and instrument ratings. He held Flight Engineer Certificate No. 2074194 with turboprop and turbojet ratings. His first-class medical certificate was issued with no limitations on January 31, 1975. He had a total of 1,767 flight-hours in civil aircraft, 676 of which were in the B-727. He was a pilot in the U. S. Air Force Reserve and had a total of 3,602 military flight-hours, 1,379 of which were in C-141 aircraft and 1,973 were in B-52 aircraft.

Second Officer McCullough passed a proficiency check on November 16, 1975, and a line check on March 11, 1975. During the 30-, 60-, and 90-day periods preceding the accident, he flew 35, 60, and 137 hours, respectively. Second Officer McCullough was a flight check engineer and was giving Second Officer Geurin his annual line check on the day of the accident.

APPENDIX C

AIRCRAFT INFORMATION

N8845E was manufactured by The Boeing Company on November 10, 1970, and was assigned serial No. 20443. It had accumulated about 12,206 hours time in service.

N8845E was powered by three Pratt and Whitney JT8D-7A turbofan engines. Pertinent engine data are as follows:

Position	Serial No.	Total Time	Total Cycles	Time Since Restoration
1	P649006B	28,600	24,837	3,636
2	P649601B	25,272	20,941	2,445
3	P657165B	19,011	16,492	2,110

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APPENDIX E
VERT. ACCEL. - 'G' UNITS
+2
+1
0
G's
MAG. HEADING - DEGREES
220
240
260
280
300
320
HDG
INDIC. AIRSPEED - KNOTS
180
160
140
120
IAS
RADIO TRANSMISSION INDICATIONS
MSL ALTITUDE - FEET × 1000
3
2
1
0
ALT
5:00
5:30
6:00
6:30
7:00
7:30
8:00
8:30
9:00
9:30
10:00
TIME - MINUTES/SECONDS
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.
LANDING APPROACH ACCIDENT
EAL, B-727, N8845E, FLT. NO. 66
JAMAICA, N.Y. JUNE 24, 1975
FLIGHT DATA RECORDER GRAPH
SUNDSTRAND FA-542, S/N 2556

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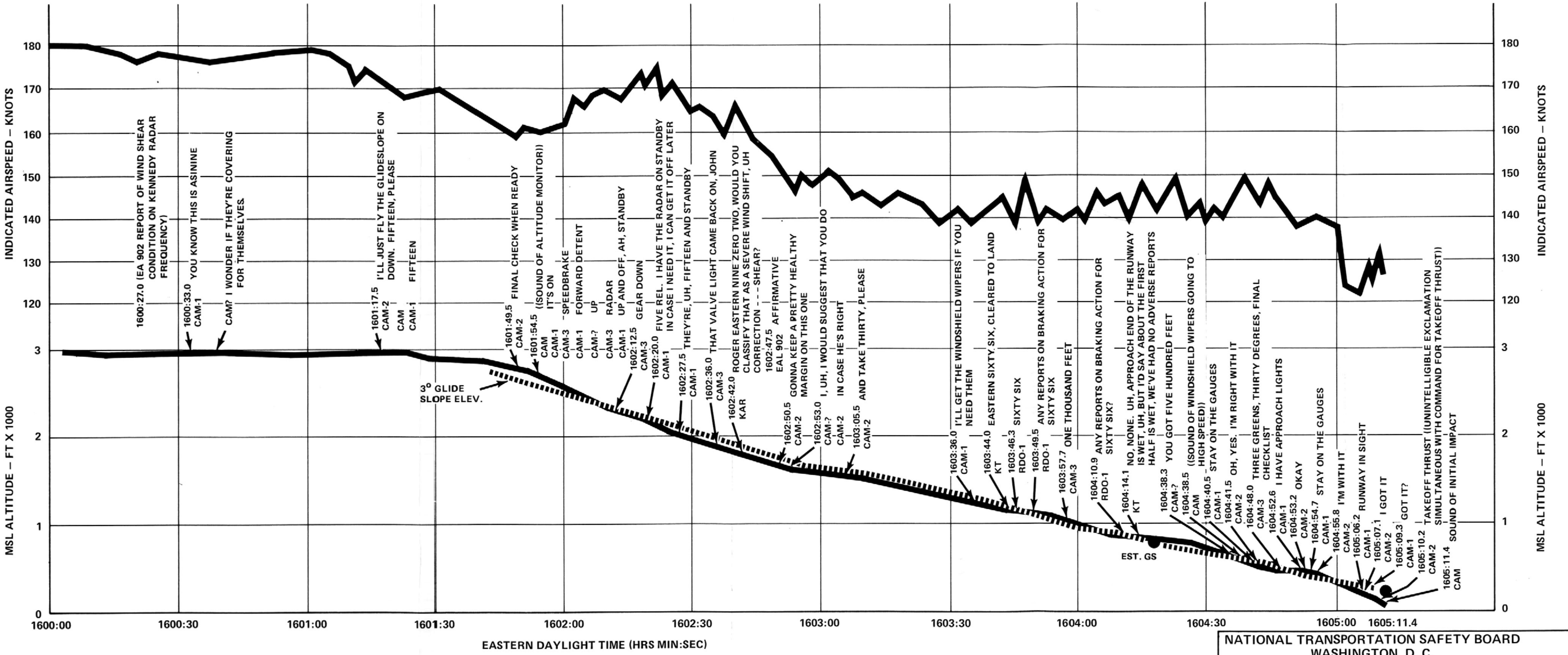

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C.
CVR, FDR, RADAR DATA CORRELATION
EASTERN AIR LINES, INC.
B727-225, N8845E, FLIGHT 66
J.F.K. INTERNATIONAL AIRPORT, JAMAICA, NEW YORK
JUNE 24, 1975

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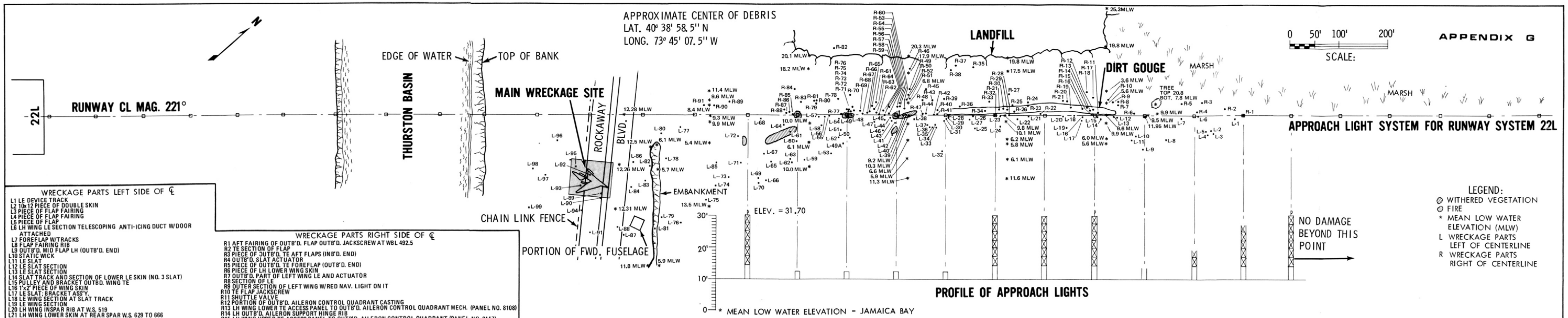
APPENDIX G



WRECKAGE PARTS LEFT SIDE OF ℄

L1 LE DEVICE TRACK
L2 10x12 PIECE OF DOUBLE SKIN
L3 PIECE OF FLAP FAIRING
L4 PIECE OF FLAP FAIRING
L5 PIECE OF FLAP
L6 LH WING LE SECTION TELESCOPING ANTI-ICING DUCT W/DOOR ATTACHED
L7 FOREFLAP W/TRACKS
L8 FLAP FAIRING RIB
L9 OUTB'D. MID FLAP LH (OUTB'D. END)
L10 STATIC WICK
L11 LE SLAT
L12 LE SLAT SECTION
L13 LE SLAT SECTION
L14 SLAT TRACK AND SECTION OF LOWER LE SKIN (NO. 3 SLAT)
L15 PULLEY AND BRACKET OUTBD. WING TE
L16 1'x2' PIECE OF WING SKIN
L17 LE SLAT; BRACKET ASS'Y.
L18 LE WING SECTION AT SLAT TRACK
L19 LE WING SECTION
L20 LH WING INSPAR RIB AT W.S. 519
L21 LH WING LOWER SKIN AT REAR SPAR W.S. 629 TO 666
L22 LE SLAT HEATING DUCT
L23 PIECE OF WING SKIN
L24 WING SPLICE PLATE
L25 WING SPLICE PLATE
L26 SPAR WEB
L27 COWL BLOWOUT PANEL
L28 PORTION OF FIN TO RUDDER PLATE
L29 PIECE OF FUEL DUMP TUBE AND SUPPORT BRACKET
L30 12x18 WING SKIN
L31 SPAR WEB W.S. 330.5
L32 TE MID FLAP SECTION INB'D. LH (OUTB'D. END)
L33 PIECE OF WING SKIN
L34 TE AFT FLAPS
L35 WING LE SECTION
L36 PIECE OF SPAR WEB AT W.S. 357
L37 PIECE OF FUSELAGE LOWER SKIN
L38 PIECE OF FIN TENSION TIE RIB
L39 ENGINE FIXED COWL AND VERTICAL FIN TAILCONE LENS
L40 MLG SUPPORT BEAM
L41 LE RIB W/SLAT TRACK AND DUCT
L42 PIECE OF FIN TENSION TIE RIB
L43 SECTION OF WING FRONT SPAR AND UPPER SKIN
L44 TE FOREFLAP
L45 HORIZONTAL STABILIZER; LE SKIN
L46 SECTION OF LE KRUGGER FLAP
L47 FLAP SECTION
L48 TAIL CONE SECTION
L49 TE FLAP TAIL CONE
L49-A PIECE OF UPPER FUSELAGE STRINGER S-2L AT LBL-7 (COCKPIT AREA)
L50 BROKEN PIECES OF RED GLASS FROM ROTATING BEACON ASS'Y.
L51 PIECE OF FUSELAGE NOSE SKIN
L52 FIN TIP FAIRING LE PANEL
L53 RH COCKPIT SPEAKER WIRE
L54 SPOILER PANEL AND WING TRAILING EDGE BEAM
L55 RH HORIZONTAL STABILIZER INB'D. SECTION
L56 STABILIZER JACKSCREW
L57 VERTICAL FIN
L58 TE FOREFLAP SECTION
L59 MAPS AND COCKPIT ARTICLES
L60 OUTB'D. AILERON TAB ASS'Y.
L61 ELEVATOR TAB SECTION
L62 MACH AIRSPEED TEST SWITCH
L63 COCKPIT SIDE WINDOW
L64 OUTB'D. SECTION OF RH STABILIZER AND ELEVATOR
L65 LARGE ROCKS; COCKPIT SIDE WINDOW
L66 COCKPIT SIDE WINDOW
L67 PART OF NO. 6 LE SLAT (RH WING)
L68 PART OF SPOILER PANEL AND ACTUATOR
L69 NO. 7 SLAT AND PART OF WING LE
L70 CAPT'S. WINDSHIELD AND STRUCTURE ABOVE COCKPIT
L71 NO. 8 SLAT AND ACTUATOR
L72 NO. 2 INLET ENGINE COWLING
L73 1ST OFFICER'S WINDSHIELD AND SUPPORT STRUCTURE
L74 PART OF 1ST OFFICER'S CONTROL WHEEL
L75 NOSE WHEEL STEERING WHEEL
L76 SECTION OF FUSELAGE STRUCTURE AND 5 WINDOWS
L77 FLAP JACKSCREW
L78 LARGE SECTION OF FUSELAGE W/DOOR FRAME AND GALLEY PANEL
L79 COCKPIT CONTROL COLUMN AND BROKEN WHEEL
L80 FLAP TRACK AND WING SUPPORT STRUCTURE
L81 LEFT NOSE WHEEL ASS'Y.
L82 FLAP TRACK
L83 LEADING EDGE DEVICE ACTUATOR
L84 SECTION OF FUSELAGE SKIN—6 WINDOWS
L85 PARTS OF CONTROL PANELS
L86 WINDOW SECTION
L87 PART OF FUSELAGE
L88 WINDOW SECTION/INTERCOM DEVICE/PART OF FUSELAGE
L89 RH WING OUTB'D. SECTION
L90 RH WING TIP
L91 FORWARD GALLEY DOOR ASS'Y.
L92 AFT SERVICE DOOR
L93 RH WING OUTB'D. TE FLAP OUTB'D. JACKSCREW
L94 RH WING LE SECTION W/BROKEN LANDING LIGHT LENS
L95 AFT CARGO COMP'T. DOOR
L96 NO. 2 ENGINE COWL PANEL, RH AFT
L97 DOOR CHUTE
L98 TE FOREFLAP OUTB'D. SECTION
L99 GALLEY EQUIPMENT

WRECKAGE PARTS RIGHT SIDE OF ℄

R1 AFT FAIRING OF OUTB'D. FLAP OUTB'D. JACKSCREW AT WBL 492.5
R2 TE SECTION OF FLAP
R3 PIECE OF OUTB'D. TE AFT FLAPS (INB'D. END)
R4 OUTB'D. SLAT ACTUATOR
R5 PIECE OF OUTB'D. TE FOREFLAP (OUTB'D. END)
R6 PIECE OF LH LOWER WING SKIN
R7 OUTB'D. PART OF LEFT WING LE AND ACTUATOR
R8 SECTION OF LE
R9 OUTER SECTION OF LEFT WING W/RED NAV. LIGHT ON IT
R10 TE FLAP JACKSCREW
R11 SHUTTLE VALVE
R12 PORTION OF OUTB'D. AILERON CONTROL QUADRANT CASTING
R13 LH WING LOWER TE ACCESS PANEL TO OUTB'D. AILERON CONTROL QUADRANT MECH. (PANEL NO. 8108)
R14 LH OUTB'D. AILERON SUPPORT HINGE RIB
R15 LH WING UPPER TE ACCESS PANEL TO OUTB'D. AILERON CONTROL QUADRANT (PANEL NO. 8147)
R16 PORTION OF WING INSPAR RIB AT W.S. 546.5
R17 LH WING LOWER TE ACCESS PANEL TO OUTB'D. AILERON OUTB'D. BALANCE (PANEL NO. 8105)
R18 LE DEVICE TRACK
R19 LH OUTB'D. AILERON BALANCE PANEL ASS'R.
R20 LH LOWER TE PANEL FWD. OF OUTB'D. FLAP
R21 LH WING INSPAR RIB W.S. 601.5
R22 PART OF NO. 4 LE SLAT FENCE
R23 PART OF RH HORIZONTAL STABILIZER TIP
R24 FLIGHT SPOILER PANEL
R25 PIECE OF LEFT WING SKIN
R26 PIECE OF ENGINE FAN CASING
R27 PIECE OF WING TE STRUCTURE AT W.S. 545
R28 PIECE OF ENGINE FAN OUTER CASING
R29 LE SLAT TRACK
R30 FUEL TANK ACCESS PANEL
R31 END OF NO. 1 ENGINE UPPER COWLING
R32 PORTION OF FIXED LE LOWER ACCESS PANEL AFT OF NO. 4 SLAT (IN TOWER) AND ALUMINUM FUEL DUMP PIPE (IN TOWER)
R33 PART OF WING STRUCTURE AND NO. 2 FLIGHT SPOILER (AREA OF W.S. 546.5)
R34 PIECE OF HORIZONTAL STABILIZER LE RIB AT LE STA.—44.6
R35 PIECE OF ELEVATOR OUTB'D. END
R36 PIECE OF LH WING INSPAR RIB AT W.S. 410
R37 PORTION OF LH HORIZONTAL STABILIZER INB'D. LE
R38 LEFT ELEVATOR TIP
R39 LH WING LE SECTION AFT ON NO. 4 SLAT
R40 OUTB'D. END OF LH WING TE INB'D. MID FLAP
R41 PORTION OF VERTICAL FIN TIP LE FAIRING
R42 LE SLAT ACTUATOR
R43 PIECE OF NO. 4 LE SLAT
R44 ELEVATOR CONTROL CABLE PULLEY
R45 3x4 PIECE OF WING STRUCTURE SHOWING INTREGRAL FUEL VENTS
R46 PORTION OF LH INB'D. FLAP TRACK FAIRING
R47 PIECES OF INSULATION BLANKET
R48 WIPER PLATE, STABILIZER TE SEAL, FIN TIP FAIRING
R49 PIECE OF TUBING AND SUPPORT STRUCTURE AT WING RIB LOCATED AT W.B.L. 348
R50 FLAP TRACK CANOE FAIRING
R51 PART OF NO. 1 ENGINE UPPER COWLING
R52 NO. 1 ENGINE COMBUSTION CHAMBER
R53 1ST STAGE FAN BLADE NO. 1 ENGINE
R54 WING RIB AT W.S. 491.5 W/PIECE OF FUEL DUMP TUBE
R55 PART OF NO. 1 ENGINE COMBUSTION CHAMBER OUTER CASING
R56 PART OF NO. 1 ENGINE COWLING
R57 FLAP CARRIAGE
R58 PART OF HORIZONTAL STABILIZER FRONT SPAR
R59 NO. 1 ENGINE MAIN OIL SCREEN
R60 PART OF NO. 1 ENGINE COWLING
R61 INB'D. FLIGHT SPOILER ACTUATOR W/ROD END LEVER
R62 PART OF WING FRONT SPAR
R63 LH INB'D. FLAP INB'D. JACKSCREW FAIRING
R64 FLAP JACKSCREW
R65 SECTION OF WING SKIN
R66 BASE OF BROKEN JACKSCREW
R67 OVER WING EMERG. EXIT LIGHT FIXTURE
R68 PIECE OF NO. 1 NOSE COWLING
R69 TE FLAP TRACK CANOE FAIRING
R70 NO. 1 ENGINE LOWER COWLING
R71 PART OF NO. 1 ENGINE COWLING
R72 STAB. UP LIMIT SWITCH
R73 ACTUATOR ASS'Y—CONTROL, GRND SPEED BRAKE
R74 LH INB'D. FLAP OUTB'D. TRACK
R75 SPOILER ACTUATOR
R76 FIBER GLASS FAIRING
R77 PIECE OF VERTICAL FINTAIL CONE W/ACCESS PANEL
R78 PIECES OF TOP WING SKIN
R79 NO. 1 ENGINE FUEL CONTROL UNIT/FUEL PUMP MODULE
R80 ENGINE INLET NOSECONE
R81 NO. 1 VOR ANTENNA
R82 LH HORIZONTAL STABILIZER AND ELEVATOR ASS'Y.
R83 NO. 1 ENGINE LESS FAN CASES
R84 NO. 1 ENGINE INLET SECTION
R85 MAIN LG ASS'Y.
R86 NO. 1 ENGINE OUTER CASE
R87 FUEL-OIL HEATER NO. 1 ENGINE
R88 ELEVATOR FEEL SYSTEM CONTROL UNIT
R89 FLAP SEGMENT
R90 NO. 1 ENGINE ACCESSORY AND COMPONENT DRIVES GEAR BOX
R91 NO. 1 ENGINE TAIL PIPE ASS'Y. AND THRUST REVERSER

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VERTICAL CONTROL
ELEVATION 0.00 IS MEAN LOW WATER AT JAMAICA BAY WHICH IS EQUAL TO 2.233 FEET BELOW MEAN SEA LEVEL AT SANDY HOOK AS ESTABLISHED BY THE UNITED STATES COAST AND GEODETIC SURVEY.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

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JAMAICA, NEW YORK
JUNE 24, 1975

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