Lo 1547

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

REVISED: 21 APR 1983

ISSUED: March 25, 1983

Forwarded to:

Honorable J. Lynn Helms
Administrator
Federal Aviation Administration
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-83-13 through -26

About 1609 c.d.t., July 9, 1982, Pan American World Airways Flight 759 crashed after taking off from runway 10 at New Orleans International Airport, Kenner, Louisiana. 1/ When Flight 759 took off, there were isolated heavy showers over the airport and to the east of the airport along the airplane's intended departure path. Low level wind shear conditions had been detected by the airport's Low Level Wind Shear Alert System (LLWSAS), and the system had alarmed several times, the last time about 4 minutes before Flight 759's takeoff. The system was not alarming at the time the takeoff clearance was issued; however, a wind shear advisory was broadcast 2 seconds after the accident.

Flight 759 lifted off the runway, climbed to an altitude of between 100 to 150 feet above the ground, and then began to descend. The airplane struck a line of trees about 2,376 feet beyond the departure end of the runway at an altitude of about 50 feet above the ground, continued on an eastward track for another 2,234 feet, and again hit trees. The airplane then crashed into a residential area about 4,610 feet from the end of the runway, and was destroyed by the impact, an explosion, and the ensuing ground fire. One hundred forty-five persons on board the airplane and eight persons on the ground were killed in the crash; six houses were destroyed and five were damaged substantially.

At 1621 e.d.t., July 28, 1982, Trans World Airlines (TWA) Flight 524, a Boeing 727, incurred structural damage when it made a hard landing after an encounter with severe wind shear at an altitude of between 20 and 100 feet while on final approach to runway 22 at LaGuardia Airport, New York. Both pilots reported that the airplane was virtually uncontrollable from the time it encountered the wind shear until it hit the runway. Had this wind shear been encountered earlier on the approach or during a takeoff, the airplane might have been damaged more heavily, and passengers probably would have been injured. A LLWSAS was in operation at LaGuardia at the time, but the tower did not broadcast a wind shear alert until TWA 524 was on the ground. The National Weather Service (NWS) Office at LaGuardia Airport had forecast thunderstorms in the area between 1600 and 2000 with possible wind gusts to near 65 knots. At 1614 and 1617, the NWS observed thunderstorms with heavy rain showers. Both the forecast and the actual observations were transmitted to the tower by telewriter; however, tower controllers did not put the information on the Automatic Terminal Information Service (ATIS) or transmit it to the crew of TWA 524. The weather conditions were such that the crew of TWA 524 could not

1/ For more detailed information, read: Aircraft Accident Report—"Pan American World Airways, Inc., Clipper 759, Boeing 727-235, N4737, New Orleans International Airport, Kenner, Louisiana, July 9, 1982." (NTSB-AAR-83-2) have seen the thunderstorm activity during the approach. Based on their observations of weather conditions from the ground, the flightcrews of three airplanes — a Northwest 727, a Delta 727, and a United 737 -- had delayed takeoff just before the approach of TWA 524.

The Safety Board believes that the incident involving TWA 524 might have been prevented had the crew been advised of the intensity of the thunderstorm activity near the airport.

Investigations of both the Pan American accident and the TWA incident demonstrate the need for action to assure that approaching and departing airplanes are not exposed to hazardous convective weather activity at low altitude. While research has shown that hazardous downdraft and outflow divergence can exist without thunder, lightning, oı even precipitation, thunderstorms and heavy rainshowers are certainly indicators of potentially hazardous winds. The Board believes that action must be taken to avoid penetration of the phenomena during low altitude operations. The Safety Board believes that operator training programs should include comprehensive coverage of factors that pilots should consider in deciding whether an approach or departure can be conducted safely, clear of severe convective weather activity. The programs should stress that the absence of a LLWSAS alarm does not by itself provide such assurance, particularly when rapidly changing wind conditions and thunderstorm or shower activity are evident in the vicinity of the airport.

Currently, there are 58 LLWSAS's in operation at airports in the United States; 110 additional systems are to be installed and placed in operation by early 1985. Until Doppler weather radar (NEXRAD program) is in operation in the late 1980's, the LLWSAS will continue to be the primary system for detection and warning of wind shear in the airport terminal area. The Safety Board believes that the systems are not being used to their fullest capability. Criteria could be developed, based upon the differences between the wind measurements on the centerfield and remote sensors of the LLWSAS, to establish aircraft operational limitations. Meanwhile, actions should be taken to make maximum use of the LLWSAS's present capabilities.

The only information generally available to the aviation community regarding the operation of the LLWSAS is contained in the Airman's Information Manual (AIM). However, specific information regarding the system, including (1) the potential use of and limitations of the LLWSAS, (2) the location of the remote wind sensors at various LLWSAS-equipped airports, and (3) the availability of remote wind information to pilots regardless of alarm status, is not included in the AIM nor is it readily available to pilots through other sources. If pilots are to utilize the LLWSAS system to its fullest extent and to make decisions based on information received from the LLWSAS, they must be informed regarding the system's capabilities and limitations.

Currently, the location of LLWSAS remote wind sensors at airports is indicated by reference to compass points. While the pilot may thereby know the approximate location of the perimeter sensors on the airport, he may not know their locations relative to his approach or departure path. For example, the remote wind sensor designated the northwest sensor at the New Orleans International Airport is, in fact, located to the north of the airport. There is no remote sensor in the entire western semicircle at the New Orleans International Airport. At the time the LLWSAS was installed at the airport, a west sensor was an integral part of the LLWSAS. However, the west sensor was vandalized and rendered inoperative on November 15, 1979. When the LLWSAS at New Orleans was commissioned on December 20, 1979, the west sensor was not considered to be an element of the system. An operative west sensor was put into service July 13, 1982, 4 days after the accident. On July 20, 1982, the west sensor was again vandalized and rendered inoperative. Without this sensor, the LLWSAS at New Orleans is deficient, particularly with respect to departures on runway 28 and approaches to runway 10. It is possible that similar deficiencies exist with respect to other LLWSAS installations. Such deficiencies should be corrected without delay. The Safety Board believes that the lack of specific information on the location of operable wind sensors could mislead pilots. The FAA should, therefore, disseminate such information by the most effective means which will provide flightcrews with ready reference data for approach and departure planning.

In general, pilots are not aware that LLWSAS remote wind information is available from controllers regardless of whether the system's alarm is sounding; strong crosswind situations can exist without setting off the alarm. This wind information could be useful to pilots during takeoffs and landings, and therefore the fact that this information can be requested from tower controllers should be made known to pilots through the AIM.

In November 1980, a Braniff Airways B-727 landed at Newark International Airport, Newark, New Jersey, in strong crosswinds. The airport was LLWSAS-equipped. Shortly after touchdown, the airplane ran off the runway; seven persons were injured, two seriously. Had the crew requested a reading from the remote wind sensor located near the approach end of the runway before landing, it might have indicated strong crosswinds, and the accident might have been avoided.

Information from perimeter wind sensors can be used by pilots to assess the development of a hazardous wind condition even though the wind measured by the perimeter sensor has not reached the threshold for a LLWSAS alarm. For example, in the Pan American Flight 759 accident, had the east wind sensor indicated a tailwind or rapidly varying wind conditions, and had the crew known of the conditions, the pilot might have delayed the takeoff and avoided the accident.

The LLWSAS's alarm indicating the detection of wind shear is dependent on the comparison of the wind velocities measured by the remote wind sensors against the wind velocity measured by the centerfield wind sensor. If the remote wind sensors are not located properly, and therefore the recorded wind velocities are not accurate and appropriate, the system may not detect hazardous wind shears affecting a given runway. In addition, if the wind sensors are improperly located, false alarms are set off. Following the near crash of an Eastern Airlines B-727 at Atlanta, Georgia, on August 22, 1979, the Safety Board discussed with the Federal Aviation Administration (FAA) the advantages of recording the output data of all installed LLWSAS's. The FAA rejected the idea as not being cost-effective. Recorded readings from the LLWSAS could be evaluated to determine statistically if the wind sensors are properly located and used to study the characteristics of wind shear and associated phenomena. Further, the false alarm rate of the system could be determined and improvements made accordingly. Based on information developed in the investigation of the Pan American Flight 759 crash, the Safety Board again urges the FAA to record the wind measurements from all LLWSAS sensors.

Currently, when a LLWSAS alarm is activated, controllers are required to advise the pilot of the alert and then give wind speed and direction from the centerfield wind sensor and the appropriate remote wind sensors. To determine how the performance of the airplane would be affected, the pilot must calculate the longitudinal and lateral wind components relative to the runway centerline; this is not easily done during a high workload situation such as that during landing and takeoff. During the public hearing on the Pan American Flight 759 accident, it was determined that the vector components of LLWSAS measurements could be resolved with appropriate system software and displayed as longitudinal and lateral components to the runway centerline. In fact, such a display was evaluated by the FAA in the early stages of testing and evaluating the LLWSAS. The FAA, however, rejected the idea because it believed that the information was not readily understood by pilots and that dissemination was too burdensome to controllers. The Safety Board believes, however, that information concerning the longitudinal and lateral wind components relative to the runway centerline would be beneficial to flightcrews, especially during high workload situations and during convective weather activity, and doubts that its dissemination would impose a significant added burden on the controllers. The Board, therefore, urges the FAA to reevaluate the use of this type of display.

During the investigation of the Pan American Flight 759 accident, the Safety Board determined that critical meteorological information on thunderstorms disseminated by the Houston Center Weather Service Unit (CWSU) meteorologist to the New Orleans Tower was not provided to flightcrews operating in the area. On June 3, 1980, the Safety Board recommended in Safety Recommendation A-80-46 that ATIS advisories contain all essential forecast meteorological information, including SIGMET's 2/ which are likely to affect airplanes operating in terminal areas served by the ATIS. The FAA concurred in the recommendation and directed that all pertinent SIGMET's be broadcast on ATIS. Although pertinent SIGMET information is required to be broadcast on ATIS, other information disseminated by CWSU meteorologists, including center weather advisories (CWA's) which are issued based on SIGMET criteria, is not. The Safety Board believes that all information developed by CWSU meteorologists pertinent to the safety of flight and disseminated to air traffic control (ATC) towers should be timely placed on ATIS.

About 1602 -- 7 minutes before Pan American Flight 759 crashed -- Republic Airlines Flight 632 (a DC-9) encountered a wind shear while departing runway 19 at New Orleans. Following the encounter, the first officer reported to departure control that "we had a wind shear on the runway." Departure control acknowledged; however, this pilot report was not passed on to controllers in the tower cab or to flightcrews in the area.

Republic's report of wind shear was not in conformance with the wind shear reporting guidelines specified in FAA Advisory Circular (AC) 00-50A, issued on January 23, 1979, since it did not definitively describe the nature of the hazard encountered. The Safety Board believes that because of the transitory nature of wind shear events and the limited capabilities of operational wind shear detection and warning systems at airports, definitive pilot reports of wind shear and ATC's immediate dissemination of the reports to flightcrews in the area are critical to aviation safety. Therefore, the Safety Board believes that the FAA should emphasize the importance of the accurate reporting of wind shear by pilots, as specified in AC 00-50A, and that the FAA should assure that these pilot reports are disseminated immediately by ATC.

During the field phase of the Joint Airport Weather Studies (JAWS) project, 3/convective wind shear events were studied (over 100 severe convective wind

---

2/ A SIGMET is Significant Meteorological advisory.

3/ The JAWS project is jointly administered by the National Center for Atmospheric Research and the University of Chicago. Funding is provided by the National Science Foundation, the Federal Aviation Administration, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration. The major objectives of the JAWS project are to define the characteristics of hazardous convective wind shear events, to determine their hazard potential, and to develop techniques to detect their presence and provide appropriate warning.

shear events were documented). Data were obtained from airborne and ground based Doppler radar, high resolution rainfall measurements, and LLWSAS. Airborne wind shear detection and warning devices were evaluated. Because of the implications to air safety, the Safety Board believes that the results of the data analysis ultimately should be used to (1) quantify the low-level wind shear hazard, (2) evaluate the effectiveness of the LLWSAS, (3) evaluate aerodynamic penalties of precipitation on airplane performance, (4) develop training aids for pilots and controllers regarding hazards of convective weather, (5) develop realistic microburst wind models for use in flight simulators, and (6) promote the development of airborne wind shear detection devices.

Doppler weather radar has been in use for over 10 years and is a proven means of detecting hazardous meteorological phenomena including wind shear. The FAA and the Departments of Defense and Commerce are currently developing weather radar for future installation which incorporates Doppler technology (NEXRAD program). The NEXRAD will have the capability of detecting and measuring wind shear in the airport terminal environment. However, production of the equipment and installation in the field will not begin until 1987, with final deliveries to be in 1991.

Had Doppler weather radar been in use at New Orleans International Airport on July 9, 1982, the crash of Pan American Flight 759 might have been prevented. Therefore, the Safety Board believes that the development, testing, and installation of Doppler weather radar should be expedited. In addition, consideration should be given to the more immediate application of Doppler weather radar add-on modules and other technology for the detection of hazardous wind shears in known high risk terminal environments.

In analyzing the circumstances of the Pan American Flight 759 accident, the Safety Board considered evidence that the airplane encountered heavy rain and the divergent winds emanating from a microburst before or immediately following liftoff. The Board noted that this is a very critical phase of flight and that pilots may be less able to recognize an imminent entry into a hazardous environment because of the dynamic flight condition. Although an airplane may theoretically have the performance capability to penetrate a downburst or microburst without ground impact, such success is contingent upon the ability of the pilot to recognize and react immediately to the hazard. The Board acknowledges that Advisory Circular (AC) 00-50A addresses this subject and observes that in order to maintain maximum response from the airplane, a noseup pitching rotation as far as the angle of attack that actuates the airplane's stickshaker may be required and often can be used to prevent ground impact. The Board believes, however, that the pilot's response time to achieve this maneuver is critical and can be affected adversely by factors such as distractions from heavy precipitation and turbulence, the need to apply abnormal control force, and reluctance to accept an unfamiliar pitch attitude.

While the Safety Board believes strongly that the most positive prevention of this type of accident is avoidance of critical microburst encounters, other actions must be taken to enhance recovery of airplanes by flightcrews who may experience the hazard without warning. Improvements to airplane flight instrumentation are essential as is increasing flightcrew awareness through repeated simulator training in the airplane's flight characteristics and in the need for rapid corrective action to prevent a critical altitude loss. Both of these actions could effectively improve pilot response time and might mean the difference between a catastrophic accident and successful microburst penetration.

Present generation flight directors provide the pilot pitch command guidance to either a fixed takeoff attitude, as is the case with most older jet transport airplanes such as the B-727 involved in this accident, or an optimum climb airspeed, as is the case with the newer wide-bodied airplanes. In either system, the pitch command guidance is not programmed to account for the environmental wind condition experienced in a downburst or microburst. These flight directors will in fact provide takeoff and initial climb pitch commands which are likely to produce a descending flightpath as the airplane experiences a downdraft and loss of headwind. The Board believes that the FAA and industry should expedite the development and installation of flight director systems such as MFD-delta-A 4/ or head-up type displays which include enhanced pitch guidance logic which responds to inertial speed/airspeed changes and ground proximity.

Although the Safety Board notes that most air carriers, including Pan American, provide pilots with wind shear penetration demonstrations during their recurrent simulator training, they may not have a comprehensive syllabus which encompasses microburst encounters during all critical phases of flight. Because of the differences in airplane configuration, performance margins, and flight director logic, among others, the Board believes that flightcrews should be exposed to microburst encounters during takeoff as well as approach phases of flight during simulator training.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Review all Low Level Wind Shear Alert System installations to identify possible deficiencies in coverage similar to the one resulting from the inoperable west sensor at New Orleans International Airport and correct such deficiencies without delay. (Class II, Priority Action) (A-83-13)
>
> Make appropriate distribution to the aviation community of information regarding (1) the location and designation of remote sensors of the Low Level Wind Shear Alert System (LLWSAS) at equipped airports, (2) the capabilities and limitations of the LLWSAS, and (3) the availability of current LLWSAS remote sensor information if requested from tower controllers. (Class II, Priority Action) (A-83-14)
>
> Record output data from all installed Low Level Wind Shear Alert System sensors and retain such data for an appropriate period for use in reconstructing pertinent wind shear events and as a basis for studies to effect system improvements. (Class II, Priority Action) (A-83-15)
>
> Emphasize to pilots on a continuing basis the importance of making prompt reports of wind shear in accordance with prescribed reporting guidelines, and assure that Air Traffic Control personnel transmit such reports to pilots promptly. (Class II, Priority Action) (A-83-16)

4/ MFD-delta-A — A modified flight director system whose logic is augmented by acceleration and groundspeed data to establish go-around criteria and pitch commands to provide minimum height loss. Described in FAA Report No. FAA-RD-117, "Airborne Aids For Coping With Low Level Wind Shear."

Require that Automatic Terminal Information Service advisories be amended promptly to provide current wind shear information and other information pertinent to hazardous meteorological conditions in the terminal area as provided by Center Weather Service Unit meteorologists, and that all aircraft operating in the terminal area be advised by blind broadcast when a new Automatic Terminal Information Service advisory has been issued. (Class II, Priority Action) (A-83-17)

Evaluate methods and procedures for the use of current weather information from sources such as radar, Low Level Wind Shear Alert Systems, and pilot reports as criteria for delaying approach and departure operations which would expose the flight to low altitude penetration of severe convective weather. (Class II, Priority Action) (A-83-18)

Study the feasibility of establishing aircraft operational limitations based on the data available from the Low Level Wind Shear Alert System. (Class II, Priority Action) (A-83-19)

Make the necessary changes to display Low Level Wind Shear Alert System wind output data as longitudinal and lateral components to the runway centerline. (Class II, Priority Action) (A-83-20)

Use the data obtained from the Joint Airport Weather Studies (JAWS) Project and other relevant data as a basis to (1) quantify the low-level wind shear hazard in terms of effect on airplane performance, (2) evaluate the effectiveness of the Low Level Wind Shear Alert System and improvements which are needed to enhance performance as a wind shear detection and warning system, and (3) evaluate the aerodynamic penalties of precipitation on airplane performance. (Class II, Priority Action) (A-83-21)

As the data obtained from the Joint Airport Weather Studies (JAWS) Project become available (1) develop training aids for pilots and controllers to emphasize the hazards to flight from convective weather activity, (2) develop realistic microburst wind models for incorporation into pilot flight simulator training programs, and (3) promote the development of airborne wind shear detection devices. (Class II, Priority Action) (A-83-22)

Expedite the development, testing, and installation of advanced Doppler weather radar to detect hazardous wind shears in airport terminal areas and expedite the installation of more immediately available equipment such as add-on Doppler to provide for detection and quantification of wind shear in high risk airport terminal areas. (Class II, Priority Action) (A-83-23)

Encourage industry to expedite the development of flight director systems such as MFD-delta-A and head-up type displays which provide enhanced pitch guidance logic which responds to inertial speed/airspeed changes and ground proximity and encourage operators to install these systems. (Class III, Longer Term Action) (A-83-24)

Recommend to air carriers that they modify pilot training on simulators capable of reproducing wind shear models so as to include microburst penetration demonstrations during takeoff, approach, and other critical phases of flight. (Class II, Priority Action) (A-83-25)

Advise air carriers to increase the emphasis in their training programs on the effective use of all available sources of weather information, such as preflight meteorological briefings, ATIS broadcasts, controller-provided information, PIREPS, airborne weather radar, and visual observations, and provide added guidance to pilots regarding operational (i.e., "go/no go") decisions involving takeoff and landing operations which could expose a flight to weather conditions which could be hazardous. (Class II, Priority Action) (A-83-26)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and McADAMS, BURSLEY, and ENGEN, Members, concurred in these recommendations.

By: Jim Burnett
Chairman