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Inadequate Weather Communication Cited In B-737 Microburst-downdraft Incident

The Australian Transport Safety Bureau said that, among other factors, air traffic controllers did not advise the flight crew — nor did the crew request — details about the lateral limits, direction of travel and groundspeed of a thunderstorm approaching the destination airport.

FSF Editorial Staff

At 0729 local time on Jan. 18, 2001, a Boeing 737-400 encountered a microburst downdraft[1] while the flight crew was conducting a go-around (missed approach) during an instrument landing system (ILS) approach to Runway 19 at Brisbane Airport, Queensland, Australia, near an intense thunderstorm. A positive rate of climb of 480 feet per minute (fpm) initially was attained at a radio altitude (height of the aircraft above terrain as calculated by its radio altimeter) of 171 feet. As the go-around continued, the rate of climb decreased from 3,600 fpm at a radio altitude of 428 feet to 240 fpm at a radio altitude of 965 feet within approximately 15 seconds. The airplane's ground-proximity warning system (GPWS) provided a "terrain" warning[2] about 12 seconds later at a radio altitude of 630 feet, and the pilot-in-command (PIC) responded by advancing the thrust levers to the forward mechanical stops and rotating the aircraft to a nose-up pitch altitude of 12 degrees. A second GPWS "terrain" warning occurred about two seconds after the first warning at a radio altitude of 661 feet. A GPWS "pull up"' warning occurred about three seconds after the first warning at a radio altitude of 882 feet when the aircraft rate of climb decreased again, this time from 2,640 fpm to 1,440 fpm. The PIC responded to the "pull up" warning by increasing the pitch attitude of the aircraft to 20 degrees nose up; the PIC then completed the go-around maneuver, flew the aircraft to an alternate airport and landed the aircraft.

None of the 137 passengers or seven crewmembers was injured, and the aircraft was not damaged during the encounter, which occurred while the B-737 was being operated in scheduled passenger service from Sydney, New South Wales, Australia, to Brisbane.

The final report of the Australian Transport Safety Bureau (ATSB) said that during final approach on the incident flight, neither the thunderstorm nor lightning could be seen clearly by the B-737 flight crew and radar reflectivity echoes behind the leading edge of the storm likely were attenuated by heavy rain, probably making the airborne weather radar system unreliable for accurate assessment of weather ahead of the aircraft. The Runway 19 approach lights[3] initially were visible to the flight crew in rain and isolated hail, but the approach lights and runway lights became obscured in heavy rain and hail, the report said.

"The approach lights for Runway 19 were visible to the crew, and the [PIC] elected to continue the approach," the report said. "At about 500 feet, the weather deteriorated rapidly, and the aircraft encountered hail and turbulence. The [PIC] discontinued the approach and applied go-around engine thrust. The aircraft commenced to climb normally at about 3,600 [fpm]; however, shortly after the go-around was initiated, the climb performance substantially reduced to less than 300 [fpm] due to the effects of the microburst downdraft and from flight through heavy rain. The [PIC] applied maximum engine thrust to improve the aircraft's climb performance, and advised the [tower] controller that the aircraft had encountered severe wind shear. The crew then diverted the aircraft to Maroochydore [Queensland], where it landed without further incident."

The PIC did not believe that the aircraft was in imminent danger of collision with the ground during the go-around, and the incident provides several lessons about integrating safety systems to prevent wind shear encounters, the report said. The operator was not identified in the ATSB report.

"The recorded flight data for the occurrence sequence indicated that the maximum horizontal wind speed sustained by the aircraft was 28 knots at 0729:09," the report said. "Within 17 seconds, [horizontal wind speed] reduced to seven knots, and during that period, the aircraft's rate of climb reduced … more than 3,300 [fpm]. During that same period, the aircraft's airspeed reduced from 168 knots to 144 knots. The airspeed therefore reduced at the same time as the wind speed reduced, which was consistent with flight through microburst wind shear conditions.

"Had the aircraft encountered those conditions just before the go-around was initiated, the time taken for the crew to recognize [the situation] and then react to the situation, may have resulted in a more serious outcome. At that stage, the aircraft would have been at an altitude of about 200 feet, with the engines operating at a relatively low thrust setting, and with the landing gear and wing flaps in the landing configuration. Entry into a 3,300-[fpm] downdraft at that point would have given the crew less than five seconds to execute the prescribed B-737 wind shear recovery maneuver to prevent collision with the ground.

"The performance of the aircraft was typical of the consequences of a microburst encounter — that is, a rapid loss of airspeed and a strong downdraft experienced near a convective cell. It is likely that those effects were due to the aircraft having penetrated [the developing third cell of the thunderstorm] during the go-around."

At the time of the incident, the rate of rainfall also exceeded the rate that is likely to result in significant aerodynamic penalties based on research on heavy rain.

After the incident, the PIC said that the crew had been operating the B-737 clear of clouds as it passed through about 6,000 feet on descent into Brisbane, and that both the airport and surrounding areas were visible.

"[The PIC had] observed a towering cumulus cloud near the [airport]," the report said. "However, its top could not be clearly seen, and he did not recall seeing any significant overhang from the cloud. He also reported that there appeared to be a 'wall of gray' to the northwest of the [airport] and a 'field' of cumulus cloud to the south–southeast. The copilot subsequently reported that he did not observe the towering cumulus cloud near the [airport] but [that he] had observed a 'wall of cloud' to the northwest of the [airport]."

The following significant factors were identified by ATSB in this serious incident (defined by International Civil Aviation Organization (ICAO) Annex 13, *Aircraft Accident and Incident Investigation*, as "an incident involving circumstances indicating that an accident nearly occurred"):

- "There was an intense thunderstorm overhead Brisbane [Airport] at the time of the occurrence;
- "The thunderstorm produced a microburst, hail and heavy rain, which the aircraft encountered during the go-around;
- "Air traffic control [staff] and [the Australian Bureau of Meteorology (BOM)] staff did not mutually exchange information regarding the thunderstorm as it approached Brisbane [Airport];
- "The controllers did not advise the crew of, nor did the crew request, details of the lateral limits, direction of travel and groundspeed of the thunderstorm;
- "The terminology and language used by air traffic controllers to the crew of [the incident B-737] and between each other did not convey their concerns about the intensity of the thunderstorm to the crew until the aircraft was on final approach; [and,]
- "The aircraft was not fitted with a forward-looking wind shear warning system [such as GPWS with the wind shear caution-alert function enabled], nor was it required to be."

The PIC held an air transport pilot (airplanes) license and had 12,409 flight hours, including 5,000 flight hours in the B-737. His last check before the incident flight was Nov. 9, 2000. The report said, "The [PIC's] most recent simulator wind shear training as handling pilot was completed on June 9, 2000. The training included encounters with undershoot shear on takeoff and landing."

The copilot held an air transport pilot (airplanes) license, and had 5,750 flight hours, including 617 flight hours in the B-737. The report said, "The copilot's most recent simulator wind shear training was completed on Dec. 20, 2000. During that exercise, the copilot acted as the non-handling pilot. The copilot's most recent simulator wind shear training as handling pilot was completed on May 3, 2000, while undertaking conversion training on the [B-737]."

The report said that the aircraft had a valid maintenance release; weight and balance were within certified limits; and no aircraft, engine or system malfunctions that contributed to the degraded go-around performance. The incident B-737 was equipped with two electronic attitude director indicators (EADIs), two electronic horizontal situation indicators (EHSIs) and two instantaneous vertical speed indicators (IVSIs). Returns from the aircraft's digital weather radar system were superimposed on the EHSIs and indicated precipitation intensity with green color to show light precipitation, yellow to show medium precipitation, and red or magenta to show heavy precipitation, the report said.

"Weather radar is subject to attenuation when operated in precipitation," the report said. "Attenuation occurs when weather radar is penetrating precipitation and may make it difficult for crews to accurately assess the severity of weather ahead."

The incident aircraft was equipped with a Honeywell Mark V (Boeing version) GPWS.

"The wind shear caution-alert function was a programmable option, but was not enabled on the operator's B737-300/400 fleet," the report said. "If enabled, [the GPWS] was capable of providing crews with an alert to warn them of an impending microburst encounter. If enabled, it would have provided the crew with a wind shear caution alert about 24 seconds prior to the first GPWS 'terrain' warning and about 31 seconds prior to the GPWS 'pull up' alert. … Boeing advised that few aircraft were delivered with the optional wind shear caution alert system activated. [Boeing] recommended against activation of the caution alert because of the possibility of nuisance alerts and the absence of defined procedures to be taken following the trigger of those alerts."

Weather analysis showed that in the early morning of the day of the incident, a surface trough moved north from northern New South Wales with a moist light northwesterly tropical airflow ahead of the surface trough. BOM told ATSB that on the day of the incident, meteorologists had a good overall view of precipitation in all sectors using three-dimensional radar data for the Brisbane area from weather radar systems located at Brisbane Airport and at Marburg, about 50 kilometers [31 statute miles] west of Brisbane. Two-dimensional images from BOM's weather radars were displayed at various air traffic control working positions.

"BOM's duty forecasting staff experienced a high workload on the morning of Jan. 18, 2001, due to the rapidly changing weather conditions in the Brisbane area, and they had limited time to analyze the three-dimensional weather radar imagery," the report said. "Data from the Marburg weather radar was subsequently examined, and revealed that the thunderstorm was a multicellular storm. It was moving northeast at a speed of about 60 kilometers per hour [kph; 32 knots], and contained two main reflectivity cells. By 0732, a new cell … was evident on the northern flank of the leading cell."

Excerpts from the ATSB report include the following communication about developing weather conditions on Jan. 18 and the actions of meteorologists, air traffic controllers and the flight crew of the incident B-737:

- At 0213, BOM issued an amended airport forecast (TAF) for Brisbane Airport, valid from 0400 on Jan. 18 until 0400 on Jan. 19, that did not forecast the presence of thunderstorms in the Brisbane area. The report said, "The BOM aviation forecaster and the shift-supervising meteorologist considered there was less than a 30 percent probability of thunderstorms during the period covered by the amended TAF. They based their decision on the fact that it was approaching the time of day when thunderstorms were least likely to occur. Also, there was little upstream thunderstorm activity observed on the BOM weather radar, and the observed upstream thunderstorm activity was decaying."

- At 0613, BOM weather radar showed that a thunderstorm had developed about 60 kilometers (32 nautical miles) south–southwest of Brisbane on the northern side of an existing area of thunderstorms;

- At 0622:20, the incident B-737 departed Sydney;

- At 0630, BOM issued a trend-type forecast (TTF) appended to a routine airport weather report (METAR) for Brisbane Airport; this TTF METAR forecast the presence of thunderstorms and rain showers from 0700 until 0900;

- At 0635, BOM issued an airport warning[4] for Brisbane Airport that forecast thunderstorms, possible hail and wind gusts greater than 41 knots from 0700 until 0900;

- At 0654, BOM issued to the public a severe thunderstorm warning, which said that several thunderstorms with possible damaging winds and large hail had been observed from near southwest Brisbane to the northern Gold Coast area, moving northeasterly at about 70 kph (38 knots);

- At 0700, BOM issued a TTF METAR for Brisbane Airport that said that lightning had been observed to the south of the airport; the TTF forecast thunderstorms and rain from 0700 until 0900;

- At 0715, BOM issued a lightning alert for Brisbane Airport ground personnel, which said that thunderstorms and lightning had been observed within 15 nautical miles (28 kilometers) of the airport, and that the storms were expected to move to within five nautical miles (nine kilometers) of the airport, then clear within the next hour;

- At 0718, BOM issued a TTF SPECI (non-routine weather observation) for Brisbane Airport, saying that thunderstorms and rain showers had been observed, and that this precipitation was forecast to continue from 0718 until 0900;

- At 0725, BOM issued another TTF SPECI for Brisbane Airport, which said that thunderstorms with hail had been observed. An associated TTF METAR forecast thunderstorms and rain showers until 0900; and,

- At 0730, BOM issued another TTF SPECI for Brisbane Airport, saying that thunderstorms with hail had been observed and the wind was from 180 degrees magnetic at 10 knots gusting to 26 knots (Figure 1).

The report said that air traffic controllers used available weather information as follows about the time of the incident flight:

- At 0636, Brisbane air traffic control (ATC) received the 0630 TTF METAR, but controllers did not provide this information to the crew of the incident aircraft;

- At 0640, Brisbane tower controllers issued automatic terminal information service (ATIS) information Juliet, which did not say that thunderstorms were present in the Brisbane area;

- At 0641:30, transcripts of ATC automatic voice recordings between the Brisbane tower coordinator and the approach control coordinator showed that they believed that the weather approaching Brisbane Airport from the southwest was "definitely serious";

- At 0655:50, transcripts showed that a Brisbane Airport tower controller and the approach control coordinator agreed to change the active runway from Runway 01 to Runway 19 because arriving aircraft crews would not want to fly through the weather 14 nautical miles (26 kilometers) south–southwest of Brisbane Airport;

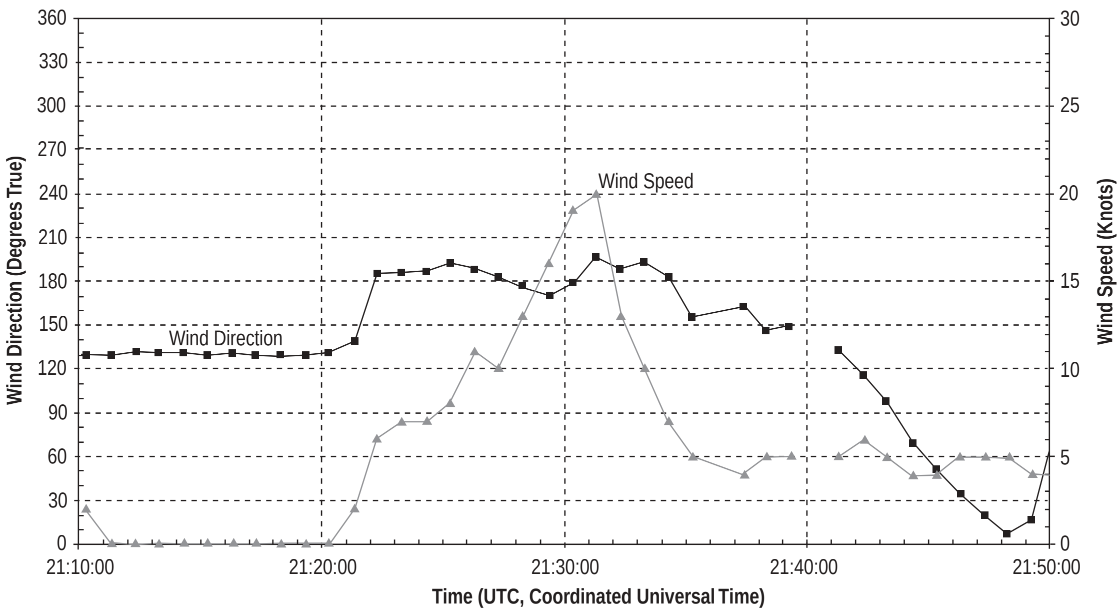
- At 0706:30, ATC issued Brisbane ATIS information Kilo, which said that Runway 19 was the runway for departures and arrivals; this broadcast did not say that thunderstorms were in the Brisbane area;

- At 0708, Brisbane ATC received the 0700 TTF METAR, which forecast thunderstorms and rain showers;

- At 0708:30, ATC issued Brisbane ATIS information Lima, which said that a thunderstorm was approaching Brisbane Airport from the south and that Runway 19 was being used for departures and arrivals; and,

- At 0711:41 the Gold Coast sector controller provided ATIS information Lima to the B-737 crew.

Australian Bureau of Meteorology Anemometer Data
Brisbane Airport, Queensland, Jan. 18, 2001



Note: Data from the digital flight data recorder on a Boeing 737 showed an encounter with a microburst downdraft at 0729 local time (21:29 coordinated universal time) and correlated with anemometer data recorded at Brisbane Airport, Queensland, Australia, by the Australian Bureau of Meteorology. High-resolution data from other anemometers at the airport supported air traffic control operations but were not recorded.

Source: Australian Transport Safety Bureau

Figure 1

The report said that the flight crew of the incident B-737 used available weather information as follows during the last phases of the flight to Brisbane Airport:

- At 0701:55, the B-737 crew began a descent from Flight Level 350 (about 35,000 feet) to Brisbane Airport;
- At 0703:00, the Gold Coast sector controller told the B-737 crew that for weather avoidance, previous aircraft inbound to Brisbane Airport from the south had tracked overhead and then to about 20 nautical miles [37 kilometers] north of Coolangatta [Queensland] before tracking towards Brisbane. A B-737 crewmember said, "Looks like the way to go;"
- At 0716:55, a Boeing 747 crew — preceding the incident B-737 in the approach sequence and in communication with the Approach North controller — declined to continue the approach to Brisbane Airport after observing on airborne weather radar a thunderstorm over the airport and accepted the controller's offer to hold northeast of the airport;
- At 0720:30, the Brisbane tower controller told the Approach South controller that the approaching storm probably would affect arriving aircraft;
- At 0720:59, the Approach North controller cleared the crew of the holding B-747 for final approach after confirming that the aircraft was clear of weather;
- At 0721:50, the Brisbane tower controller issued a landing clearance to the crew of another B-737 and provided the crew with information about the approaching weather; the controller said to the crew of this aircraft, "The rain is just to the south of the field now, as you can probably see on your radar";
- At 0722:15, the Approach South controller told the crew of the incident B-737 about the approaching weather when this airplane was about 12 nautical miles (22 kilometers) northeast of Brisbane Airport, on a downwind leg for Runway 19, descending through 4,200 feet. This controller said, "The tower just told me the weather is virtually at the field or will be shortly. … When you get on final, let me know if you want to continue with the approach";
- At 0722:50, the crew of the B-747 told the tower controller that their aircraft was on a nine-mile (17-kilometer) final approach to Runway 19; the tower controller told this crew about the rapidly approaching storm;
- At 0723, Brisbane ATC received the 0718 TTF SPECI about thunderstorms and rain showers observed at Brisbane Airport;
- At 0724:30, ATC issued Brisbane information Mike; the broadcast included information about wet runway conditions, visibility 2,000 meters (6,562 feet), high-intensity approach-lighting system (HIALS) for Runway 19 activated and the rapidly approaching storm. Information Mike was not communicated to the crew of the incident B-737, the report said;
- At 0725:25, the Approach South controller told the crew of the incident B-737, "For information … looks like the weather is just to the south of the field approaching the airport boundary";
- At 0726:46, the tower controller told the crew of the incident B-737 to continue the approach and said, "Visibility is down to about 1,500 meters [4,921 feet] and there is hail falling on the southern end of the runway at the moment";
- At 0728:10, the tower controller issued a landing clearance to the crew of the incident B-737 and said that there was hail on the airport and that the wind was from 150 degrees at 18 knots;
- At 0728:30, Brisbane ATC issued ATIS information November; the broadcast included information about the wet runway, hail, thunderstorm, visibility of 1,000 meters (3,281 feet) and that HIALS was activated;
- At 0729:09, the crew of the incident B-737 told the tower controller that they were "going around," and the controller told the crew "to climb the aircraft to 4,000 feet and to track left as required"; and,
- At 0732:25, the crew reported to the Approach South controller severe wind shear on final and "suggested that a weather warning may be warranted."

In ATSB's analysis of factors involved in the incident, the report included the following findings among those involving the flight crew:

- "The crew departed Sydney without any expectation that thunderstorm activity was likely at Brisbane [Airport];
- "The crew did not comply with the provisions of the operator's operations manual [about] thunderstorm avoidance;
- "The crew had visual contact with the approach lights for Runway 19 during the approach;
- "The crew conducted an approach into an area of intense convective activity that was conducive to microburst activity;
- "The crew were not aware of the thunderstorm's intensity and its associated microburst until the aircraft

performance began to deteriorate during the go-around; [and,]

- "The [PIC] responded appropriately when the aircraft performance rapidly deteriorated and the GPWS Mode 2 [excessive terrain-closure rate] 'terrain' and 'pull up' aural alerts sounded."

The report said that the operator's flight-dispatch service "did not proactively provide timely and comprehensive weather information to the crew about the deteriorating weather conditions at Brisbane" and included the following findings among those involving the operator's documentation and procedures:

- "The operations manual contained advice that crews should stay clear of thunderstorm cells and heavy precipitation and areas of known wind shear;
- "The operations manual contained advice that the presence of wind shear could be indicated by a variety of factors, including thunderstorm activity. However, it contained no guidance on the probability of the presence of microburst wind shear in different meteorological conditions;
- "The operations manual contained advice on wind shear recovery maneuvers;
- "The operations manual contained advice on microbursts. However, it contained no advice about aircraft performance in wind shear conditions or the aerodynamic penalties associated with flight through heavy rain;
- "The operations manual contained advice on the use of weather radar, including attenuation due to heavy rain; [and,]
- "The operations manual contained advice on permitted flight tolerances during the approach phase of flight."

The report included the following findings among those involving ATC:

- "The Brisbane controllers did not comply with the provisions of [the *Manual of Air Traffic Services* (MATS), published by the Australian Department of Defence and Airservices Australia] and local instructions that required them to pass updated weather information to flight crews;
- "The controllers did not provide specific weather information to the crew until the aircraft was on final approach; [and,]
- "The controllers did not inform the crew of the precipitation echoes that were being depicted on their [meteorological radar (METRAD)] display."

The report included the following findings among those involving BOM:

- "The 0213 [amended] TAF issued by BOM on Jan. 18, 2001, did not indicate that thunderstorms were likely to be present at Brisbane [Airport] at the time of the aircraft's arrival;
- "BOM did not issue a warning on the expected existence of wind shear associated with the thunderstorm that could adversely affect aircraft on the approach [path] or takeoff path, contrary to the requirements of ICAO Annex 3 [*Meteorological Service for International Air Navigation*]; [and,]
- "BOM did not place special emphasis on the provision of information about the hazardous weather phenomena near Brisbane [Airport] that were likely to be associated with the thunderstorm, contrary to the recommendations contained in ICAO Doc 9377-AN/915 [*Manual on Coordination Between Air Traffic Services and Aeronautical Meteorological Services*]."

In ATSB's analysis, the report said that the following problems should be addressed to improve convective-weather decision support within the Australian airspace system:

- Integration of radar imagery with lightning data to provide 20-minute forecasts of storm movements and gust fronts that are likely to affect aircraft operations at an airport;
- Dissemination within the aviation weather system of hazardous-weather information currently used in public weather warnings, airport warnings and lightning alerts; and,
- Ensuring that flight crews are aware of the intensity of a thunderstorm before becoming established on final approach, and that they are updated by controllers with all relevant information for situational awareness.

"The crew relied on the Brisbane TAF, issued by BOM at 0213, when planning for the flight prior to their departure from Sydney," the report said. "Brisbane Tower was responsible for initiating a hazard alert when there was an amended TAF or TTF issued that forecast deterioration below the alternate minima within 60 minutes of its issue. … The first information provided to the crew that there was a thunderstorm approaching Brisbane [Airport] was when ATIS [information] Lima was issued at 0708:30. At that point, the aircraft had commenced its descent into Brisbane."

The report said that the TTF issued at 0630, the TTF issued at 0700 and the TTF issued at 0718 were not communicated by ATC to the crew of the incident B-737.

"ATIS [information] Mike was issued at 0724:30 when the aircraft was to the north of the [airport] being radar-vectored towards the final approach path, but was not passed to the crew," the report said. "Had the controllers passed that information to the crew, [this information] may have provided the crew with an opportunity to seek further information about the storm and to perhaps consider the advisability of continuing the approach. Had the crew received ATIS [information] Mike and then elected to discontinue the approach, the microburst encounter may have been avoided and, thus, would have improved safety margins."

ATSB's analysis also showed that if the unstabilized approach (as defined by the operator)5 conducted by the incident PIC had been identified immediately and discontinued, an earlier go-around would have reduced the risk of collision with the ground after penetrating a microburst downdraft at low altitude. Nevertheless, the report said that the unstabilized approach was not a factor in the reduced rate of climb during the go-around.

The analysis identified the following problems in how controllers used meteorological information: Controllers did not attempt to clarify with BOM forecasting staff their expressed concerns about weather radar returns; controllers showed inadequate understanding of the time-delay factor and calculation of the thunderstorm arrival time; and controllers used imprecise terminology about the approaching thunderstorm.

Among safety recommendations, ATSB said that Airservices Australia should review air traffic controllers' initial training and recurrent training and develop a comprehensive refresher course to ensure that the content addresses adequately the effect of convective weather on aircraft performance, the limitations of airborne weather radar and the requirements of flight crews; and expedite the development of an integrated weather radar/ATC radar video display system.

Airservices Australia said that airport services will develop a refresher-training module based on the circumstances of this incident and will require completion of this module by all full-performance controllers.

ATSB said that BOM should ensure that all public weather warnings are communicated as quickly as possible to affected ATC facilities; expedite research, development and introduction of systems to detect hazardous wind shears and wind shifts in high-risk airport terminal areas; and retain recorded data from all available wind sensors and low-level wind shear alert systems for a minimum of 30 days. The ATSB report did not include a response by BOM.

ATSB said that the Civil Aviation Safety Authority of Australia (CASA) should ensure that operators increase their emphasis in training programs on the effective use and limitations of all available sources of weather information (including airborne weather radar) for crew operational decisions, the hazards of low-level flight through thunderstorms and the effects of wind shear encounters.

CASA said that consideration was being given to reviewing the procedures of the ATC group in advising aircraft of significant weather; procedures for vectoring aircraft to final approach that increase workload for the aircrew during poor-weather approaches; exploration of the availability of composite moisture-stability charts for aircrews; and continued development of Civil Aviation Safety Regulation Part 174, which will "prescribe the regulatory requirements and standards for organizations providing meteorological services in support of air navigation and air traffic services within Australia and its territories."

ATSB issued the following recommendations to multiple agencies and said that maximum safety benefit would be achieved by coordinated efforts:

- Airservices Australia, BOM and CASA should "develop a standard scale of thunderstorm intensity for use within the aviation industry";
- Airservices Australia and BOM should "develop a position in major air traffic control locations, to be staffed with [BOM] meteorologists, to be the focal point for weather information coordination;" and,
- BOM and CASA should "review the meteorology syllabus for initial [training] and periodic recurrent training of all pilots and air traffic controllers to ensure that the syllabus includes comprehensive information on convective weather phenomena and their effects on aircraft performance."

In the absence of extensive Doppler weather-radar capabilities — technology that provides data about the internal dynamics of thunderstorms — or other appropriate systems designed to detect hazardous wind shear, meteorologists, controllers, pilots and operators require collaborative decision making in response to convective weather that is intense or severe, the ATSB report said.♦

[FSF editorial note: This article, except where specifically noted, is based on Australian Transport Safety Bureau Air Safety Investigation Report no. 200100213, "Boeing 737-400, VH-TJX, Brisbane, QLD [Queensland, Australia], 18 January 2001." August 2002. The report contains 88 pages with tables, appendixes and illustrations.]

Notes

1. The Australian Transport Safety Bureau (ATSB), in its final report on this incident, said, "Microbursts are associated with convective activity, and comprise intense local downdrafts with divergent surface flows. … Wind shear is a change in wind speed and/or direction, including updrafts and downdrafts. An aircraft may experience a significant deterioration in flight performance when exposed to wind shear of sufficient

intensity or duration. Wind shear is hazardous if it reduces the energy state of an aircraft faster than it can be restored with engine thrust. [The incident operator's meteorology manual said that a microburst involves] 'a very strong downward flow, as high as 6,000 feet per minute [fpm], which becomes strong horizontal winds near the ground, with greater than 80-knot variations through the base area … maximum horizontal winds occur about 75 feet above the surface.'"

2. Analysis of data from the incident Boeing 737's digital flight data recorder by ATSB "revealed that the radio altimeter indicated a loss of altitude on three occasions, signifying a terrain-closure rate." Although the two "terrain" warnings from the ground-proximity warning system (GPWS) were perceived by the flight crew to be genuine and the crew responded appropriately, ATSB said "the GPWS Mode 2 [excessive terrain-closure rate] warnings did not result from excessive terrain-closure rate, and were consistent with 'technical' warnings triggered by flight through heavy rain and/or hail." Technical warnings are caused by known equipment malfunctions or equipment-design deficiencies (such as activation by weather phenomena), ATSB said.

3. The report said, "The Runway 19 lighting system included a high-intensity approach-lighting system (HIALS) and 'T' visual approach slope indicators (T-VASI). … The pilot-in-command reported that he observed the T-VASI and HIALS as the aircraft passed 2,500 feet altitude on descent into Brisbane. At 1,500 feet, the T-VASI became obscured; however, the HIALS was still visible. At about 1,200 feet, the intensity of rain began to increase, and by 1,000 feet, both the T-VASI and HIALS were becoming obscured. The copilot reported that the T-VASI and HIALS were visible at about 1,500 feet. A short time later, the visibility reduced to the extent that by 500 feet altitude, both the T-VASI and HIALS were no longer visible because of heavy rain and hail."

4. ATSB said, "[The Australian Bureau of Meteorology (BOM)] issues [airport] warnings in accordance with international practice and by regional or local arrangement. … The office responsible for the issue of [airport forecasts (TAFs)] and/or [trend-type forecasts (TTFs) appended to a routine weather report] for an [airport] is also responsible for issuing warnings … [that] relate to the expected occurrence of one or more of the following phenomena: tropical cyclone; gale; squall; thunderstorm; sandstorm; dust storm; rising sand or dust; hail; frost; hoar frost or rime; snow; and/or freezing precipitation."

5. The report said that stabilized-approach criteria in the operator's flight-administration manual specified that a rate of descent greater than 1,000 fpm below 1,000 feet exceeded the operator's allowable tolerances for the approach phase of flight.

Airport Operations

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