Day & Night Thunderstorms Kill

Lessons learned by NTSB Investigations

By Steve Chealander, National Transportation Safety Board

In March 2004 in Pyote, TX, a helicopter emergency medical service team was flying a Part 135 on-demand mission when it encountered a severe nighttime thunderstorm. The atmospheric conditions were typical for the season. A stationary front extended east-to-west across the state, with scattered thunderstorms and rain showers forecast. Nighttime conditions prevailed with no illumination from the moon.

Earlier that evening, the chief pilot advised the on-call pilot, who was enroute to the hangar, of the expected weather accross the area, and he also advised him of a potential medivac mission later that night.

A few hours later, the unit received a call to transport an infant and his mother from Alpine, TX, to a high care facility 220-miles northeast in Lubbock. The pilot, who took the call, held a commercial airman certificate, was instrument rated and had more than 17,000 hours of flight time with more than 4,200 hours in helicopters. He was advised that "yellow" weather conditions existed over the region, indicating that visual flight rule (VFR) conditions existed over most of the operating area, with weather conditions in some locations below VFR limits. The operation specifications did not allow flight in instrument meteorological conditions (IMC).

While proceeding northeastward over Texas, the helicopter was close to an area of severe weather to the east when it made course deviations to the north, then back to the northeast, then eastward and then 270-degrees back to the north. At the same time, the pilot contacted dispatch and began to make a position report.

"Hold on a minute dispatch," he said, breaking up, "…look at, give me something to look at." There was no further communication from the helicopter.

The helicopter impacted terrain after encountering severe weather. When the aircraft did not arrive in Lubbock at its estimated time of arrival, it was reported missing and search and rescue operations were launched. However, because of the weather conditions, airborne search operations were delayed several hours. The next morning, wreckage of the helicopter was found near Pyote, within a mile of the last position report. The pilot, flight paramedic, infant passenger and the escorting passenger were killed in the crash, and the flight nurse incurred serious injuries.

Debriefing

That night in 2004, the Texas-based pilot obtained no formal weather briefing, didn't review any other weather information and had no formal flight dispatch services. Had he reviewed the area weather, he would have noted that the National Weather Service (NWS) surface analysis chart depicted a squall line south of the stationary front, which was in the immediate vicinity along the flight route to Lubbock. The NWS Severe Storm Center in Norman, OK, also forecasted the potential for severe thunderstorms along the front, with an unstable atmosphere with a lifted index of -5 (positive numbers indicate a stable atmosphere, negatives indicate instability), winds changing direction and speed aloft creating enough shear favorable for the production of several large clusters of multicellular to supercell-type thunderstorms.

A supercell, one of the most severe forms of thunderstorms, is often referred to as a rotating storm with a mesocyclone or small-scale, low-pressure system within the storm to create a persistent and strong updraft and a downdraft that descends in the opposite direction to create a long-lived storm. Supercells are recognized by a hook-echo shape observed on weather radar.

The radar summary chart depicted a solid line of thunderstorms (equivalent to the squall line on the surface analysis chart) moving west-southwest over the region, with tops to 41,000 feet. Severe thunderstorm activity identified by a squall line should alert all pilots of the increased potential of encountering heavy rainfall, strong gusting winds, severe to extreme turbulence, large hail, windshear and localized IMC conditions. Any thunderstorm identified as being severe should be avoided by at least 20 miles.

Following the accident, a review of the local NWS Weather Surveillance Radar-1988 Doppler depicted a fine line and scattered echoes associated with the gust front over the accident site at the time of the accident, with a line of very strong to intense echoes east of the accident site. The weather conditions were conducive to strong gusting winds, turbulence and blowing dust, resulting in low-visibility “brownout” conditions. The satellite imagery confirmed that the accident site was located on the western side of a large convective system of cumulonimbus clouds.

A convective significant meteorological condition (SIGMET) was present in the immediate vicinity of the accident site for an area of thunderstorms with tops to 41,000 feet, moving to the southwest at 30 knots. A family traveling northeastward on the interstate near the accident site reported seeing a defined thunderstorm in the distance from the time they left El Paso until they were approximately 15 miles west of Pecos (about 25 miles southwest of Pyote). At the approximate time of the accident, they encountered a “strong storm front” with no precipitation but extremely high winds and dust that restricted visibility. They also described one large continuous bolt of lightning to the north and frequent in-cloud lightning. They described the storm as “vicious” and said that it “almost took them off the road.” The family said they could barely control their vehicle through the storm, which caused them to slow down at times until they were approximately 15 miles beyond the accident site.

Local authorities also reported strong to severe thunderstorms throughout the area, including strong winds and large hail. The National Transportation Safety Board (NTSB) determined that the probable cause of the accident was the pilot’s inadvertent encounter with adverse weather conditions that resulted in his failure to maintain terrain clearance. Contributing factors were the dark night conditions, the pilot’s inadequate preflight weather preparation and planning and the pressure to complete the mission as a result of the nature of emergency medical service.

Often, pilots think of rain and lightning as the hazards associated with thunderstorms. However, the winds and turbulence associated with the storms, although not necessarily immediately within the area, can be just as dangerous and are often difficult to detect while flying, particularly in nighttime conditions.

Today, helicopter emergency medical service crashes in the U.S. have increased to one of the highest accident rates for aviation, based on NTSB statistics. In-flight encounters with weather at low altitude are listed as the leading cause or factor in fatal helicopter medevac accidents, with the majority occurring during the hours of darkness. But with some knowledge of the formation of thunderstorms, pilots and medical crewmembers can learn to avoid them and decrease those accident rates.

Anatomy of a Thunderstorm

Every thunderstorm produces updrafts and downdrafts. The severity of the storms typically depends on the number and strength of the updrafts and corresponding downdrafts, which is dependent on the instability of the air mass, usually measured by the lifted index and the lifting source. When downdrafts and rain-cooled air reach the ground, the rain-cooled air spreads out along the ground and forms an outflow boundary or gust front.

The gust front is the boundary between the cooler, denser outflow air from the storm and the surrounding warm environmental air. There, multiple surges of cold, dense air are possible. Stronger, more organized storms, like squall lines, tend to produce stronger outflows that can propagate miles away from the storm complex. The squall line gets its name from the outflow winds it produces from the gust front. A schematic of a gust front similar to the one encountered by the Texas-based helicopter in March 2004 is shown in figure 1.

Studies of gust fronts in the Midwest during the 1960s and 1970s documented the gust front as a major cause of low-level windshear prior to the identification and documentation of microbursts. These studies resulted in low-level windshear alert system installations. The gust front is the leading edge of a 2- to 50 - mile pressure dome separating the outflow air in the thunderstorm from the environmental air. This boundary is marked by upward motion along the leading edge, or nose, and downward motion behind it. It is followed by a surge of gusting winds on or near the ground.

A gust front is often associated with a pressure jump or rapid increase in pressure caused by the cold, dense air that follows it, a wind shift, temperature drop or sometimes heavy precipitation. Gust fronts often can be identified during daylight hours by a shelf or roll cloud (figure 2) that marks the leading edge. At night, some of the features may be illuminated by lightning, but they often go undetected by pilots.

Across the southwestern U.S., gust fronts can be marked by blowing dust and/or sand picked up by the winds to create brownout conditions, such as those experienced in the Arizona monsoon-type storms (figure 3). The hazards associated with the turbulence region of a gust front are identified from the nose, which is marked by a sudden wind shift and increase in wind speed, as well as potentially moderate to severe turbulence up to 1,000 feet and occasionally to 3,000 feet agl.

Behind the leading edge of the gust front, another area of turbulence is typically found near the “wake.” This can cause wave formations as the density discontinuities between the warm and cold air masses result in moderate to severe turbulence (figure 4). Gust fronts are often observed extending up to 15 miles from the main precipitation core of a thunderstorm.

Another hazard associated with gust fronts occurs when small waves develop and grow into “vortex rollers” at the top of the gust front between the colder dense air and the warmer, less-dense air of the environment. Figure 5 shows fluid dynamic models of a gust front over time; vortices are created on the top of the density boundary as turbulent mixing develops.

A helicopter at low altitude, without visual clues due to heavy rain, blowing dust and/or in nighttime conditions, would have little chance of continued flight if it encountered the worst of these turbulent conditions.

Avoiding Thunderstorms

To avoid severe weather, obtain a preflight weather briefing, as required by Federal Aviation Regulations 91.103 preflight action. The majority of weather-related accidents involve pilots who do not become familiar with weather conditions before flight, as in the Pyote accident.

Any forecast of a thunderstorm implies the potential of a gust front, and a forecast or report of severe thunderstorms increases the potential of gust fronts and damaging winds. Convective SIGMETs, a weather watch issued for your area, NWS radar summary charts of organized lines or an area with a fine line identified and local weather radar imagery should also be utilized. Be sure to note the storm movement.

A simple rule of thumb to estimate the potential wind gusts from a thunderstorm is to take its movement and multiple it by 1.5. For example, a thunderstorm moving at 30 knots is capable of producing gusts to 45 knots. Study your local terminal aerodrome forecasts for wind warnings, such as temporary conditions of gusts over 35 knots, heavy precipitation and cumulonimbus clouds. Monitor METAR reports of strong gusting winds with thunderstorms and/or lightning in the vicinity or distance.

Every thunderstorm or cumulonimbus cloud should be avoided. You cannot see all the hazards associated with these storms. Even away from a thunderstorm, watch for signs of outflow from any defined shelf or roll clouds ahead of the convective system. Lightning only comes from cumulonimbus clouds, and severe thunderstorms tend to produce more frequent lightning than ordinary non-severe thunderstorms.

In the Pyote accident, the information the pilot needed to make an informed decision about the weather conditions was available; he just didn’t use it. The wind conditions likely reduced visibility by blowing dust, and the pilot likely experienced associated updrafts and downdrafts and moderate-to-severe turbulence. Don’t let this happen to you.

Steven R. Chealander was sworn in as the 38th member of the National Transportation Safety Board on January 2007. Prior to joining the Board, he was with American Airlines, serving since 1991 as a pilot and Captain qualified on the DC-10, B-737, MD-80, and F-100 aircraft, and as a Chief Pilot in Los Angeles. At American, he also was a flight safety manager, performing safety and compliance audits and participating in investigations, and was most recently the Manager of Flight Operations Efficiency.