Cracking the Microburst Code

Meteorology confronts a mysterious threat to flight safety.

BY RICK DARBY

BOOKS

From 'Adverse Winds' to Microbursts

Warnings: The True Story of How Science Tamed the Weather

Smith, Mike. Austin, Texas, U.S.: Greenleaf Book Group Press, 2010. 304 pp. Photographs.

Mark Twain's quip that everyone talks about the weather but no one does anything about it has been made obsolete by today's meteorology, to aviation safety's great benefit.

Mike Smith, himself a meteorologist, has been involved for most of his career with measuring and forecasting extreme weather to enhance safety. Despite minuscule financing compared with that for cancer research, heart disease research and traffic safety innovations, meteorology has resulted in "a far more impressive reduction of deaths," Smith says.

The annual death rate from tornadoes in the United States has decreased from three per million people in the 1920s to 0.068 per million in 2006 through 2009, he says. Weather science's influence on aviation safety is also significant.

"From 1964 to 1985, a number of microburst-related plane crashes in the United States killed hundreds of people at a time," he says. "Today, this type of fatal airline accident has practically been eliminated. From 1986 to 2008, the number of microburst fatalities in the United States was 37, a decrease of 93 percent, in spite of a near doubling of airline flights during this period."

But the path to prediction and avoidance of microbursts was anything but smooth.

Smith credits meteorologist Ted Fujita with pioneering many of the methods used today in storm analysis and prediction.

"Without Fujita's techniques, increasing our knowledge of thunderstorms and similar small-size meteorological events during the 1950s, 1960s, 1970s and 1980s would have been nearly impossible," Smith says. "He had a creative perspective and a mind that viewed the world in four dimensions, the north/south dimension, the east/west dimension, vertical dimension (altitude) and time. … To perform his analysis, Fujita almost single-handedly created the art of meteorological photogrammetry [measuring by photography]. He triangulated the photographs from different locations in order to track the evolution of the storm's features."

Smith cites, as an example of the prevailing attitude in aviation at the time, the accident involving Eastern Air Lines [EA] Flight 66 at John F. Kennedy International Airport (JFK), New York, in June 1975:

"Reports to the JFK control tower from an aircraft awaiting takeoff that it was being buffeted by the storm's high winds were disregarded by the air traffic controllers and, thus, not relayed to the aircraft on approach. Another airplane landing ahead of EA 66 barely avoided crashing. The flight crew of EA 66 knew there was bad weather ahead — it was visible on their on-board radar — but pressed on anyway. One hundred and twelve people were killed."

The U.S. National Transportation Safety Board (NTSB) determined the probable cause to be "the aircraft's encounter with adverse winds associated with a very strong thunderstorm located astride the ILS [instrument landing system] localizer course, which resulted in a high descent rate into the non-frangible approach light towers." Smith comments, "To most people in aviation, the NTSB is the final word, and the NTSB believed the cause of the accident to be 'adverse winds.' And it was — sort of."

But the probable cause was not the sort of adverse winds the NTSB had in mind, Smith says. Fujita, called in to investigate the Flight 66 crash, "conducted a detailed study of the 11 aircraft that landed safely ahead of EA 66. He studied the weather, the radar and flight paths, and he talked with the surviving crews."

That led to a new and unorthodox theory, described in a 1977 paper by Fujita and Horace Byers, describing a previously unknown weather phenomenon they called a downburst — "a rapidly sinking column of air that originated in a thunderstorm and then spread out, and accelerated when it reached the ground," Smith says. "As the air spread out, it could reach speeds of 70 mph [113 kph] or more. A pilot flying through the sinking air, with its rapid change in wind speeds and directions, would be severely challenged to keep control of the plane."

Other meteorologists were unconvinced or expressed outright disbelief. No one had seen or recorded such a downburst. Fujita persevered in his research and identified "a smaller, more intense form of downburst he named a 'microburst.' Yet even as Fujita's body of evidence grew, many in both the meteorological and aviation communities remained deeply skeptical."

Smith himself, along with a companion in "storm chasing," helped provide additional evidence in the form of what he describes as "the first microburst ever photographed," near Wichita, Kansas, U.S. The photo is included in the book.

"Downbursts were further confirmed by Project NIMROD (Northern Illinois Meteorological Research on Downbursts), conducted in the Chicago area around O'Hare International Airport," Smith says.

The Flight 66 accident helped motivate the U.S. Federal Aviation Administration (FAA) to begin installing the low level wind shear alert system (LLWAS) at U.S. airports.

The issue of downbursts and microbursts received renewed attention 10 years later with the fatal accident involving Delta Air Lines Flight 191 at Dallas/Fort Worth International Airport in August 1985.

Flight 191, a Lockheed L-1011, was on final approach. The cockpit voice recorder recorded the first officer, the pilot flying, saying, "Stuff is moving in." The captain, the monitoring pilot, radioed to the tower, "Delta One-Ninety-One heavy, out here in the rain. Feels good."

Smith says, "Now under the cloud base, the crew could see what appeared to be a light rain shower between them and the runway. Other planes were flying through the shower and landing normally. But once Delta 191 entered the rain shower, all hell broke loose." Soon the

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ground-proximity warning system was generating its "whoop whoop pull up" automated voice message. The captain called for a go-around, but it was too late to avert the accident. The aircraft touched down a mile short of the runway, bounced, touched down three more times, skidded, and struck a large water storage tank. The jet fuel ignited.

"The microburst, a phenomenon that many meteorologists said did not exist, had claimed another commercial jetliner and 137 lives," says Smith. He notes that airport weather instruments measured winds gusting to 100 mph (161 kph) at the eastern runways, while the west side runways were dry, with partial sunshine.

Once again, Fujita was invited to investigate the accident. Smith says, "Fujita himself flew over the airport, surveyed the on-site instrumentation from a cherry picker [boom lift], photographed the exact location of the anemometer [wind speed sensor] and wind vane, and collected every scrap of data he could. With Fujita, one never knew which type of data might turn out to be crucial.

"In addition to the data collected by the instrumentation at the airport, Fujita collected weather satellite imagery, radar data, eyewitness reports, and data from the cockpit voice recorder and flight data recorder. Once he had all of the data, he began to weave it into a coherent picture."

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As Smith describes it, the picture looked like this:

"As the L-1011 neared the north end of the runway, it gradually slowed and descended along the glideslope. When the plane initially encountered the microburst, the leading edge of the wind struck the aircraft. … Delta 191 encountered high winds and rising air. This increased the speed of the aircraft and lifted it above the descending trajectory it was supposed to follow.

"This is where the insidious nature of the microburst presents itself. Almost instantly, the plane went from being too high to nose-diving toward the ground. As it reached the south half of the microburst, the wind direction shifted from out of the south (a headwind) to the north (a tailwind), causing an instant drop in airspeed and even more sink."

The book devotes a chapter about the controversy — including a lawsuit brought by the captain's widow against the FAA and the National Weather Service (NWS) — to why Flight 191 was flying an approach in a thunderstorm at all when "just about everyone on the east side of the airport — traffic controllers, pilots preparing to take off, the crew of Delta 191 and the airport weather observer — had all seen the storm."

The NWS was legally charged with the responsibility for providing weather information to the FAA, which in turn passed it on to controllers and pilots. Smith says that the hand-off worked better in theory than in practice at the time.

National weather radar charts were sent from Kansas City, Missouri, but were not received by airports or air traffic controllers until nearly an hour after the radar observations had been made, a delay that can be like a century for aviation purposes. Local NWS radar facilities were often located not only outside airports, but outside the cities they served, to provide better advance warning of approaching storms and reduce clutter on the radar screens. The NWS radar for the Dallas–Fort Worth area was in Stephenville, about 50 mi (80 km) from the airport.

"The data from that radar [were] fed to two NWS facilities in Fort Worth: the Fort Worth forecast office, located in the federal building downtown, and the NWS Center Weather Service Unit (CWSU) inside the FAA's air route traffic control center near the Dallas/Fort Worth airport," Smith says.

Among other problems, "the NWS radar technician in Stephenville was at dinner, away from the radar console, when the microburst-producing thunderstorm developed just north of Dallas/Fort Worth International [Airport]. Right after he finished eating, he helped launch the evening weather balloon, leaving the radar still unmanned. He did not return to the radar until 6:00 p.m. At 6:04, two minutes before the crash, he telephoned the Fort Worth downtown office to inform it of the storm near the airport. The 6:04 p.m. call came too late to allow a warning to have been issued because … it took the NWS office six to 10 minutes to prepare an aviation weather warning for the Dallas/Fort Worth control tower."

In short, "there was … no real mechanism to *instantly* convey a threat directly to aircraft," Smith says. "This faulty system is one that continues, to some extent, even today."

But progress has been made in mitigating the danger from microbursts and wind shear. "The NWS, recognizing that the split radar/warning responsibility contributed to some of the worst failures in its history, changed its entire forecast structure in the 1990s so that radar data and warning responsibility were co-located 100 percent of the time," Smith says. "Much follow-on work based around Fujita's research began in order to train pilots how to avoid microbursts, and if they were to inadvertently fly into microburst wind shear, how to escape it (if possible)."

The FAA contracted with an industry advisory group to create the *Windshear Training Aid* and established wind shear training requirements for U.S. Federal Aviation Regulations Part 121 and Part 135 operators.

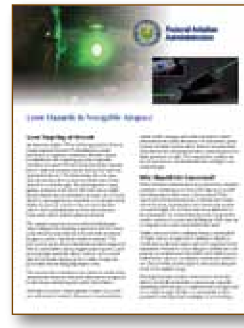
The last crash attributed to a microburst was U.S. Airways Flight 1016 at Charlotte, North Carolina, U.S., in July 1994. Smith says, "Given the ever-increasing number of people and planes in the air, the number of lives saved due to Fujita's pioneering research that eventually led to implementation of microburst avoidance procedures in the United States is well over 2,000, not to mention the hundreds of millions of dollars of aircraft losses prevented."

REPORTS

Look Away

Laser Hazards in Navigable Airspace

U.S. Federal Aviation Administration (FAA) Civil Aerospace Medical Institute (CAMI). AM-400-10/3. Available from CAMI, Shipping Clerk, AAM-400, P.O. Box 25082, Oklahoma City, OK 73125 U.S.A. Also available via the Internet at <www.faa.gov/pilots/safety/pilotsafetybrochures/media/laser_hazards_web.pdf>. 2010.



The FAA has recorded more than 3,000 reports of aircraft targeted by laser beams. While aeromedical researchers work to understand the physiological aspects of laser beams on vision (*ASW*, 12/10–1/11, p. 50), CAMI has issued this brochure to explain the nature of the threat to pilots and recommend actions to minimize the effects of a laser beam striking the cockpit.

Among the recommendations are these:

- "When operating in a known or suspected laser environment, the non-flying pilot should be prepared to take control of the aircraft";
- "Check aircraft configuration and (if available) consider engaging the autopilot to maintain the established flight path";
- "Use the fuselage of the aircraft to block the laser beam by climbing or turning away";
- "Inform Air Traffic Control of the situation. Include location/direction of the beam, your present location, altitude, etc."; and,
- "Turn up the cockpit lights to minimize any further illumination effects."