Wind Shear: Has It Been Tamed?

Learning from **seventy years of experience**

BY **JAMES ALBRIGHT** james@code7700.com

Years ago, pilots were a bit self-deluding when it came to wind shear. Many didn't even recognize it as a problem and chalked up the occasional loss of an airplane to pilots who didn't quite have what it takes. However, that changed on June 24, 1975, when wind shear brought down Eastern Air Lines Flight 66, a Boeing 727, during an approach to New York's JFK International Airport. Six crew and 106 passengers were killed.

There had been plenty of evidence of wind shear's existence and power prior to this mishap, but that was the one that got the attention of the entire pilot community.

Now, four decades later, we have better procedures, airborne and ground-based detection systems, and six-axis simulators to test our mettle. You hardly hear of a wind-shear disaster anymore. So, the battle is won and it is at long last time to celebrate our victory. Or is it? Perhaps our foe is due a bit more respect.

The Flight Safety Foundation has cataloged 87 occurrences of wind shear and downdrafts resulting in mishaps to airliner, military transport category and business jet aircraft between 1943 and early 2015. The term "wind shear" wasn't used in any of these accident reports until 1953, and even then only sporadically. "Severe downdraft," "divergent winds" or a "sudden reversal of wind" were more often cited as causal. This lack of understanding makes analyzing the statistics appear to be fruitless, but there are trends hidden in the numbers.

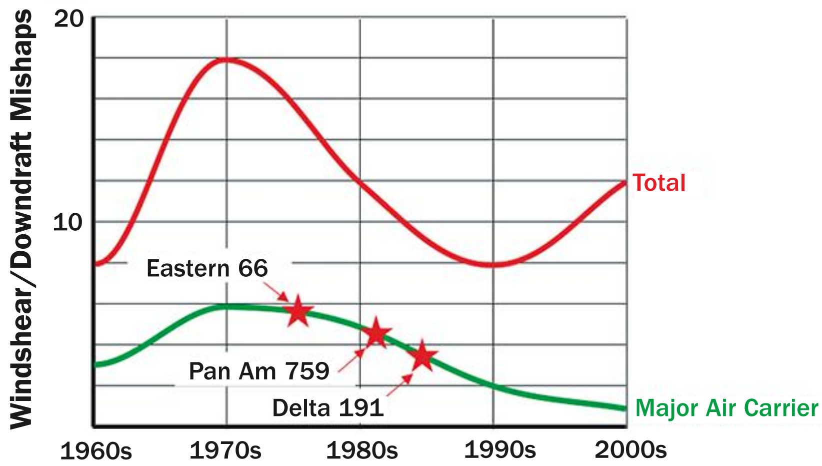
By isolating the data starting in 1960 and ending with 2009, we can look for trends by decade. The rate appears to go up through the 1970s, in keeping with the general rise in commercial airline traffic, but it goes down and up again. The rate among major air carriers, however, peaks in the 1970s and has continued to decline through the present day. Why are major air carriers apparently doing better than the rest of the aviation community?

The answer to this question is important because it will help us to realize what tactics have worked and should be further emphasized, and it will point the way for those segments of the aviation world that still have work to do.

One of the obvious advantages to being a major air carrier is having a revenue stream and impetus to invest in new technology that ensures passenger safety and that flight schedules are met. Accordingly, they were early adopters of inertial navigation systems, which gave their pilots real-time wind and ground

A320 crosswind landing at San Jose, Costa Rica

BERNAL SABORIO



Wind shear/downdraft mishaps, 1960s to 2000s. Data extracted from Flight Safety Foundation statistics.

speed indications. Pilots no longer had to guess about the differences in winds along the approach and those on the runway. They also adopted high-resolution, color weather radar that could detect contours in rainfall to reveal the danger that lurked within the clouds ahead. Many aircraft these days are equipped with inertial and GPS-based wind-shear detection systems that not only promise to identify an impending wind shear but also provide pilots with pitch cues to escape wind shear once encountered.

These major air carrier pilots were also frequent flyers to larger airports where Low-Level Wind-shear Alert Systems (LLWAS) and Terminal Doppler Weather Radar (TDWR) systems provided automated warnings. These ground and airborne systems have made a significant difference in wind-shear detection and avoidance. But they are not a panacea.

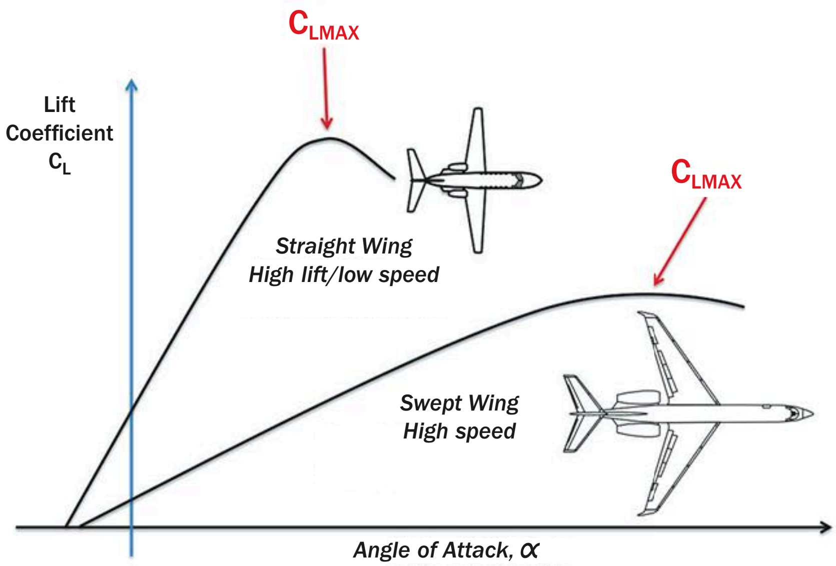
Airborne systems still suffer from frequent false positives; that is, they generate wind-shear alerts for conditions that are either nothing more than gusty winds, or are easily within the airplane's capability. Like the boy who cried wolf too many times, these systems can easily become a part of the background noise pilots tend to ignore.

Ground-based systems are improving but continue to miss frontal- and microburst-generated wind shears. Accident reports continue to warn that these systems do not always detect shears at altitude, beyond their physical locations, or when generated at perimeter and central sensors simultaneously.

Sometimes the best detection system is the airplane ahead of yours. But PIREPs are also subject to false positives. What the Piper Tomahawk pilot calls wind shear may be nothing more than a hiccup in the glideslope to the crew of a following Bombardier Global Express. But it could be more.

None of this will be of any use unless pilots are willing to take action when alerted.

The crew of Eastern Flight 66 had several warnings when arriving for the ILS to JFK's Runway 22L. Another Eastern flight had just gone missed approach and notified approach control about "a pretty good shear pulling us to the right and down." The crew of Flight 66 heard this and thought it was nothing more than the preceding crew making excuses for going missed. Meanwhile, a Flying Tiger DC-8 crew that had just landed pleaded with ground control to change the landing runway. Ground control did not act



Lift coeffieient, straight- versus swept-wing aircraft.

on the request; their instruments told them the winds were only 15 kt. and straight down the runway.

False positives, failed detections and oblivious crews are with us still. But now many companies have in place better procedures that require wind shear to be avoided once detected, and better procedures to follow when it is encountered.

Better Procedures

Early on, the response to almost any wind-shear encounter was confused and the pilots' priorities were unclear. Generally, the aviation community underestimated the danger and failed to respect the phenomon's true power and unforgiving nature. We did not realize that a wind shear, especially one associated with a microburst, could overpower any airplane.

On July 9, 1982 — seven years after the Eastern Flight 66 crash —Pan American World Airways Flight 759 was departing New Orleans International Airport. While the day had begun VFR with calm winds, as the Pan Am 727 taxied to the active, the winds picked up to 8 kt. in just 4 min., and 3 min. later to 17 kt. gusting to 23. Ground control advised the crew that "we have low-level wind-shear alerts all quadrants. Appears to be a frontal passing overhead right now. We're in the middle of everything."

Regardless, the pilots proceeded and took off from Runway 10. The Boeing reached an altitude of about 100 ft. when it encountered a microburst, which slammed it into a residential area, killing all 145 people on board and another eight on the ground. The tragedy was later compounded by a statement buried in the NTSB's report: "The captain's decision to take off was reasonable in light of the information that was available to him."

We now know better. Any pilot who doesn't understand the prime directive when it comes to wind shear — avoidance — should consider a new line of work. Advisory Circular 00-54, Pilot Wind-shear Guide, provides several clues for wind-shear detection and procedures on how to escape wind shear if encountered. While these procedures are very good and can be lifesavers, aircraft manufacturers may provide additional guidance.

Gulfstream, for example, directs G450/550 pilots to disconnect the autopilot, apply power to the mechanical forward limit, rotate 3 to 4 deg. per second to increase pitch so as to intercept VREF — 20 KCAS. Some models of the Dassault Falcon 2000EX EASy and Global Express BD-700 have the flight director programmed to command the proper wind-shear escape maneuver.

You cannot assume the wind-shear escape procedures for one airplane will work for another. The wing sweep, for example, will determine just how much lift is available once stall warning occurs. Highly swept wings continue to produce lift even as stall speed is reached, while straight wings have very little lift left over.

Many operators dismiss memory items, what used to be called "BOLDFACE" in some circles, as too dependent on pilot ability. Case study after case study shows that a moment of hesitation can turn a survivable wind-shear encounter into a catastrophe. Wind-shear escape procedures must be memorized and practiced in a simulator until they can be executed flawlessly.

Better Training

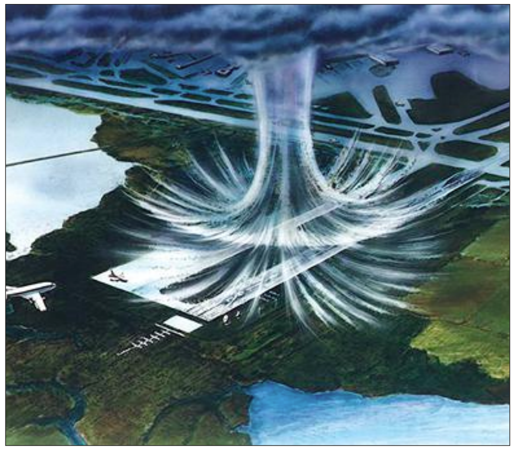
Early attempts at simulator wind-shear training were easily cheated by those in the box. Pilots learned to fly the airplane into ground effect until physically outside of a pre-programmed wind-shear zone and walk away with an unblemished record and very little learned. Even today, some pilots have memorized wind-shear profiles and can anticipate the shear before it happens. All of these pilots are missing the point.

We spend all of our operational flight hours attempting to provide a very comfortable ride utilizing the MAX setting on our internal smoothness muscles. We try very hard to provide an illusion to those sitting behind us, an illusion that belies the fact they are flying in a hollow aluminum tube through the weather and darkness at eight-tenths the speed of sound as if it were the most natural thing to be doing. The purpose of wind-shear training is to break all these habit patterns and program into our muscle memory the need to apply maximum power and pitch at a moment's notice. The practice needs to be under supervision to ensure the procedures are correct for the aircraft being flown.

Ten years after Eastern Flight 66's crash, the crew of Delta Air Lines Flight 191 missed a few steps in the wind-shear avoidance part of the prime directive. They could have been forgiven, initially. A string of airplanes preceded them into Dallas/Fort Worth International Airport by just a few minutes. Two aircraft even called the nearby thunderstorm cell "harmless." The cell, however, was moving and by the time Flight 191 was on approach, it was parked right on final.

Had the crew of Flight 191 used their radar, they would have noticed the cell not only moved in front of them but also that it had intensified. Unaware of its true danger, they flew directly into a cumulonimbus cloud that they observed was producing visible lightning.

Once in the cloud, their airplane was subjected to a 40-fps downdraft followed by a 10-fps updraft. The pilot flying applied maximum thrust and pitched up



An artist's depiction of a microburst.

NASA

the airplane to satisfy the flight director's go-around command, which in this airplane was not programmed for wind shears. Investigators surmised that the pilot's actions would have been sufficient to escape the wind shear except for what happened next. With the nose pitched up the stick shaker activated and the pilot flying pushed the nose over. Of the 163 persons on board, 134 perished along with another on the ground.

More Work to Be Done

We have come a long way in our battle against wind shear, but the war continues. On Dec. 20, 2008 — or more than 30 years after the crash of Eastern Flight 66 — a Continental Airlines Boeing 737 was destroyed while attempting to take off from Denver International Airport because of failures in detection equipment, procedures and training.

The crash of Continental Flight 1404 was not classified as a wind-shear mishap because the gusty crosswind could have been accommodated had the captain been better trained to handle strong crosswinds. But he would have been more prepared if he and the tower controllers had a better understanding of what information was available to them from the installed LLWAS. An examination of the data produced by the 32 remote sensors revealed a variety of wind conditions from varying directions and speeds. Armed with this knowledge the captain's decision may have very well been to wait before attempting the takeoff. While no one was killed in the departure accident, the captain and five of the 110 passengers on board suffered serious injuries and the Boeing was heavily damaged.

In 2011, I was flying a Gulfstream 450 from the West Coast to Bedford, Massachusetts, with my company's top-three executives. They were happy to conclude a successful trip and eager to return to our hangar at Hanscom Field where their cars were ready to take them home for the weekend. Capt. Justin Serbent and I had our eye on a weather system developing just south of the airport. It was moving slowly to the north and threatened to graze the BED traffic area. The accompanying photo is taken at 24,000 ft., about 100 miles west of the field. It looked like our timing would be perfect.

As we set up for the landing to Runway 29, about 8 mi. to the east, our radar showed the outer edges of the system were still about 3 mi. to the west. The airport was still VFR, the winds were light and there were no wind-shear alerts. The Learjet in front of us landed. Looking at the smaller airplane roll out against the backdrop of the towering thunderstorm, I thought that if we had to go missed approach for any reason, we would be in trouble. Even without a go-around, the conditions were ripe for wind shear. As if reading my mind, Serbent said, "I'd rather be at Logan."

"Me, too," I responded. Ten minutes later we were on the ground at Boston's Logan International Airport and our dispatcher immediately found a limousine ready to drive our passengers the 20 mi. back to Bedford. As the passengers got off the airplane, each stopped to thank us. That we had inconvenienced them there is no doubt. But left unsaid was the fact we got them on the ground safely, another case of wind shear avoided. It wasn't until that evening that we learned that much of the state had been savaged by tornadoes. It was time to stand up and take a bow.

We need to do more of that. Instead of commiserating ourselves for failing to complete the Point A to Point B mission, we need to celebrate the fact we had planned for a Point C. Wind shear is a formidable adversary worthy of respect. Victories do not come from successfully flying through wind shear. They come from avoiding wind shear in the first place. Celebrate! B&CA

Radar display and view from the pilot's seat of a thunderstorm approaching the Boston area, June 2011.