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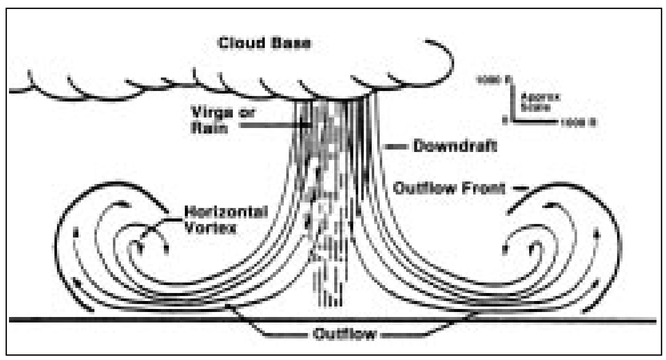
Improved Microburst Warnings Aim for Safer Terminal Operations

New technology and techniques are being tested in continuing efforts to reduce takeoff and landing accidents caused by localized downdrafts.

National Center for Atmospheric Research

Low-altitude windshear has caused more U.S. air carrier accidents than any other weather hazard. Since 1964 there have been approximately 650 passenger fatalities in 35 aircraft accidents directly attributed to windshear. The most recent U.S. windshear-caused accident was the crash of Delta Airlines Flight 191 on August 2, 1985. Flight 191 encountered a severe form of low-level windshear — a microburst — during landing at Dallas-Fort Worth Airport, and 137 lives were lost. Last year, the crash of Cubana de Aviacion Flight 3046 during takeoff from Havana, Cuba, on September 3 killed 115 passengers and crew and 24 people on the ground. Evidence strongly suggests that a severe thunderstorm-induced microburst encounter led to the crash.

Microbursts, the most hazardous and sometimes deadly form of windshear, are produced by powerful, small-scale downdrafts of cold, heavy air that can occur beneath thunderstorms or even benign-looking cumulus clouds. As the intense downdraft hits the earth's surface, it spreads horizontally, much like the water from a garden hose blasting straight down onto concrete. Aircraft flying through a microburst at low altitude (during takeoff or landing) experience a strong headwind, then a downdraft, and finally a tailwind that produces an immediate, sharp airspeed reduction and loss of lift. Severe turbulence often accompanies microbursts. The resulting loss of aircraft performance can be deadly.



Schematic diagram of microburst formation in dry climate. The downdraft development of wet-climate microbursts is forced by heavy precipitation loading rather than by evaporative cooling (FAA, 1987).

TDWR and LLWAS

Since the mid-1980s, the U.S Federal Aviation Administration (FAA) has worked with several organizations, including the National Center for Atmospheric Research and the Massachusetts Institute of Technology Lincoln Laboratory, to develop a windshear detection and warning system. The Low-Level Windshear Alert System (LLWAS), originally developed in 1976 as an airport six-station wind-sensing system, has been upgraded recently at Stapleton International Airport, Denver, Colo., U.S., to a more sophisticated 16-station LLWAS. The Terminal Doppler Weather Radar (TDWR), which utilizes the wind-measuring capabilities of a remote Doppler radar to detect airport-threatening microbursts, has been developed and refined. During the summers of 1987, 1988, and 1989, these two systems were operationally tested at Stapleton. In 1989, the systems were integrated with the goal of disseminating easily understood information from the combined system to FAA controllers and supervisors.

Map indicating preliminary placement of 47 TDWRs in the contiguous United States.

Based on the success of the Stapleton prototype TDWR, the FAA has ordered 47 TDWRs and plans to install them at high-risk airports beginning in 1993.

How It Works

TDWR and LLWAS information on microbursts, gust fronts, wind shift prediction, and precipitation is sent via a 56-kilobaud line from the Doppler radar and the operations center (located with the Research Applications Program, National Center for Atmospheric Research, NCAR, Boulder, Colo., U.S.) to the Stapleton control tower and terminal radar approach control (TRACON). The information is automatically displayed to air traffic controllers and supervisors for air traffic management decision making.

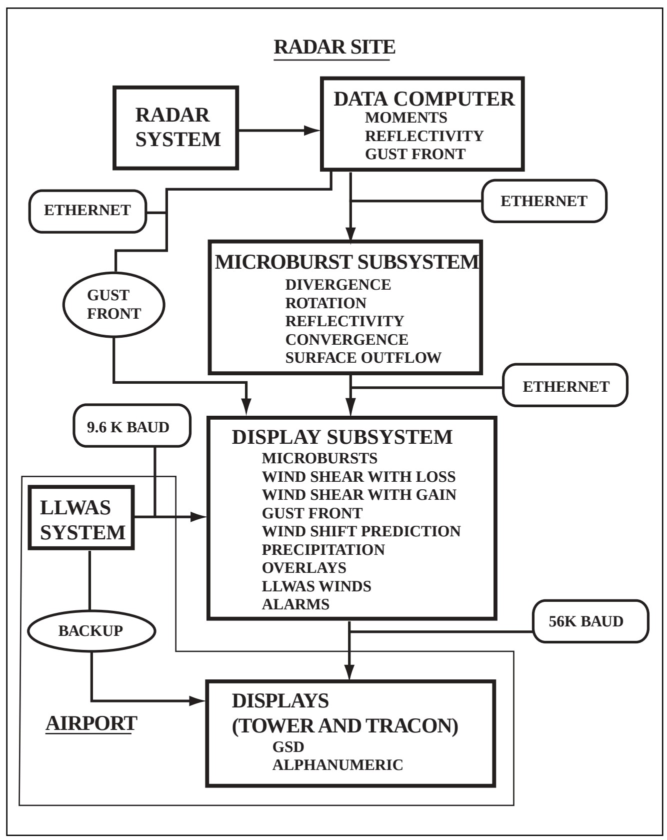
An alphanumeric display is designed to easily relay microburst and windshear information to pilots landing and departing. The accompanying figure is an example of an alphanumeric display at Stapleton. A pilot landing on Runway 26 would receive the following information from air traffic control:

"Flight 236, microburst alert, five zero knot loss, one mile final"

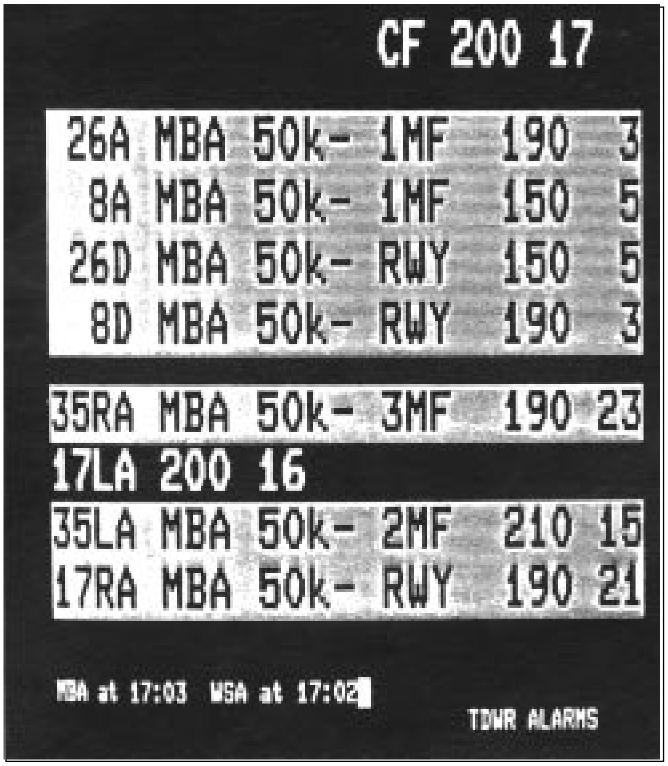
The geographic situation display (GSD), located at the operations center and the tower, is designed for ease of operation. It displays the four products overlaid on the runway configuration and the 16 wind-sensing stations. For example, a microburst forming over Runway 26A will be depicted by a bright red bandaid shape that is impossible to miss visually; an alarm sounds in the tower, also.

Pilot Windshear Warning Messages

Pilots Operating into and out of Stapleton this summer (as well as Orlando, Florida, where a similar test is being conducted by MIT Lincoln Laboratory) should expect two types of alert message: a windshear alert will be given for windshear expected to produce a headwind gain



Schematic of the TDWR system data and information flow from the radar to the displays in the tower and TRACON.



The alphanumeric display from which controllers read windshear warning messages to pilots. Runways affected by the windshear are highlighted.

of 15 knots or more or a headwind loss between 15 and 30 knots. A microburst alert will be issued for windshear expected to produce a headwind loss of 30 knots or more. The wind speed change is the maximum expected, and the location is where on the runway the event is likely to be first encountered. The airspace is divided into windshear warning boxes that are 1 nm square along the approach and departure paths: 1/2 nm on both sides of the extended runway centerline, 3 nm on the approach end of the runway, and 2 nm on the departure end of the runway. An alarm is issued whenever a windshear event, as defined above, impacts one of these warning boxes.

Saving Lives is the Goal

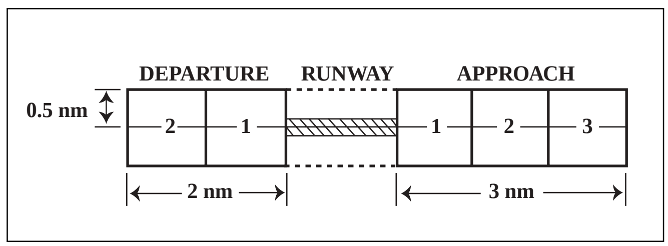
The TDWR system at Stapleton saves lives. On July 11, 1988, a severe, 80-knot loss microburst over the runway was detected by TDWR while five air carrier jet transports were in various approach locations. Because most airline crews were given guidance to avoid microbursts, the first pilot avoided the microburst totally, and the remaining four executed missed approaches through the microburst. Some ambiguity in the warning message, "Microburst alert … cleared to land," was noted. Flight crews currently have clear guidance from the airlines to avoid microburst events.

On July 8, 1989, the enhanced 16-station LLWAS detected a very dry environment microburst with a 95-knot loss. The pilot of an incoming aircraft, after being cleared to land, heard three microburst alerts and executed a missed approach at approximately 600 feet agl. The controller, who queried adjacent flights for windshear reports, exercised good judgment, as did the flight crew when they made an avoidance decision.

Interestingly, on September 2, 1989, the integrated TDWR/LLWAS detected a 30-knot loss microburst and an approaching flight crew received a microburst alert, but the captain elected to continue his approach, even though he was directly asked by the controller if he wanted to continue the approach. The flight landed with major difficulty and the five-G landing cause structural damage.

Say Intentions

During this summer at Stapleton, it is hoped FAA standard operating procedures will eliminate the ambiguity of the microburst alert message. Improved safety will be emphasized. Controllers will continue to issue a "cleared to land" windshear alert message, as appropriate, but microburst alert messages will replace the "cleared to land' phrase with "SAY INTENTIONS." For example:



Windshear warning boxes showing airspace where aircraft susceptible to low-altitude windshear.

"Flight 236, microburst alert, five zero knot loss, one mile final, SAY INTENTIONS."

It is critical that flight crews and air traffic control personnel understand the lethal microburst phenomenon as it impacts aircraft operations. Controllers are becoming sensitive to pilots' needs for making time-critical decisions in the presence of hazardous weather. The TDWR and LLWAS operational tests at Stapleton have been technically successful. With continued user training and feedback, the TDWR deployment will truly enhance the safety of the aviation system. Microburst events clearly represent a hazard to be avoided. ♦

References

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