NASA Facts

National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia 23665-5225

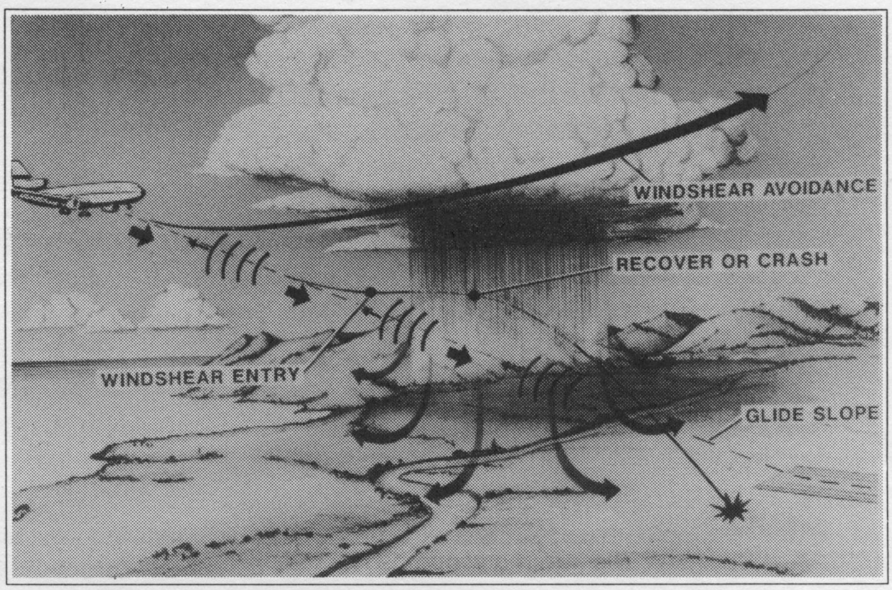
INSIDE

- The three types of windshear sensors.
- What the FAA says airlines must do, and when.

NF176 - June 1992

Making the skies safe from windshear

Langley-developed sensors will help improve air safety



This artist's sketch shows how windshear affects an aircraft. The downbursts are a danger to planes primarily during takeoff and landing.

NASA's Langley Research Center is part of a joint NASA and Federal Aviation Administration (FAA) effort to develop technology for the airborne detection of windshear, a hazardous weather condition that has been blamed for the loss of hundreds of lives in airplane crashes.

■ Reducing danger: studies now in flight-test stage

Windshear studies at Langley started in 1986 with analysis, moved to simulation and now are in the flight-test stage. This effort was prompted by fatal accidents in New York in 1975, New Orleans in 1982 and Dallas-Fort Worth in 1985. About 500 fatalities and 200 injuries have resulted from windshear crashes involving at least 26 civil aircraft between 1964 and 1985. Since 1985, windshear also has caused numerous near accidents in which aircraft recovered just before ground contact.

■ Windshear and how it affects an airplane

Windshear is a generic term referring to any rapidly changing wind currents. A type of weather phenomenon called "microbursts" can produce extremely strong windshear, posing great danger to aircraft. These are local, short-lived downdrafts that radiate outward as they rush toward the ground. As a downdraft spreads down and outward from a cloud, it creates an increasing headwind over the wings of an oncoming aircraft. This headwind causes a sudden leap in airspeed, and the plane lifts. If the pilots are unaware that this speed increase is caused by windshear, they are likely to react by reducing engine power. However, as the plane passes through the shear, the wind quickly becomes a downdraft and then a tailwind. This reduces the speed of air over the wings, and the extra lift and speed vanish. Because the plane is now flying on reduced power, it is vulnerable to sudden loss of airspeed and altitude. The pilots may be able to escape the microburst by adding power to the engines. But if the shear is strong enough, they may be forced to crash.


The cockpit of Langley's 737 research aircraft displays windshear data prior to penetrating a microburst.

■ Greatest danger: Takeoff and landing

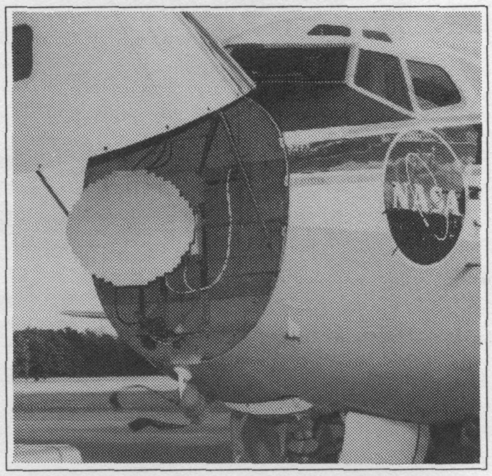
Windshear poses the greatest danger to aircraft during takeoff and landing, when the plane is close to the ground and has little time or room to maneuver. During landing, the pilot has already reduced engine power and may not have time to increase speed enough to escape the downdraft. During takeoff, an aircraft is near stall speed and thus is very vulnerable to windshear.

■ "Wet" and "dry" windshear

Microburst windshear often occurs during thunderstorms. But it can also arise in the absence of rain near the ground. Some of the sensor systems that Langley is flight testing work better in rain, while others perform more successfully during dry conditions.

■ Three airborne predictive windshear sensor systems

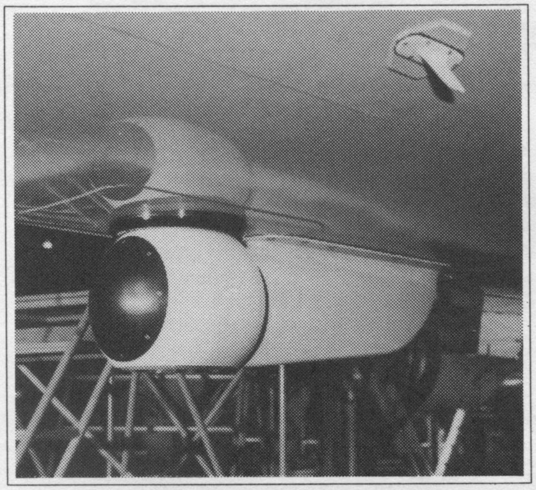
Pilots need 10 to 40 seconds of warning to avoid windshear. Fewer than 10 seconds is not enough time to react, while more than 40 is too long—atmospheric conditions can change in that time. Three systems are being flight-tested to give advance warning of windshear:



The microwave radar sensor is in the nose of the 737.

Microwave radar: Sends a microwave radar signal ahead of the aircraft to seek raindrops and other moisture particles. The returning signal represents the motion of those raindrops and moisture particles, and this is translated into wind speed. Microwave radar works better than other systems in rain but less well in dry conditions. Because it points toward the ground as the plane lands, it picks up interfering ground returns, or "clutter." However, researchers are progressing in efforts to eliminate this interference. The radar transmitter is made by Rockwell International's Collins Air Transport division in Cedar Rapids, Iowa. NASA's Langley Research Center has developed the research signal-processing algorithms and hardware for the windshear application.

Doppler LIDAR: A laser system called Doppler LIDAR (light detecting and ranging) reflects energy from "aerosols" (minute particles) instead of raindrops. This system can avoid picking up ground clutter—

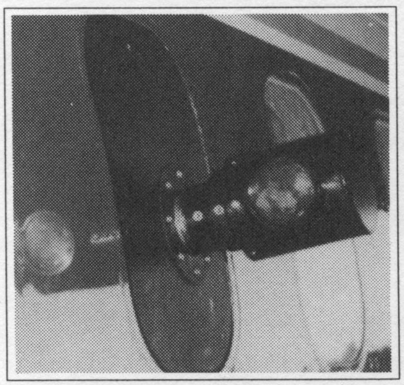


The LIDAR sensor is mounted in the belly of the 737 research aircraft.

moving cars, etc.—and thus has fewer interfering signals. However, it does not work as well in heavy rain. The system is made by Lockheed Corp.'s Missiles and Space Co., Sunnyvale, Calif.; United Technologies Optical Systems Inc., West Palm Beach, Fla.; and Lassen Research, Chico, Calif.

Infrared: Uses an infrared detector to measure temperature changes ahead of the airplane. The system monitors the thermal signatures of carbon dioxide to look for cool columns of air, which can be a characteristic of microbursts. This system is less costly and not as complex as others, but does not directly measure wind speeds. This system is made by Turbulence Prediction Systems in Denver, Colo.

■ Windshear-alert systems using ground-based radar



The infrared sensor is located on the side of the 737.

A Low-Level Wind-Shear Alert System has been installed on the ground at more than 100 U.S. airports. Wind speed and directional sensors report to a central computer, and controllers can alert pilots in the event windshear is detected. But the systems cannot predict when windshears are approaching. However, a ground-based radar (Terminal Doppler Weather Radar) system has been tested at Orlando, Fla., and Denver Stapleton airports and is scheduled to be stationed at more than 40 other airports by mid-1994. Even with such systems installed, however, airborne detection will still be needed because windshear is a global phenomenon—and most airports will not have predictive, ground-based systems installed.

■ FAA mandate: Airlines must install windshear sensors

In 1988 the FAA directed that all commercial aircraft must have onboard windshear detection systems by the end of 1993. Three—American, Northwest and Continental—received exemptions until the end of 1995 in order to install and test predictive windshear sensors rather than "reactive" systems that do not report the condition until an airplane already has encountered it.

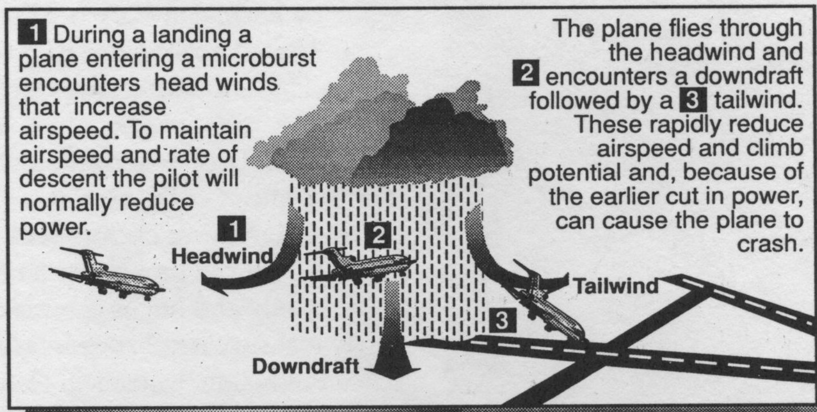
■ NASA and the FAA: Working together for a solution

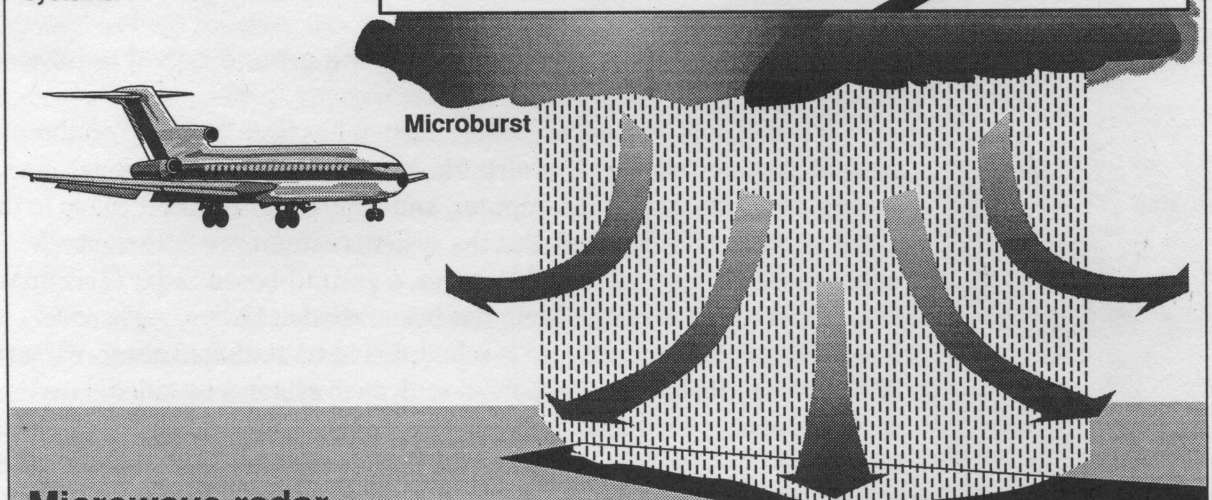
Langley's flight tests are the most recent step in a government/industry effort to produce a database on microbursts and detection systems. The effort began in 1986, when NASA and the Federal Aviation Administration (FAA) agreed to work together to develop methods of detecting and avoiding hazardous windshear. The NASA/FAA joint effort is a response to congressional directives and National Transportation Safety Board (NTSB) recommendations following documentation of numerous windshear accidents. The FAA created a flight safety program and supported NASA development of windshear detection technologies. The data gathered from analyses, simulations, laboratory tests and flight tests will help the FAA certify predictive windshear detection systems for installation on all commercial aircraft.

MAKING THE SKIES SAFE FROM WINDSHEAR

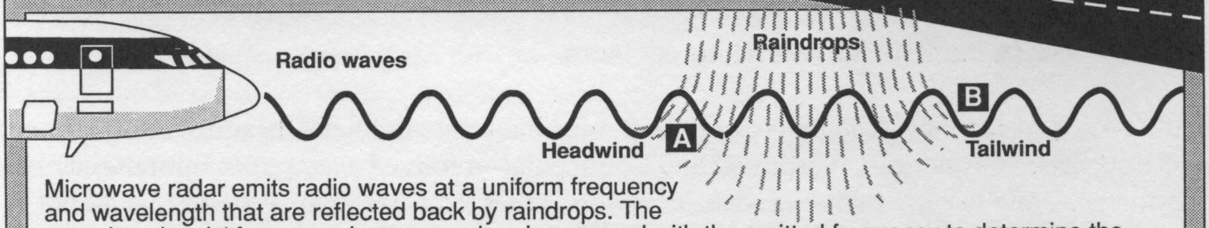
Onboard windshear warning systems

A microburst is a weather pattern that can create windshear. This condition has been linked to commercial plane crashes, especially during takeoffs and landings. Researchers feel that a 15- to 40-second warning will allow pilots to deal with this hazard. NASA Langley and the FAA are working on a variety of airborne detection and early warning systems. They include onboard microwave radar, infrared and LIDAR systems.





Microwave radar



Microwave radar emits radio waves at a uniform frequency and wavelength that are reflected back by raindrops. The returning signals' frequency is measured and compared with the emitted frequency to determine the direction and speed of the raindrops. A Doppler reading of varying wavelengths can indicate a wind shear condition.

A 

The raindrops borne by headwinds return a shorter wavelength.

B 

The raindrops borne by tailwinds return a longer wavelength.

Infrared

A small, relatively inexpensive system used to measure infrared radiation, which we feel as heat. A sensor measures the changes in temperature in front of a plane. These changes can be an indication of wind gusts. The sensor would activate a warning light in the cockpit.

LIDAR

LIDAR, short for Light Detecting and Ranging, uses light waves in the form of a laser beam much like Doppler radar uses radio waves. Instead of measuring the speed of raindrops, it measures the speed of aerosols and dust particles in the atmosphere to detect changes in the wind.

Sources: NASA Langley, KRTN, Chicago Tribune, Daily Press