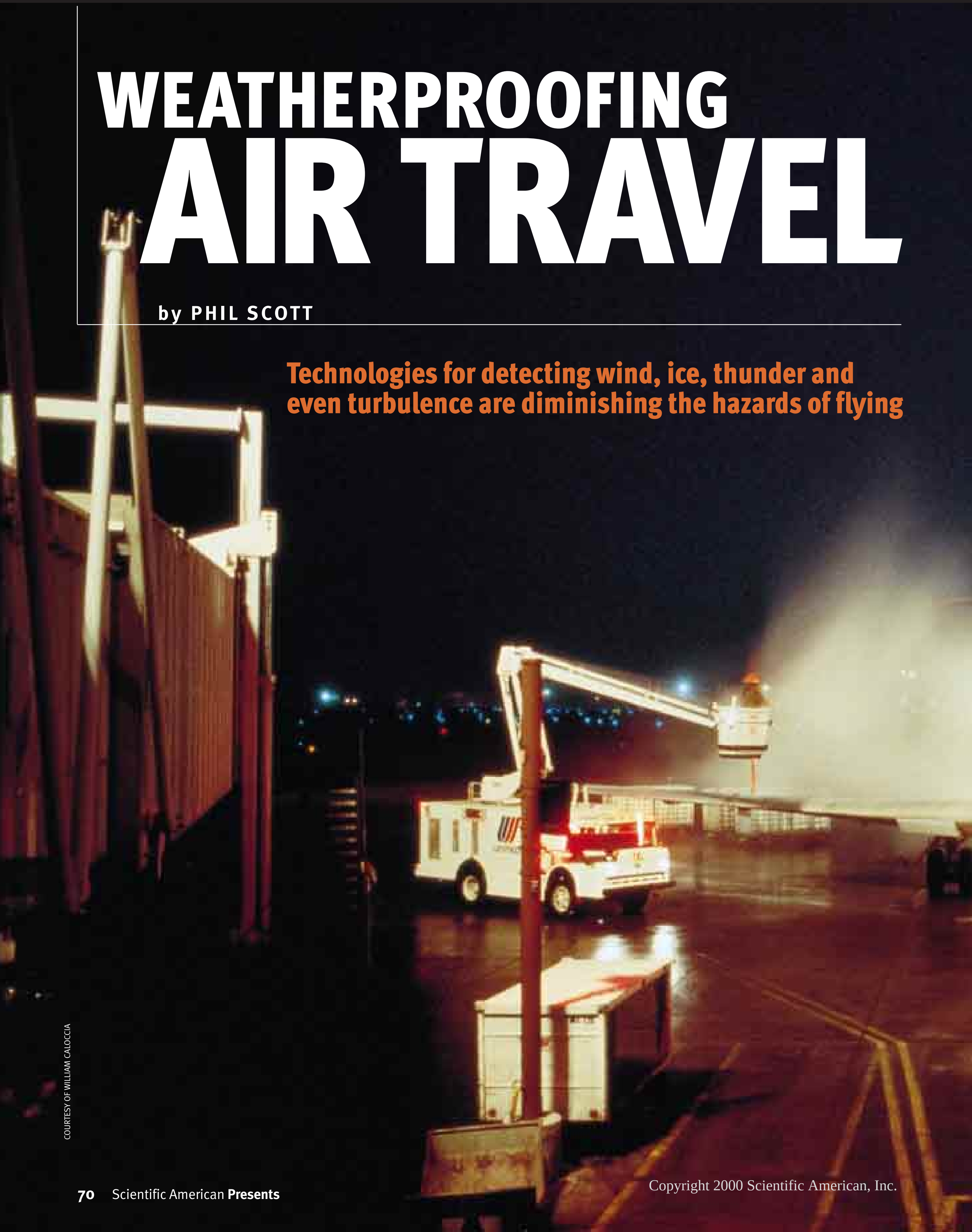
WEATHERPROOFING AIR TRAVEL

by PHIL SCOTT

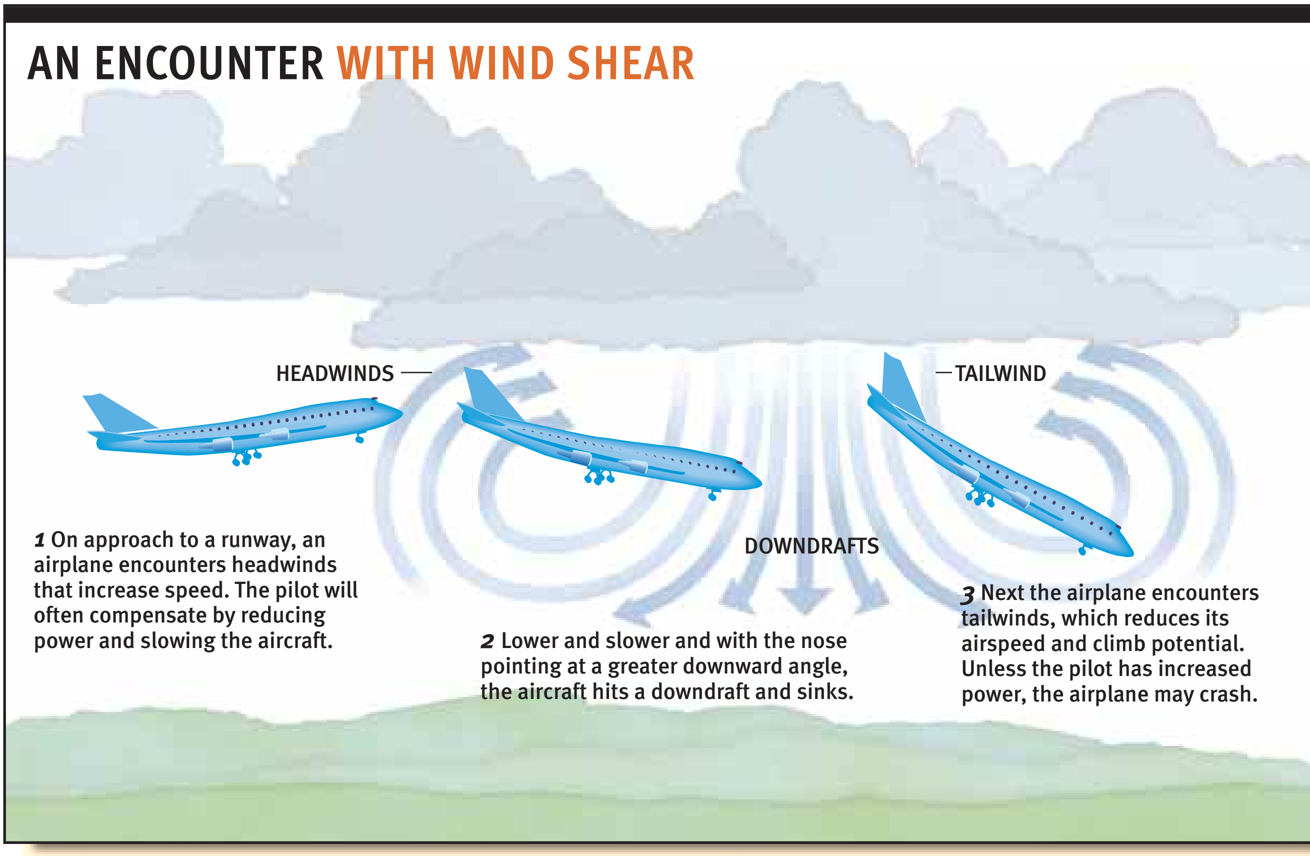
Technologies for detecting wind, ice, thunder and even turbulence are diminishing the hazards of flying



COURTESY OF WILLIAM CALOCCIA

The modern commercial airliner is a symbol of sleek modernity, an emblem of our success in conquering the elements. Yet few commonplace human endeavors place people so thoroughly at the mercy of nature quite like aviation does. In fact, 26 percent of commercial airline accidents and almost 20 percent of all general aviation—small aircraft—accidents list weather as a contributing factor. Weather also helps lead to flight delays and wreaks unexpected havoc with the hub-and-spoke system, which flies travelers into a central

RITE OF WINTER: Deicing with a solution of antifreeze prevents ice accretion that can change the shape of the wing and rob the aircraft of the necessary aerodynamic lift on takeoff.



port to change planes. A storm in Atlanta can delay flights out of San Francisco. And with air traffic scheduled to increase by nearly 50 percent over the next decade, smooth flow of flights will rely on weather and modern forecasting.

In aviation, however, an unfortunate, oft-cited aphorism preaches that it takes a major accident to spur the government to improve the system. "It's called tombstone technology," explains John McCarthy, a meteorologist at the National Center for Atmospheric Research (NCAR) in Boulder, Colo. NCAR works with the Federal Aviation Administration (FAA), the National Weather Service (NWS), research universities and private enterprise to push aviation weather forecasting to new limits. And over the past three decades McCarthy has often been in the middle of such efforts. "We have an old maxim in the aviation weather business that weather is not a big problem until it is a big problem," he adds.

Numerous accidents have demonstrated how existing technology—which provides nationwide forecasts around the clock—needs improvement. Pilots confronted by severe weather up ahead might make better decisions if they knew what was likely to happen during the next half an hour. Traditional forecasting predicts up to 36 hours ahead, but greater accuracy is required over short spans of an hour or less. To provide nearly immediate weather information, the FAA and government and university researchers are developing "nowcasting" techniques that can predict whether a thunderstorm is likely within the next 30 minutes. Called the Integrated Terminal Weather System (ITWS), it uses information from GOES weather satellites, NEXRAD radar and NWS computer model data to make its predictions.

Four prototypes are up and running, and the first production version will be available to air traffic controllers in 2001 or 2002. Simultaneously, another research team is working on enhancing the ITWS by extending the prediction out to one hour. "One hour turns out to be a very big deal," says Dave Sankey, the FAA's program manager for aviation weather research. "The software taking it out to 30 minutes or so does a fairly good job, but beyond that you have to have a model to account for the decay and growth of thunderstorm cells. And cells have a lifetime of only about an hour."

Isolating a Killer

Optimism about the benefits of the newest weather-related research stems in part from researchers' track record in alleviating wind shear. Wind shear was still a problem on August 2, 1985, when a Delta Air Lines L-1011 on final approach to the Dallas/Fort Worth International Airport began behaving as though it were possessed by some supernatural evil: the fully loaded airliner began rising suddenly, forcing the pilot to pull back on the power and lower the plane's nose in order to return to the approach path to the runway. Then, just as suddenly, a huge blast of wind from above slammed the jet toward the ground. With its power settings too low and without enough time for the engines to spool up, the plane struggled in vain to stay aloft. It clipped two cars on a highway, killing a driver, then crashed into a field short of the runway. All 137 people on board perished.

Amid a tremendous public outcry, the government began an intensive search to isolate the killer. McCarthy, a pilot as well as a meteorologist, was one of the scientists drafted for the effort. He and his NCAR colleagues began by building on the research of legendary storm investigator T. Theodore Fujita, a.k.a. "Mr. Tornado." Fujita, while inspecting damage from a superoutbreak of tornadoes in 1974, had stumbled on a curious pattern: instead of flying around in a swirl, trees and plants had been blown outward from a central point, as if flattened by an explosive blast. Then, the next year, Eastern Flight 66 crashed mysteriously at New York's John F. Kennedy International Airport, and Fujita suspected that the two incidents had had similar causes, which he called downbursts. Although the idea of such a weather phenomenon was controversial at the time, two research projects were funded to detect and study downbursts.

In one, set up at Denver's Stapleton International Airport in 1982, researchers theorized that they could use Doppler radar to log perhaps an instance or two of this seemingly rare phenomenon. They got more than they could ever hope for. "We found that we could detect microbursts [the name that replaced downbursts] unambiguously with Doppler," McCarthy recalls. Over the test's 86-day duration, they logged 186 of them.

The NCAR team went to work developing the technology to warn pilots and controllers of microbursts. In its first real-world test, at Denver Stapleton, on July 11, 1988, the Doppler system detected an 80-knot microburst; air traffic controllers waved off five airliners while it lasted. "All of them believed the system saved their bacon," McCarthy says. As a result, 47 Terminal Doppler Weather Radars have been ordered for at-risk airports across the nation; today all but two, one for New York and one for Chicago, are up and operating. The effort didn't stop there: the FAA ordered the airlines to install cockpit wind-shear detectors by 1993. The earliest was the so-called passive-warning system, which analyzed an aircraft's vertical and forward speed and its power settings and would audibly warn crews of wind shear. The latest wind-shear alert systems being integrated into all new airliners use a forward-looking microwave Doppler channel tied to existing onboard weather radar; they show microbursts in the aircraft's path.

The NCAR team also helped to establish a microburst training program now required for commercial pilots. The scenarios in the simulator program that teach pilots how to fly through wind shear were developed from the flight data recorders taken from the accident at the Dallas/Fort Worth airport. "In the mid-1980s low-altitude wind shear was the largest cause of aircraft accidents," McCarthy says. "In the U.S. now, it's a rare event, but 10 or 15 years ago that was all we talked about."

Ice on the Wing

The problem of ice formation on aircraft wings now occupies researchers' attention the way wind shear once did. "We're a reactionary agency," Sankey says. "The joke here has been that icing is the number-one thing—until an aircraft crash occurs because of something else."

The best-known recent icing accident occurred near Roselawn, Ind., in the autumn of 1994: busy controllers at Chicago's O'Hare International Airport directed an inbound American Eagle ATR-72 turboprop to fly holding patterns in freezing rain for more than an hour. With its wings iced over—ice deforms the wing into a shape that robs an aircraft of necessary lift—the commuter plane nosed over and crashed into a field, killing all 68 on board. "Up to then, icing accidents had been in small airplanes with one to three people killed," says Marcia Politovich, an NCAR project scientist. "Prior to Roselawn, icing

CHARLES BENNETT *AP Photo*

FATAL DELAY: Investigators inspect the remains of an American Eagle ATR-72 that crashed when its wings iced over while it was flying in a holding pattern, waiting to land at Chicago's O'Hare International Airport. All 68 passengers aboard the aircraft died in the crash.

studies had been backburnered; such a rare event was not high on the priority list, but it got moved up to priority in a big hurry."

In the past, pilots had no way to anticipate icing. Only after they saw ice begin to form on the wing did they activate various heaters on the windscreen, propellers, wings and control surfaces. But Politovich and her colleagues at NCAR have focused their efforts toward predicting the conditions that lead to icing. To find out more about how and where such conditions occur, researchers repeatedly fly a heavily instrumented de Havilland Otter, a twin-engine commuter airplane, into cold clouds and see how much ice they can pick up. Such flights have helped NCAR create the Integrated Icing Diagnostic Algorithm, which combines ground-based radar and satellite data to paint a three-dimensional grid that indicates where icing is present, information that is then fed to pilots. Today, Politovich says, it's a fairly well developed product, used by several of the airlines as well as missions flown by atmospheric researchers.

And the National Aeronautics and Space Administration, along with NCAR, is trying to put in place onboard sensors to help warn pilots that they could be flying into ice-producing clouds. Although no one is exactly sure what form the instrument should be—radar, radiometer or laser—it will send a signal in front of the aircraft that will aid the instrument's sensors in measuring the moisture and temperature of the clouds ahead. If the levels are within the known range found in supercooled droplets that freeze when they make contact with aircraft surfaces, the pilot will be able to decide to activate the plane's deicing equipment or to plan the best path through the weather system.

Icing also takes place on the ground, and one accident underscored the necessity of better understanding the effects of earthbound freezing moisture: Air Florida Flight 90 departed from Washington, D.C.'s National Airport on January 13, 1982, during a snowstorm and immediately struggled to stay airborne. The Boeing 737 struck a bridge and plunged into the freezing currents of the Potomac River. Only five out of 79 on board the jet survived to be plucked from the icy water; four motorists were killed on the bridge. The National Transportation Safety Board investigation revealed that although ground crews had sprayed the aircraft with antifreeze, the 737 had remained on the ground 50 minutes after the treatment, too long for it to remain effective.

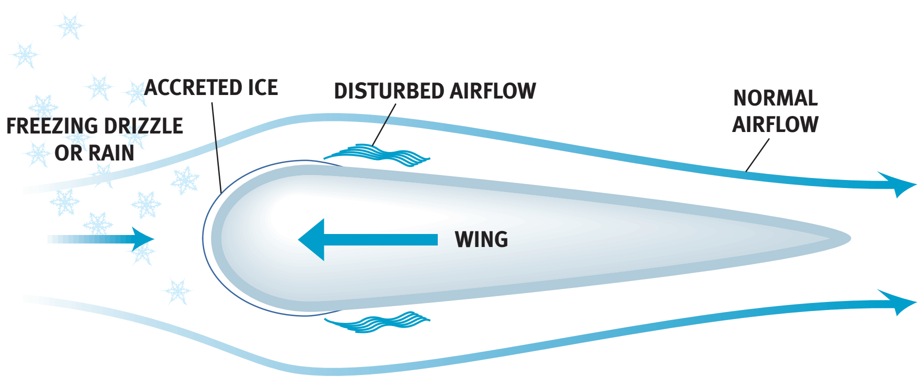
As a result of Air Florida's and subsequent icing-related accidents, the FAA and NCAR have funded the development of a system called Weather Support to Deicing Decision Making, also known as WSDDM. Using NWS and FAA Doppler radar data and a network of snow gauges and observation data, WSDDM lets airport operators know how much snow has fallen, how much is going to fall and its liquid content. "It can predict 30 minutes ahead of time what the intensity of the snowfall is going to be," Sankey says. With that kind of knowledge, ground crews can spray aircraft with the best, most economical antifreeze solution for its takeoff conditions.

Bump Detectors

Perhaps it's an indication of how much progress scientists and researchers have made in such traditionally deadly areas as wind shear and storm detection—or perhaps it's a sign that the hidebound FAA is trying to better anticipate problems—but today much energy is being focused on detecting upper-air turbulence. "It's rarely a killer, but it does kill," McCarthy explains. And it's the leading cause of injuries in the air. From 1981 through December 1997, major air carriers reported that turbulence caused 769 minor injuries, 80 serious injuries and three deaths. Every year an average of 58 people are hurt—50 percent of them flight attendants—costing the airlines $100 million. But there's also a significant psychological factor. "Turbulence is the largest cause for fear of flying in the U.S.," McCarthy adds. "People don't seem to be afraid of a catastrophic event, but they get upset when the ride gets exceedingly rough. It's a distressing environment."

Until recently, reporting turbulence has been up to the discretion of pilots flying en route, and thus gathering data can be spotty and tenuous. "For turbulence, the main thing we rely on

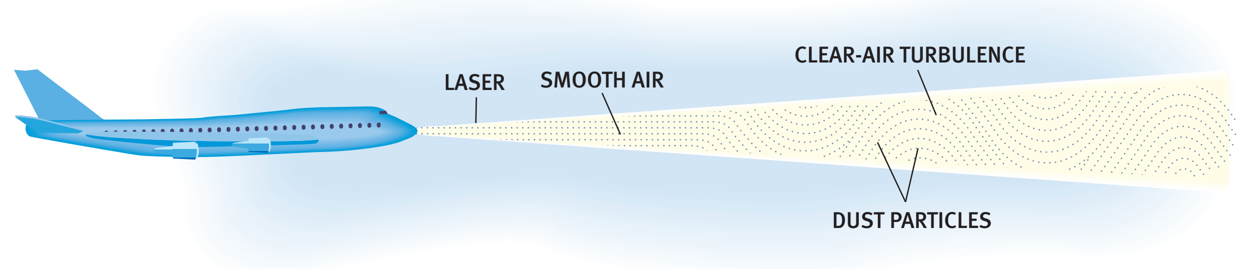
ICE ON THE WING



NASA GLENN RESEARCH CENTER (*photograph*); LAURIE GRACE

Freezing rain or drizzle can lead to ice buildup on the wings, which can disturb the air flowing over their surface and can sometimes affect the ability of the pilot to fly the aircraft. Onboard sensors may eventually warn pilots of ice-producing clouds.

DETECTING CLEAR-AIR TURBULENCE



LAURIE GRACE

A sensor on board an aircraft detects unseen turbulence by measuring the shift in frequency of laser light transmitted from the nose of the airplane and scattered by dust particles in the agitated air ahead. The frequency of light reflected back to the airplane is compared with that of light transmitted to determine whether turbulence is present, so that the pilot can warn passengers.

are pilot reports from commercial and general aviation aircraft," says James H. Henderson, deputy director of the NWS's Aviation Weather Center in Kansas City, Mo. "But it's a subjective thing and aircraft dependent. 'Severe turbulence' for a pilot flying a four-seat Cessna may be 'light turbulence' to a Boeing 737."

By October 2000, some 200 Boeing aircraft will be equipped with software that uses deviations from expected flight characteristics (such as pitch, roll and yaw) to detect turbulence and report it to air traffic controllers on the ground. Such remote sensing feeds data to NWS computer models whose output provides guidance to other planes.

In addition, NASA is looking at developing an onboard sensor that will warn the pilot of turbulence up ahead. Detecting thunderstorm-generated turbulence is fairly easy: beefing up current onboard weather radar with new software and enhanced processing technology allows it to detect foul-weather turbulence. But clear-air turbulence, which has no moisture off which a radar signal can be reflected, presents a stickier problem. So NASA is experimenting with LIDAR, or Light Detection and Ranging. In it, a laser beam bounces off dust particles in the clear air and measures the scattering of the air. Onboard processors analyze the return for signs of roiling currents in its path. Thus far the results are promising. "Now we're looking at how to get more range out it," says Bruce Carmichael, NCAR's manager for FAA and NASA programs. "Instead of a one-minute warning, we want to get several minutes. We want to be able to give enough warning for the pilot to do something: get the passengers seated and belted and the drink carts tied down."

The Skyway Ahead

While investigators were laboring to give travelers a smoother ride, the FAA received a mandate last summer from its administrator, Jane F. Garvey, to get more weather information into all cockpits. "In fact, an airline passenger equipped with a satellite digital cell phone and a laptop computer with a modem can receive real-time weather data that the crew flying the airplane cannot receive in the cockpit," testified Capt. Paul McCarthy last July to the House Aviation Subcommittee of the Transportation and Infrastructure Committee. McCarthy is executive air safety chairman of the Air Line Pilots Association International.

Airline pilots get their weather briefings while they file their flight plans at the airport, whereas general aviation pilots who are not flying solely by reference to instruments are responsible for familiarizing themselves with the level of information appropriate to their flight. In the air they can radio a service called FlightWatch for further updates.

To bring more advanced technology to small, private airplanes (which have been technologically stagnant in recent years), NASA, in concert with avionics manufacturers, formed a project in 1994 called AGATE, for Advanced General Aviation Transport Experiments. Part of it, Flight Information Services-Broadcast, or FIS-B, is a system that broadcasts—on aviation VHF bands—weather information directly to a display system in the cockpit. In the most basic version, that information comes across in the ancient alphanumeric teletype code that all pilots still learn in primary ground school. For a subscriber fee, however, the broadcast can include a weather radar overlay on a moving map display. "Flying along, the pilot will be able to see where the weather is," says Scott C. Asbury, AGATE project engineer at the NASA Langley Research Center in Hampton, Va. A similar project directed toward commercial carriers is also under way there.

But cooler heads warn against overloading the pilot with information, cautioning against adding yet another warning device to the overcrowded instrument panel of the modern airliner. "Pilots need a lot of weather information, but the information needs to be well integrated," Capt. McCarthy says. "If you've got all hell breaking loose in the cockpit, with all these bells and bonks and gongs going off, it doesn't mean you did the job right." In other words, if all that the new weather technology does is add more stress to the pilot's job, then the solution could well be worse than the problem. W

PHIL SCOTT is a freelance writer who lives in New York City. His most recent book is *The Pioneers of Flight: A Documentary History* (Princeton University Press, 1999).