NOMINEE: The NASA Langley Research Center, the Federal Aviation Administration, and the Government/Industry Wind Shear Sensors Team

BY: The National Aeronautics and Space Administration

“For the conception, development, and flight verification of airborne detection technologies that enable the elimination of wind shear as a deadly aviation hazard.”

JUSTIFICATION

A dramatic improvement in the flight safety of transport aircraft worldwide has become possible through the development of sensor systems that detect hazardous wind changes miles ahead of an aircraft. This development—the result of unique cooperation between NASA, the FAA, and industry—involved fundamental breakthroughs in the understanding and measurement of commercial aviation’s most lethal weather threat, the phenomenon known as microburst wind shear.

Prior to this work, wind shear was invisible to airborne detection. As a result, it has been a leading factor in U.S. civil transport accidents for 30 years. Now, however, flight tests have demonstrated conclusively that airborne sensors can present pilots with clear warning of wind shear hazards. Spurred by the rapid transfer of NASA technology, the U.S. avionics industry is positioned to provide this lifesaving enhancement to a worldwide market. Once completely blind to the potential danger, pilots soon will be able to take early corrective action to safely avoid the wind shear threat.

Unanticipated wind changes at low altitudes have caused aircraft accidents since the beginning of powered flight. In the U.S. alone, wind shear has been identified as a contributing factor in at least 26 civil transport accidents and incidents since 1964. The Wind Shear Airborne Sensors Program has attacked the problem on a broad front since the signing of a NASA/FAA Memorandum of Agreement in 1986. The multi-agency, multi-disciplinary, multi-industry approach now is hailed as a model for future cooperative development efforts. In progressing rapidly and logically from problem analysis to simulation, hardware development, and ultimately flight test, the enormously successful program has been a textbook example of the aeronautical research process.

U.S. avionics manufacturers from small to large have capitalized on NASA wind shear research and consulting guidance. Major participants have been Westinghouse Electric Corporation, Rockwell International, Allied Signal Aerospace Company, Lockheed Missiles and Space Company, and Turbulence Prediction Systems, Inc. These companies have produced multiple independent sensor development efforts in the best entrepreneurial tradition. Technology applications include Doppler radar, lidar (laser radar), and infrared sensor systems, each of which required ground-breaking advances in state-of-the-art design and signal processing. Many companies now are nearing FAA production certification and commercial sales. Because of the intense cooperation among NASA, the FAA, and industry, no other nation is close to producing such a mature and capable product.

NASA’s piloted simulations in the late 1980s clearly established that as few as 10 seconds of wind
shear warning yields a substantial safety advantage. Subsequently, NASA developed mathematical models whose unprecedented accuracy illustrated the complex meteorological evolution of thunderstorms and microbursts. This paved the way for simulation model evaluations of radar, lidar, and infrared sensors to determine their potential to remotely detect microburst wind shears. Widely used by industry, the models enabled rapid development of unique hardware designs and software-processing techniques to overcome the limitations of existing sensor technology.

NASA also developed a hazard index that relates wind shear strength to aircraft performance capability. The index, easily depicted on a cockpit display, was a fundamental breakthrough in the understanding of wind shear and has become an international standard in aviation terminology and measurement-systems applications.

Based on this research, NASA and industry gained the confidence needed to build prototype detection system hardware.

Flight testing of the hardware during the summers of 1991 and 1992 proved the feasibility of remote wind shear detection. With prototype sensor systems installed, NASA’s Boeing 737 and industry aircraft measured and purposely penetrated hundreds of microburst wind shears. Both pilots and flight research crews regarded the tests as the most intense and stressful flying of their careers. The large-scale, highly complex flights included operations at very low altitudes (less than 1,000 feet) in severe weather conditions marked by frequent lightning, hail, heavy rains, turbulence, and extremely limited visibility. Rapid maneuvering and real-time reactions were required to measure and penetrate microburst phenomena that developed and dissipated in as little as 10 minutes.

The flight tests were extremely successful. For the first time, deadly wind changes lying in wait on a aircraft’s flight path were predictable by airborne sensors. While the design goal for the systems was 10 seconds of warning, three to four times this requirement routinely was achieved in flight.

With flight tests ending in 1992, two years ahead of schedule, this lifesaving technology is ready for commercial application. Technology challenges in radar processing and laser hardware design previously predicted to be insurmountable have been unquestionably conquered. Additional promising applications include detection of trailing wake vortices, clear air turbulence, and aircraft gust load alleviation.

In 1986, the NASA and FAA team set a timetable for developing and demonstrating a solution to a problem then responsible for more than 50 percent of U.S. commercial aviation fatalities in the previous decade. Dr. Roland Bowles and his associates at NASA Langley Research Center deserve special recognition as tireless catalysts and critical researchers for the entire national wind shear airborne sensors effort. Their striking accomplishments are a superlative example of the original NACA charter to “supervise and direct the scientific study of the problems of flight with a view to their practical solution.” In the very near future, all airline passengers will travel with the threat of aviation’s largest weather hazard effectively removed.