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Next Generation Weather Radars To Increase Flight Safety

Utilization of the Doppler principle in weather radars now under development, promises real-time information and accurate forecasts. Three U.S. government agencies are cooperating to develop and implement a system that will provide detailed weather data not only to pilots, but to the nation's general population by the mid-1990s.

by

Tirey K. Vickers

Existing weather radars depend on the reflectivity of precipitation in the air to determine the location and relative intensity of storm areas. The development of Doppler radar now makes it possible to detect areas of turbulence, as well as the direction and velocity of winds aloft. A Doppler radar compares the frequency of the radar returns with the frequency of the radar signal transmitted by the radar antenna. If the precipitation is moving toward the radar antenna the frequency of the returns will be slightly higher. Conversely, if the precipitation is moving away from the antenna, the frequency of the returns will be slightly lower.

Three new applications of Doppler radar are being developed to provide more detailed and accurate data on significant weather hazards and wind patterns aloft. The new radars are NEXRAD, Terminal Doppler Weather Radar, and Wind Profiler.

Government Cooperation Birth NEXRAD

Three U.S. agencies are cooperating in the development and procurement of an advanced nationwide weather warning system called NEXRAD, (next generation weather radar).

- The National Oceanic and Atmospheric Administration (NOAA), which is responsible for severe weather warnings, flood warnings, general aviation forecasts and other weather-related advisories vital to the protection of life and property.

- The Federal Aviation Administration (FAA), which is responsible for the safe and efficient use of the U.S. airspace.

- The U.S. Air Force Weather Service and the Naval Oceanography Command of the Department of Defense, which are responsible for weather information and warnings to the military, to protect resources, provide increased flight safety, and support decision making.

The NEXRAD system will be a U.S. network of long-range Doppler weather radars. Each NEXRAD radar will have a range of 252 nautical miles (290 statute miles). Its circular parabolic antenna, 28-feet in diameter, will rotate horizontally at a rate of 6 rpm, while the antenna is tilted upward in steps to sweep the beam from -1° to +20° in elevation, during a scan cycle of 5 to 6 minutes. At the end of this scan cycle the antenna is tilted down again to -1° to start the next cycle.

Like existing weather radars, NEXRAD will use the reflectivity principle to show precipitation intensity to its full range of 252 nautical miles. It will also use the Doppler principle to measure the velocity of precipitation particles toward or away from the antenna. NEXRAD will exercise its Doppler capability out to a range of 126 nautical miles (half its maximum range). Within this area it will probe cloud masses to provide data on air circulation within the storm. This information will enable operators to detect severe storms and damaging tornadoes in their earliest stages. The use of NEXRAD will substantially increase the lead time for tornado warnings.

By doubling the detection probability of existing weather radars, NEXRAD will improve the forecasting of the movement and severity of thunderstorms and increase the accuracy of identifying areas that are threatened. It is also expected to reduce the present false alarm rate by 50 percent.

Dust and Insects Identify Clear Air Turbulence

In clear air conditions, the operator will be able to switch to the "clear air" mode. The radar will transmit longer pulses, and use a longer scan cycle (10 minutes), in order to utilize the weaker returns from dust particulates and insects to detect air motion. It will be able to detect clear turbulence.

A NEXRAD facility will include the Doppler radar plus a signal processor, a data processor and a communications system. Each user will have a Principal User Processor (PUP) for displaying NEXRAD data. The PUP includes twin color displays, a graphic table, a "mouse", a monochrome terminal and keyboard. Information is selected for display using the graphic table and the mouse. A device is also available to print hard copies of displays.

Color to Aid Data Interpretation

NEXRAD will use a technique called false color imagery to show the differences in observed wind speeds and directions. This technique uses different colors for the various ranges of wind speeds within an air mass. Cool colors such as blue and green indicate air movement toward the antenna. Warm colors such as yellow, orange, red and brown indicate air movement away from the antenna. A storm will be displayed as a matrix of tiny squares of various colors which depict the storm's overall size and shape as well as its internal dynamics.

The NEXRAD processor will automate many of the otherwise subjective interpretations of radar meteorology. By using meteorological algorithms the computer will develop products which provide a detailed picture of storm dynamics and the potential for severe weather. When a storm reaches a predetermined threshold and is detected within an area selected by the operator, an automatic alert will be sounded at the display.

The processor will also be able to correlate data from various rain gauges deployed throughout the area, and integrate this data with the precipitation intensity data from the radar to determine precipitation rate and accumulation maps for possible flash flood warnings.

The NEXRAD equipment is being produced by UNISYS under a $450 million contract. The first system is being installed in Norman, Okla., and operational tests begin in October 1988. Actual production will not start until the tests have been successfully completed. A total of 195 NEXRAD radars is planned for the ultimate network.

NEXRAD will be an invaluable tool for en route air traffic control to aid pilots in avoiding dangerous weather conditions. But it will be much more than an aviation aid, as it will serve the general public by providing early warning of tornadoes and flash flooding, and an improved means of water resource management.

Terminal Radar to Update Faster

The long-range NEXRAD requires five minutes to six minutes to generate a complete radar picture. This internal update is not fast enough to provide complete protection against microbursts, which can form within a two-minute interval. To remedy this situation, the FAA will supplement NEXRAD coverage with a number of Terminal Doppler Weather Radars (TDWR's) installed in the vicinity of major airports. TDWR will have many of the features of NEXRAD, except that it will operate in a different frequency band and will have a range of only 48 nautical miles with a much shorter scan cycle. This will enable it to detect microbursts, as well as wind shear, turbulence, tornadoes, and wind shifts, out to its maximum range.

Normally the TDWR antenna will rotate continuously. However, the TDWR operator will be able to select any 120° sector of special interest and sweep the antenna from one side to the other side within this area at a faster rate, to provide a detailed look at the development of a microburst or other weather phenomenon.

It is expected that the FAA contract for procurement of the TDWR will be signed during the fall of 1988.

Profiler Network Determines Winds Aloft

A third application of Doppler radar technology is the wind profiler, which is being produced by UNISYS under a contract to the National Oceanic and Atmospheric Administration (NOAA). Wind profiler systems will form an unattended network to measure the direction and velocity of upper winds at each altitude level from 2,000 feet to 53,000 feet above the earth's surface. The equipment will be able to measure horizontal velocities up to 174 knots (200 mph) and vertical velocities up to 43 knots (50 mph).

The wind profiler will improve airline flight safety and fuel economy by providing data to determine the most efficient and smoothest flight levels for various routes. Because weather patterns are carried by winds aloft, data from the wind profiler network should significantly improve the accuracy of weather forecasting.

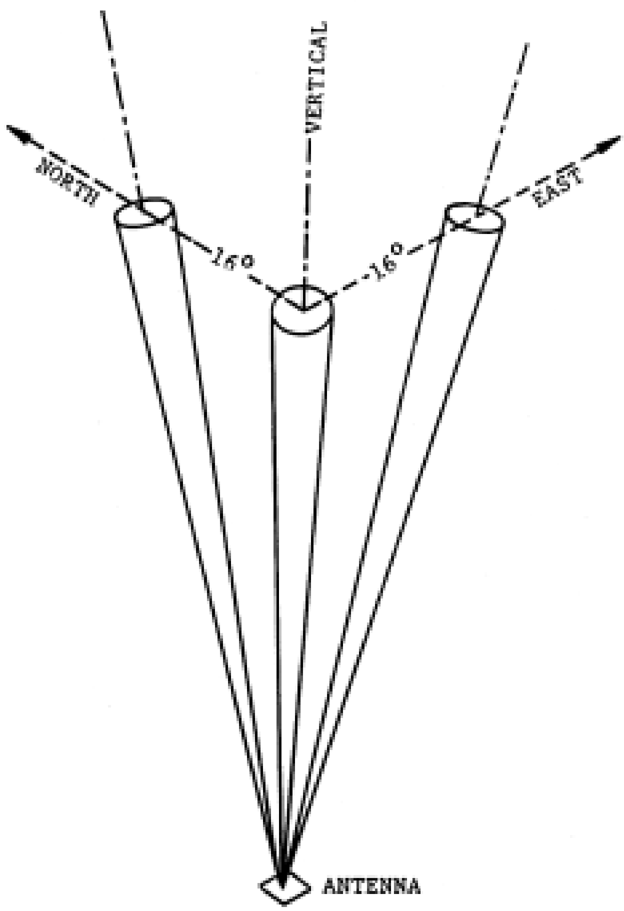
Other uses of the profiler will include the provision of real-time wind data for space shuttle launch and recovery, as wen as for rocket, missile and artillery testing. The wind profiler will also serve as a research tool for meteorological analysis, and will provide a calibration reference for Doppler data gathered by the NEXRAD weather radar network.

The profiler will provide a complete vertical profile of winds every six minutes. It will use a dual planar array of coaxial collinear antenna elements to generate three beam patterns in a computer-controlled sequence: One vertical, one pointing 16° obliquely in a northerly direction, and one pointing obliquely 16° in an easterly direction. The system will measure Doppler frequency shifts to determine the vertical, north-south and east-west components of the wind at each altitude level.

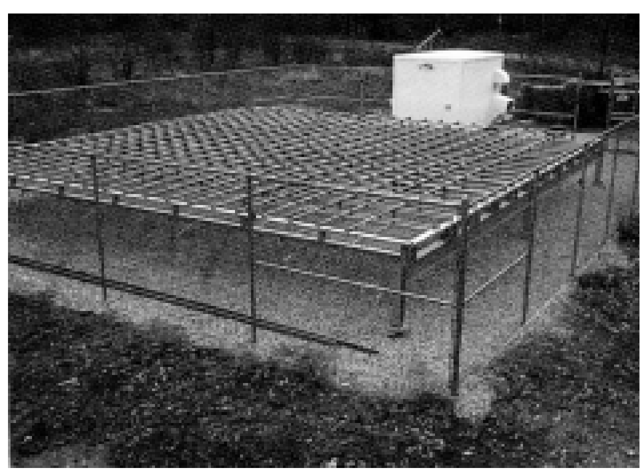
Proposed Mode S Provides Enroute Access

Designed for unmanned operation, the wind profiler system *will* automatically monitor its own performance to ensure the accuracy of its data. The data will be transmitted automatically at intervals via satellite or landlines to weather centers for integration, display and analyses. The FAA's proposed Mode S system will be able to access weather centers directly so that pilots can obtain weather data in flight via the Mode S Data Link.

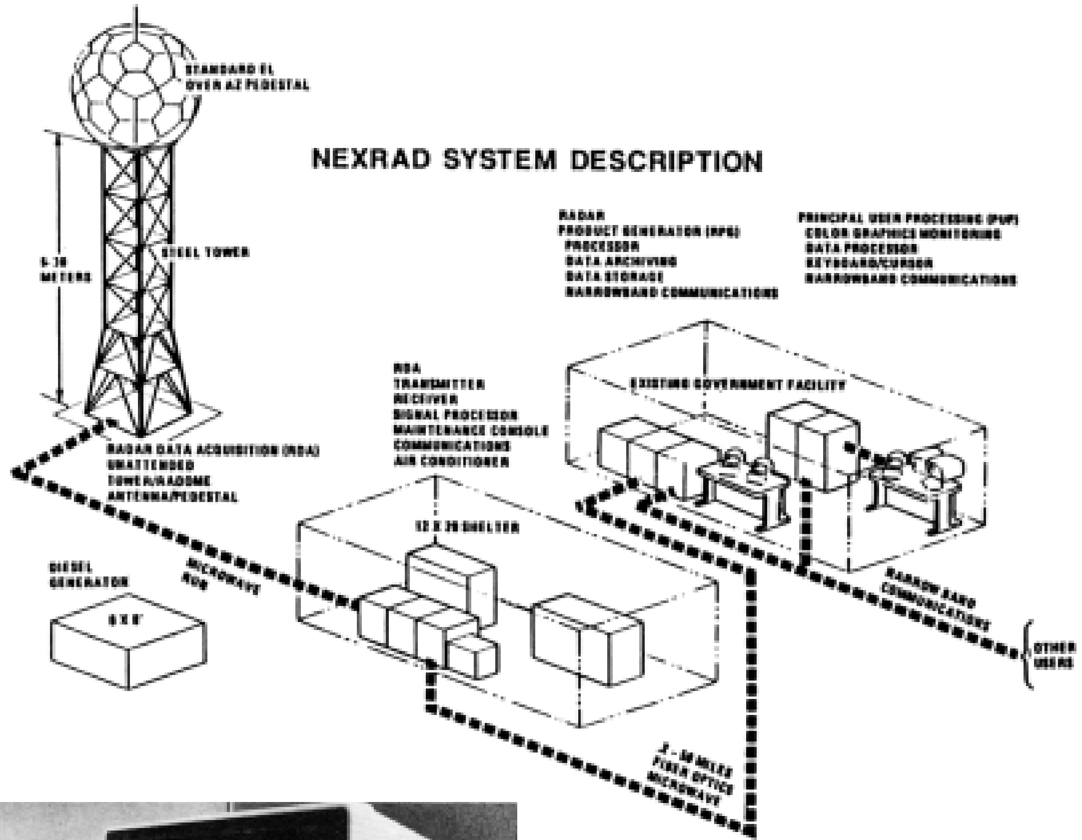
All three types of Doppler systems described above are planned to be commissioned by the middle 1990s. It is expected that they will be able to make significant improvements in the accuracy and timeliness of weather information available to pilots. These improvements in turn will contribute to an increase in flight safety.♦

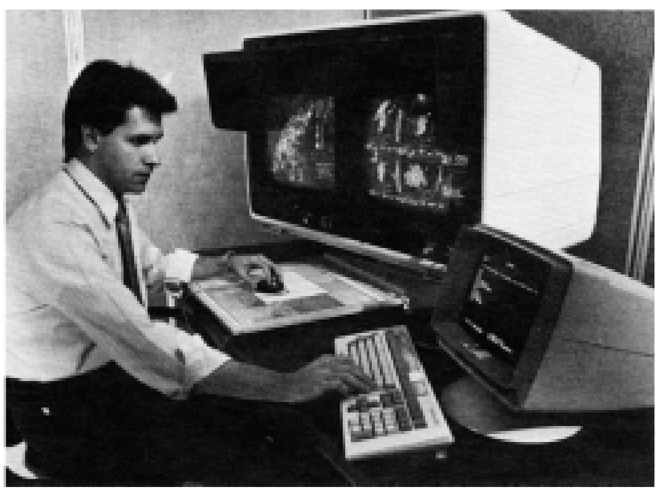


Beam Alignment Of Wind Profiler



Wind Profiler Antenna





The Principal User Processor (or PUP)for NEXRAD is composed of three main subsystems: the twin color CRT displays; a graphic tablet and "mouse;" and a monochrome terminal and keyboard. Information can be displayed on the color screens using the graphic tablet and buttons on the "mouse." Text on the storm formations are displayed to the right of each display. (Unisys photo)

About the Author

Tirey K. Vickers began his career in air traffic control during the 1940s and was chief ATC specialist at the U.S. Federal Aviation Administration's (FAA) Technical Development Center when he left the government. He directed his career to include a solid background in the air navigation system and airport development. Currently, he is a consultant to MS1, a Washington, D.C., consulting company, and he specializes in air traffic control.

Vickers is editor of the "Journal of Air Traffic Control," published by the Air Traffic Control Association, headquartered in Arlington, Va., U.S. He has been the publication's editor for 20 years, but still finds time to be a frequent contributor to technical publications and books on the science of air traffic control.

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