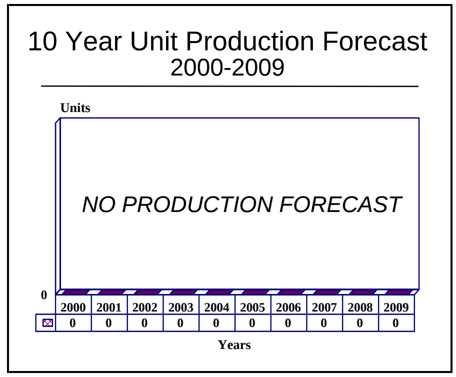
# MPR (Microburst Prediction Radar) - Archive 08/2001

## Outlook

- Designed for smaller airports
- Competition from commercial weather information
- No contractual vehicle as yet
- Exploring other applications




## Orientation

**Description.** Microburst Prediction Radar, an on-airport, ground-based system designed to predict microburst and wind shear conditions which can threaten aircraft on take-off and landing.

**Sponsor.** Company-sponsored development.

**Contractors**

Lockheed Martin Corp
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**Status.** Prototype development/demonstration.

**Total Produced.** An estimated four systems were built for development and testing support.

**Application.** Wind shear/microburst detection/prediction for air traffic control at airports.

**Price Range.** US$500,000 to US$700,000, including installation.

## Technical Data

| | Metric | US |
|---|---|---|
| **Dimensions** | | |
| Antenna pedestal | | |
| Width: | 1.5 m | 5 ft |
| Height: | 1.5 m | 5 ft |
| Pedestal height up to: | 2.7 m | 9 ft |
| Radome: | 1 x 1 x 1 m | 3 x 3 x 3 ft |
| Fiber optic link max distance: | 4 km | 2.5 mi |

**Characteristics**

| | |
|---|---|
| Frequency: | 9.945 GHz typical<br>8 selections possible (8 - 12 GHz) |
| Peak power: | 60 W |
| Average power: | <2 W |
| PRF: | 7092 Hz |
| Pulse width: | 1.25 μsec |
| Antenna | |
| Prediction: | Linear phased array<br>12 beams (six pairs)<br>6.5º elevation<br>7.0º azimuth<br>10º - 70º electronic steering |
| Surface beam: | Flat plate, slotted dipole radiators<br>single beam<br>3.2º elevation<br>3.2º azimuth<br>1.8º fixed elevation scan |
| Azimuth scan: | Mechanical 360º<br>3 rpm |
| Range resolution: | 225 m (test) |
| Unambiguous range: | 10 Km radius |
| Unambiguous velocity: | ± 56 m/sec |
| Detection update: | Every 20 sec |
| Warning time: | 2 to 4 min |

Design Features. The Microburst Prediction Radar was designed to be a small, low-cost radar that could be located on an airport to detect microburst conditions and provide advance warning of hazards developing on approach and departure corridors. The on-airport location makes it possible to use a short-range, low-power system; reducing cost and making off-the-shelf components feasible. The MPR was, according to the company, put together in nine months for less than US$1 million in development money.

It uses a rotating platform mounted on a pedestal to house a radar assembly with two antennas: one phased array antenna to produce a series of prediction beams, and a flat-plate antenna that generates a surface search beam. The radar electronics are on the rotating platform and covered by a radome. The entire assembly is small and light enough to be mounted on top of a building or on a 9 ft pedestal (to get the radar beam above vehicle clutter).

The radar data can be transmitted up to 4 km via fiber-optic link to a standard Pentium-based processor in the air traffic control facility. A special PC Interface card in a commercial computer adapts it to functioning as the MPR processor/display system.

The receiver/transmitter is a modernized version of a mature, solid state commercial I/J-band radar modified to MPR standards. The 8-12 GHz operating band performs better in precipitation. Eight frequency possibilities can be used to prevent interference with other radars.

The remote site system features full monitoring and has fault isolation built into all of the electronics. Faults can be isolated to the line replaceable unit and MTTR is typically less that 30 minutes.

The antenna assembly consists of a small, electronically scanned linear array. The elevation scan, prediction beam scans in elevation to detect downdrafts aloft. A flat-plate pencil beam antenna generates a fixed-elevation beam to scan the surface and detect microburst surface outflow. The entire antenna assembly rotates at 3 rpm. This updates any surface detection at 20-second intervals.

The digital signal processor is fully programmable and uses Texas Instruments TMS320C31 DSP chips to execute clutter filtering and auto-variance processing. The signal processor, beam steering electronics and timing/control electronics were built to "good commercial practice" standards using existing, commercially available technology. Throughput is 320 MFLOPS.

The Weather Data Processor is a standard commercial Pentium processor which also serves as the display unit. An MPR-specific circuit card is inserted to manage the interface between the remote unit and the local site. A magnetic tape storage device can archive over 24 hours of radar data for off-line analysis.

Operational Characteristics. By analyzing the conditions aloft, the Microburst Prediction Radar determines the probability of hazardous conditions developing along aircraft approach and take-off corridors. Radar beams scan the upper atmosphere, searching for the downdrafts that give birth to hazardous surface wind shear. A surface beam analyzes wind speed and direction close to the surface. The system can detect and predict dry microburst activity with warning times of from two to four minutes. When severe conditions develop, the MPR monitors them continuously.

The MPR display presents a complete picture of the microburst hazard on and near the airport. It is divided into three areas: graphics, alphanumerics and command.

The graphics area of the display shows the location and intensities of microburst predictions, surface wind shear directions and precipitation regions. The presentation is map-like, includes runway outlines and is color-coded for ease of analysis.

The Alphanumeric area contains warning messages which indicate which runways and air corridors are impacted by the microbursts. MPR fault messages are also displayed.

The Command area contains “buttons” activated by PC mouse to bring up various features. For example, *Runways* brings up a computer window that allows the user to enter the active/corridor configuration for the graphics display area. This setting also affects the alphanumeric display, since warning messages are generated only for the active runways and corridors. Other Command windows are: tape archive control, electronics reset/recycle, remote site power control, system shutdown.

The two principal weather products are *Microburst Surface Wind Shear Detection* and *Microburst Prediction.*

# Variants/Upgrades

There are no variants, but designers had plans to upgrade the system so it could detect the wind shear generated by a gust front, conditions that are not as severe as microburst from a downdraft situation, but which can be hazardous nonetheless. It will transmit a 6 µsec pulse at reduced PRF.

The processor has the capability to import WSR-88D NEXRAD storm information to the display.

# Program Review

Background. The common precursor of microburst is an intense, moisture-laden downdraft. When the descending downdraft reaches the surface of the earth, it spreads out horizontally, creating a significant hazard to aircraft. The outflow occurs at low altitude, with the maximum flow rate typically 50 to 150 meters above the surface; but the wind shear conditions that generate this flow can extend up to 300 meters AGL. This puts the hazard at the altitude of aircraft on approach or departure, when they are most vulnerable to wind shear. The outflow and wind shear can add to or take away from an aircraft’s airspeed unexpectedly, causing a crash when the pilot cannot compensate in time. The onset of hazardous conditions can be rapid and unpredictable. Advance warning could make a significant impact on aircraft safety.

These weather conditions cause the most serious hazard within 5 miles of an airport. The high cost of the Terminal Doppler Weather Radar (TDWR) limits their deployment to large, busy airports. The FAA has 47 of these multi-million dollar systems, and other users may become interested in a few more.

On-board wind shear detection systems currently available can detect microburst only after it develops, too late for safety if an aircraft on final approach hits the condition unexpectedly. In 1990, engineers found that a small, low-cost radar could be developed to provide a microburst early warning capability for airports that would not be receiving the TDWR system. The system should cover the critical area roughly 20 km around the airport. Severe weather further from the airport would be detected by other weather sensors, such as the WSR-88D NEXRAD.

A proof-of-concept test at Denver’s Stapleton Airport took place during the summer of 1991. This test demonstrated the ability of a low-power, 8-20 Ghz band radar to detect microburst surface wind shear and microburst downdraft signatures prior to surface outflow.

An improved MPR underwent validation at Orlando International Airport, Florida, between July 1 and September 1, 1992. Comparison of MPR performance to TDWR data in Orlando showed that the system could detect surface microburst wind shear greater than 30 knots 100 percent of the time with a false alarm rate of less than 1 percent. The analysis verified that the radar could provide at least two minutes warning of increasing microburst surface wind shear with a 96 percent probability rate and 6 percent incorrect prediction rate.

During the summer of 1994, a third field test was conducted at Memphis, Tennessee. A complete real-time MPR was used for the test. The National Severe Storms laboratory performed an independent evaluation of the new radar using the Memphis TDWR as a "truth" weather radar. Although the weather was unusually dry and weather conditions less severe than usual during the evaluation, the results were favorable.

In January 1994, company engineers introduced the Microburst Prediction Radar (MPR) at the American Meteorological Society's 74th annual meeting. The company made a major presentation on the system at the IEEE Radar '95 International Radar Symposium in May 1995.

Work proceeded, with engineers working through the development and testing the new system's performance. This work was delayed when Lockheed Martin decided to close the Long Island facility where the program was residing and moved it, along with twenty other weather-related projects, to the Ocean, Radar, and Surveillance Sensors facility in Syracuse New York. By June 1997, the program personnel were settling in to the new location and re-starting the MPR development, testing, and re-work efforts.

Reorganization and restructuring of the division continued to keep the MPR development and marketing effort behind other activities in the priorities queue. The increasing availability of weather products from commercial sources had an impact. Developers continue to research the system, and have found other possible applications of the general technology and frequency band. Biological/chemical detection and bird strike preventions are the uses being looked at.

## Funding

The project was company-funded. Procurement will be from facilities accounts at purchasing airports. Future FAA F&E funding is a possibility, although none of the programs in the latest Aviation System Capital Investment Plan lead to this.

## Recent Contracts

No contracts or contractual vehicle recorded as yet.

## Timetable

| Month | Year | Major Development |
|---|---|---|
| | 1990 | Concept development |
| Summer | 1991 | Proof-of-concept test |
| Jul-Sep | 1992 | Validation tests |
| Summer | 1994 | Field test, Memphis |
| Jan | 1994 | Introduction at AMS |
| May | 1995 | Presentation at IEEE Radar '95 |
| | 1997 | Facilities moved to OR&SS |

## Worldwide Distribution

International interest was hoped for.

# Forecast Rationale

In the past, nothing much could be done about weather conditions; but advances in radar and data processing made it possible to detect and analyze the atmospheric conditions which spawn deadly microburst and wind shear phenomena, then forecast the development of danger. This makes it possible to avoid the most hazardous areas instead of discovering the situation when it is too late to do anything about it.

Doppler techniques and advanced software algorithms proved their worth, and the WSR-88D NEXRAD and TDWR sensors, were the result. But these systems are large and expensive, they have much more capability than is needed for a small facility, and cost far too much to be installed at all airports. The MPR designers used off-the-shelf equipment and reduced operational requirements, to create an affordable radar that could be installed simply, yet provide the critical warning information needed.

At smaller, less busy airports, air traffic controllers can get by with the simple warning that a microburst situation is developing on the approach or take-off corridor to/from the field so they can steer aircraft away from danger. Although aircraft are beginning to carry wind shear and microburst warning radars, many of the aircraft using the smaller airports do not carry these advanced radars.

Planners decided that although the MPR radar does not produce the sophisticated data products that TDWR and NEXRAD do, it could give controllers the information they need. Planned improvements will increase the value of these radars, increasing their marketability.

The delay in the program resulted from a move that was strictly facilities-based. It had nothing to do with dissatisfaction with the MPR program. According to program personnel, testing accomplished before the move showed that the false alarm rate was within the targeted goal, but engineers have reportedly solved that problem.

But the lost time had an impact, and advances in the availability of newer weather products diluted some of the market potential for this system. Other, higher priority programs impacted progress as well and no significant activities have been noted. The FAA's interest in weather system improvements over the next few years will emphasize improvement to existing systems like MPR, and not development of a smaller radar. There is the possibility that competition could develop from the Doppler radars coming on to the commercial market for TV stations. Though a little more expensive relative to MPR, airport installations could cut costs by not requiring many of the tower and other facilities included in estimates for TV station installations. The full impact of these new systems on the overall weather detection and prediction market is yet to be seen.

Interest continues, however, and the investigation of other applications may eventually let the system find a market. Many users are interested in the MPR and could probably be persuaded to buy if they could see it in the field. Typically, no one wants to be first.

## Ten-Year Outlook

Forecast is to be determined based on developing events.

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