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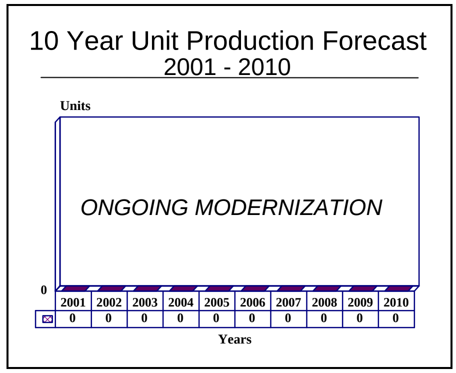
TDWR - Archive 06/2002

Outlook

- NYC site finally being installed
- Current production complete; ongoing logistics support in place
- Upgrades planned for computer/processors and antenna drive motors



Orientation

Description. The Terminal Doppler Weather Radar (TDWR) is a Doppler radar designed to detect wind-shear and similar wind-related events in terminal air traffic control areas.

Sponsor

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USA
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Web site: http://www.faa.gov

Contractors

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Harris Corp
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(Night Hawk 3200 computers)

Northrop Grumman Corp
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PO Box 17319
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Web site: http://www.northropgrumman.com
(Transmitters)

Status. Current production completed, ongoing support.

Total Produced. A total 47 systems had been produced.

Application. TDWR provides windshear detection and wind shift prediction in terminal areas.

Price Range. The cost of a TDWR installation is US$4-8 million, depending on site-specific costs and problems.

Technical Data

	Metric	US
Dimensions		
Antenna diameter:	8.5 m	28 ft
Siting from airport:	13 to 19 km	8 to 12 mi
Characteristics		
Range		
Doppler (wind gust):	90 km	50 nm
Accuracy:	± 1m/sec	
Reflectivity:	460 km	275 nm
Accuracy:	± 1 dB	
Frequency:	5.6 to 5.65 GHz	
Power:	250 kW peak 550 W average	
Pulse width:	1.1 µsec	
PRF:	300 pps (long-range surveillance) 1,200-1,700 pps (Doppler velocity hits)	
Antenna scan rate:	25º/sec	
Az/El beamwidth:	0.5º (pencil)	
Sidelobes:	(1º - 5º) -27 dB (>5º) -40 dB	
Scan pattern:	16 elevation tilts encompassing 120º sector centered near airport 2- to 5-minute volume scan period, with near-surface windshear detection scans once per minute	
Ground clutter suppression:	55 dB	
Gust front warning time:	10 to 20 min	
MTBF:	550 hr	
MTCBF:	1,500 hr	
Availability:	0.9997 (actual availability 96%)	
Data products:	Microburst detection Gust front detection Wind shift prediction Precipitation intensity	
Storm structure display:	Rain: Green & yellow Hail: Orange Gust Front: Purple Downburst: Red	

Design Specifications. The TDWR is functionally similar to the WSR-88D NEXRAD, but operates at a lower frequency to enhance its ability to see through precipitation. TDWRs will have dedicated displays and be capable of unattended operation. The system design was optimized for microburst and windshear detection in a terminal area. Algorithm development shared much of the NEXRAD effort.

It is a fully coherent, high-sensitivity, high-resolution radar. The processor features a data decontamination capability that generates a high-quality database on reflectivity, velocity and the spectrum width characteristics of returns. This is critical for automatic, low false-alarm-rate operation of the microburst and gust-detection algorithms.

The Doppler radar allows the system to detect the movement of air masses that can form into a windshear or a microburst. The data processing algorithms are predictive and designed to forecast the development of microburst phenomena and project wind direction shifts. Unlike earlier weather radars, TDWR is not dependent on precipitation to determine the existence of weather activity. The Doppler radar processes detected microscopic dust particles and insects to determine wind speed and direction.

The radar transmits narrow pencil beams that can scan 10 elevation segments every five minutes. In the hazard mode, the radar scans a selected 120º segment with updates every minute. Data processing focuses on a series of range cells 0.5º in azimuth and 0.5º in elevation. These cells range from 130 meters out to 90 kilometers. The processor analyzes the velocity and direction of air mass movement, while specialized predictive algorithms recognize a developing windshear situation and automatically issue a warning to air traffic controllers. TDWR concentrates on scanning airport approach and departure areas rather than scanning a continuous 360º sweep. For design purposes, a microburst was considered a severe downdraft with a diameter no larger than 2.2 miles.

Currently, weather data are presented on the display in the tower and traffic control centers and then relayed to pilots. Mode S automatic datalink capability will make it possible to transmit data directly to an aircraft's cockpit display.

Harris Night Hawk 3200 computers are used to process windshear detection and product generation algorithms in real time. It alerts the control tower to a developing weather/wind hazard, and is expandable and capable of handling remote-control functions. When a developing hazard is detected, the system notifies controllers in the tower, turns on TDWR displays, and commands the radar to focus more intently on the hazard. The processor records the data on a disk for future reference. There are two types of TDWR displays: an alphanumeric presentation of windshear hazard information controllers can relay to pilots, and a Geographic Situation Display (GSD) for supervisors both in the tower and in the radar control room.

The system has two transmitters, two receivers, and one data processor. A hot spare processor will be available at most installations. Multiple plasma ribbon displays and display drivers can be installed. SUN Microsystems computers will drive the displays. The receiver system combines with processing techniques to provide over 55 dB of isolation between unwanted ground clutter and desired weather returns.

Operational Characteristics. The TDWR measures winds, turbulence, and storm formations in and around an airport as often as once every minute. Frequent monitoring is important since some of the adverse winds that create the worst hazards are transitory.

Although detection of microbursts and low-level windshear is the radar's main function, the wind shift prediction capability can forecast the location of a gust front 10 to 20 minutes in advance. This allows ATC supervisors to anticipate shifts that require runway changes. Besides the obvious safety implications, this capability saves fuel and time.

TDWR met four requirements:

1. Accurate measurement of windshear severity; the forecasting of the development of windshears (windshear must be reported if it produces a wind-speed rate of change of 20 knots/nm over a distance of 0.5 to 4.0 nm)
2. Scanning of all airport runways and flight paths
3. At least a 90 percent probability of detecting all windshears within six nm of the airport (with a 10 percent or less false alarm rate)
4. Full automation (automatic translation of radar signals into useful information), with a pilot warning time of at least one minute in a simple and objective format

The radar drives a geographic situation display which gives tower and approach control supervisors a map-like view of the local weather situation. Microburst and gust fronts are color-highlighted. Tower controllers will have a smaller, ribbon plasma alphanumeric display close to their positions to monitor microburst alerts. Data are presented alphanumerically, indicating runway approach affected, wind-speed change, and location on the final approach leg. A similar display is being made available for aircraft equipped with the Mode S datalink.

The system combines with longer range, en-route coverage from the NEXRAD weather radar system to improve safety and course selection throughout the air traffic control system. TDWR concentrates on specific approach and departure corridors, detecting and anticipating hazardous weather developments during the most susceptible portions of flight, take-off and landing. Unlike NEXRAD, which analyzes a variety of weather conditions over a large area, TDWR focuses on specific types of conditions in a limited area. Warning can be more timely, and the details of terminal air traffic operations more appropriate.

Variants/Upgrades

New software was developed to make it possible to display the direction in which a storm is moving. In addition, the system has been integrated with the Low-Level Windshear Alert System (LLWAS). Other upgrades and improvements will continue.

Planned improvements include replacing the main computer/processor to increase system capacity and support system upgrades. To extend the life of TDWR systems, a new design for the antenna motors is being developed. This should correct a major mechanical problem that has caused several outages on commissioned systems.

Growth and Decay Tracker. The Massachusetts Institute of Technology developed Growth and Decay Tracker software which uses Doppler radar data to project storm line movement. The software compares the location of data to determine and predict movement. Demonstrations at the Dallas-Ft. Worth airport showed that the new system can predict short-term (10 min to 2 hr) storm front movement and position. Initial attention is on perfecting 30-minute projections, later expanding to 60 and eventually 120 minutes. The system appears to be particularly effective with lines of thunderstorms, but not as effective in predicting air mass storms.

Although the DFW NEXRAD was used for the March 1998 Terminal Convective Weather Forecast Demonstration, plans are to incorporate TDWR and ASR-9 inputs as well. More accurate predictions from this system will be particularly helpful as inputs to decisions regarding gate closures and runway changes, for example. Making changes too early or too late can be expensive and create unnecessary delays in traffic flow.

If successful, the Growth Decay and Tracker will be added as a preplanned product improvement to the Integrated Terminal Weather System (ITWS) being developed for the FAA.

Program Review

Background. The FAA identified the microburst as the primary windshear hazard. The effect of low-level windshear on aircraft causes many air crashes and lost lives, especially during take-off and landing when low altitude and low airspeed make it impossible for an aircraft to react to the hazardous conditions. Pilots and air traffic controllers need to be able to anticipate developing conditions.

Engineers determined that Doppler radar could detect this weather phenomena and examined alternative designs, frequency comparisons, and other considerations from the NEXRAD program, using these inputs in TDWR specification development. The TDWR requirement was developed by a user working group that included air traffic controllers, FAA officials, and pilots to define an automated system.

Development began in 1985 with research into algorithm prediction development and equipment feasibility studies. The TDWR development and production contract was awarded to Raytheon in late 1988. A prototype radar was installed at the Orlando (Florida) airport. It performed successfully and at the request of the tower controllers was left in place.

The FAA implementation plan slipped by 10 months. Plans called for Memphis International Airport to be the first operational system. Installation began in late 1991, with the radar planned for delivery in November 1992. Under the original plan the first system would have been operational by June 1993, but problems such as antenna motor damage from contaminants, computer troubles and unacceptably poor power levels from commercial power sources caused this date to slip to April 1994. The motors have been redesigned.

Site procurement problems delayed many installations and commissionings, but have not impacted delivery schedules. Site problems have included environmental/archeological concerns, wetlands, and hazardous waste. Also, owners have either been reluctant to sell their land for what the government was willing to pay, or have inflated the asking price unreasonably.

The order of installation depended on on-site acquisition. The FAA moved available radars to sites as quickly as property could be acquired and sites prepared. To save time, the FAA decided to install five land-acquisition-delayed sites itself. This included the radars at Las Vegas and Ft. Lauderdale.

The FAA integrated the TDWR with the low-level windshear alert (LLWAS) systems at seven selected airports.

In the FY96 budget, the FAA requested US$4.9 million for the TDWR. The House Appropriations Committee noted that the FAA identified 102 airports where there was significant risk of windshear hazards. The FAA had appealed the House addition, stating that at some airports the more cost-effective way to meet windshear requirements was through the ASR/windshear alert program. This would add a TDWR-like capability to the ASR-9 terminal radar.

In conference, the negotiators removed the added US$40 million but left the US$2.5 million in for Las Vegas and New York. The conferees stated that they were not convinced that the ASR/windshear alert program would prove to be a cost-effective alternative to TDWR. They also expressed concern that the capability was not expected until 2002. Congress addressed this issue again in 1997.

As an interim, the conferees told the FAA to move forward with site surveys for the next five TDWR sites and report their progress 60 days after the legislation was passed. The conferees also directed the FAA to review those sites that were experiencing significant installation delays and certify whether or not the radar would be commissioned. Based on the results of that review, the FAA requested funds reprogramming as needed to ensure that the program continued through 1996.

By the end of 1997, 42 sites had been installed and accepted; 33 were commissioned. The radar at Hong Kong had been accepted and was to be commissioned before the new Chek Lap Kok airport went operational. This system had been acquired in 1994 for operation by the Royal Observatory in Hong Kong.

Between January 1997 and September 1998, 16 TDWR systems were commissioned. The GAO reported that the FAA's failure to properly estimate the cost of installing TDWR systems added US$30 million to the cost of the program. Environmental issue-based problems increased the cost by US$26 million, and land acquisition problems ran it up another US$15.3 million. The GAO found that most schedule delays were the result of land acquisition and environmental problems.

These ongoing problems may well impact the commissioning of the Chicago and New York JFK systems. The Chicago-Midway radar installation had been delayed for two years by problems associated with buying land. As a last resort, the FAA used land condemnation procedures to close on the acquisition in June 1998.

Finding a suitable location for the New York radar delayed things four years. Fears of electromagnetic radiation health hazards drew objections from residents and politicians. Some residents objected to the system, saying that it was unsightly and they did not want it in their neighborhood. A site on public land was picked and environmental study begun. Court action delayed final implementation. In September 1999, the Departments of Transportation and Interior managed to come to an agreement to site the NYC TDWR at Floyd Bennett Field inside the Gateway National Recreation Area in New York. This system will serve both JFK and La Guardia airports.

The only TDWR operational outside the US was the system installed in Honk Kong for the new Chek Lap Kok airport. Lincoln Laboratory developed a storm motion algorithm for the Hong Kong Royal Observatory. This would be used to detect microbursts and gust fronts, the main causes of windshear. Within a day and a half of installation, the new software detected a microburst and continued to regularly detect the hazardous weather conditions.

The following schedule is based on the information available in the FY00 FAA appropriation:

City	Delivery dates	Commissioning dates
Oklahoma City-FAA Academy, OK	December 9, 1991	NA
Memphis, TN	July 1993	December 13, 1994
Houston Intercontinental Airport, TX	March 1993	July 2, 1994
Atlanta, GA	April 1993	December 1995
Washington National Airport, DC	February 1994	January 1995
Denver, CO	December 1993	August 1995
Chicago O'Hare, IL	March 1994	July 1996
St. Louis, MO	May 1994	February 1, 1995
Orlando, FL	June 1994	April 1996
New Orleans, LA	July 1994	March 1996
Tampa, FL	December 1994	April 1996
Miami, FL	November 1995	June 1996
Pittsburgh, PA	December 1994	July 1997
Andrews AFB, MD	December 1994	August 1996
Newark, NJ	December 1994	October 1997
Boston, MA	April 1995	January 1996
Kansas City, MO	December 1994	July 1995
Detroit, MI	March 1996	September 1996
Houston Hobby Airport, TX	August 1995	July 1996
Dallas Love Field, TX	May 1995	January 1996

City	Delivery dates	Commissioning dates
Oklahoma City PSF	December 14, 1994	N/A
Dallas Fort Worth, TX	June 1995	June 1996
Dayton, OH	May 1995	April 1998
Wichita, KS	June 1995	September 1995
Indianapolis, IN	July, 1995	October 1996
Cincinnati, OH	July 1996	June 1997
Philadelphia, PA	July 1996	October 1997
Phoenix, AZ	March 1997	March 1997
Milwaukee, WI	March 1997	November 1997
Chicago Midway Airport, IL	January 2000	July 2000
Cleveland, OH	July 1996	October 1996
Columbus, OH	December 1996	May 1997
San Juan, PR	May 1998	June 1999
West Palm Beach, FL	February 1996	May 1997
Nashville, TN	April 1997	February 1998
Louisville, KY	June 1997	March 1998
Washington Dulles Int., VA	November 1996	March 1998
Charlotte, VA	September 1995	December 1995
Salt Lake City, UT	March 1997	March 1999
Fort Lauderdale, FL	February 1998	May 1999
Baltimore-Washington Int., MD	November 1996	May 1997
Raleigh/Durham, NC	April 1997	January 1998
Minneapolis, MN	March 1997	May 1997
Oklahoma City, OK	March 1997	April 1997
Tulsa, OK	May 1997	April 1998
New York City JFK, NY[a]	February 2000	September 2000
Las Vegas, NV	November 1998	May 1999

[a] The radar for New York City serves both JFK and La Guardia airports. The radar originally planned for LGA was relocated to Las Vegas. A September 1999 agreement settled on a site location. Delivery and commissioning dates depended on site preparation schedules.

Funding

US FUNDING

	FY98		FY99		FY00		FY01	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
Facilities & Equipment (FAA)								
TDWR	-	2.3	-	4.3	-	9.3	-	5.1

All US$ are in millions.

Recent Contracts

No recent contracts over US$5 million recorded.

Timetable

Month	Year	Major Development
	1982	FAA windshear/microburst detection research start
	1985	Development start
	1987	Concept studies complete

Month	Year	Major Development
Nov	1988	Raytheon selected for TDWR
Jun	1990	First demonstrations of TDWR
	1993	First installations planned to be operational
Jul	1994	Houston Intercontinental Airport TDWR commissioned
	1996	US installations (47) to be complete
	1997	Hong Kong Chek Lap Kok installation
Feb	1997	Last currently scheduled commissioning
3Q	1999	Planned New York system installation
Sep	1999	Site selection for NYC system
Sep	2000	Program complete (original plan, NYC system schedule will determine final date)
3Q	2000	Begin improvements
4Q	2001	End improvements

Worldwide Distribution

This is primarily a **US** program. The **Hong Kong** government procured a TDWR system for installation at the Royal Observatory Hong Kong for the Chek Lap Kok airport. This is the only TDWR known to be operational outside the United States.

International sales are possible. **Japan** has indicated an interest in a TDWR which would operate at 6.1 GHz. **Taiwan** and **Singapore** are also interested; **Seoul**, **South Korea,** is considering a system for the new airport it has planned.

Forecast Rationale

TDWR was developed as part of an overall effort by the National Weather Service and Federal Aviation Administration to reduce or eliminate crashes caused by undetected windshear, microburst, and mesocyclones. This was a high-priority effort; since 1970, 18 aviation accidents and 575 deaths in the US have been attributed to hazardous windshear, microbursts and gust fronts in airport terminal areas.

Siting was a major problem and delayed many installations. The radar must be located roughly 12 miles from the airport so the most effective part of the beam covers the most critical airspace. Many selected sites could not be used due to environmental contamination or land acquisition difficulties. Some landowners were unwilling to sell their property for what the FAA would pay. Compounding the problem was the fact that many installations were slated for heavily populated areas where land acquisition is doubly difficult. Public objection to having towers in neighborhoods and fears of electromagnetic effects compounded the acquisition problems.

US production is complete. The final site was installed in the New York City area. The delay in negotiating an acceptable site pushed the final installation and commissioning of this system well past the originally planned date.

Hong Kong was the first to acquire a system, and the system is being marketed internationally. Pacific Rim nations are a possible market for TDWR systems because weather problems around many Pacific sites can be dangerous and change rapidly, especially during the monsoon season. But problems could arise if these nations want the system to operate in a different frequency range than the US radars. TDWR was designed to FAA specifications, and major redesign efforts would be necessary to accommodate desired changes. It is a very sophisticated system, and thus very expensive. Planners must seriously consider traffic levels, weather patterns, and their budget when considering TDWR. For some nations, the radar is simply beyond their means.

Funding constraints often make it necessary for the international aviation community to exclude systems such as TDWR in favor of infrastructure, such as new control centers and interfaces with the developing international ATC system. Lower-cost alternatives will be attractive to international airport operators and any acquisition will now probably be delayed a few years.

The Massachusetts Institute of Technology developed Growth and Decay Tracker software which uses Doppler radar data to project storm line movement. The software compares the location of data details to determine and predict movement. Demonstrations at the Dallas-Ft. Worth airport showed that the new system can predict short-term (10 min to 2 hr) storm front movement and position. Initial attention is on perfecting 30 minute projections, later expanding to 60 and eventually 120 min. The system appears to be particularly effective with lines of thunderstorms but not as effective in predicting air mass storms.

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Ten-Year Outlook

No further production forecast. Upgrades will continue.

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