THE DOW MOBILE MULTIPLE-DOPPLER NETWORK

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1. Prototype DOW1: 1994-1997

The DOW radar program began in 1994 with the goal of fielding a mobile, but fully capable, pencil-beam, scanning, pulsed Doppler radar, with the real-time multiparameter displays, and versatile programmable volume scanning ability typical of stationary weather research systems. The prototype DOW1 (Fig.1)(Wurman et al. 1997) was constructed in a very short period from 11/94 - 4/95, rushed to completion, and fielded in the VORTEX tornado program (Rasmussen et al 1994). The DOW1 employed a surplus transmitter from the CP-2 radar (Keeler 1982), as well as a surplus antenna, pedestal, receiver hardware, and vehicle. Its capabilities, 0.93° beamwidth, 75 m range resolution, reasonably fast volume scanning capability, and Doppler processing, gave it capabilities similar to much larger stationary research radar systems, though with some trade-offs, particularly the use of 3-cm radiation, which was severely attenuated by heavy precipitation. An abbreviated summary of DOW1 radar characteristics is shown in Table 1. While suffering from many limitations due to its prototype nature, and the rapidity of its design and construction, the DOW1 collected unprecedented fine-scale observations in tornadoes (Wurman and Gill 2000), hurricanes (Wurman and Winslow 1998), and a variety of other phenomena. In addition to tornado and hurricane studies, the DOW1 participated in the Small Cumulus Mesoscale Study (SCMS) in Florida in 1995, the FLATLAND/LIFT Boundary Layer Experiment in Illinois in 1996, a microburst study run by MIT/LL and the FAA in 1996, and was used in a radar meteorology course at OU.

Table 1. DOW1 Radar Characteristics (1995)

Tx Power (Peak)	*40 kW*
Antenna Dimension	*1.88 m Parabolic*
	(increased to 2.44 m in 1996)
Beamwidth (3dB)	*1.22°*
	(decreased to 0.93° in 1996)
Pulsewidth	*0.5 - 2.0 ms*
Gatelength	*75 - 300 m(0.5 - 2 ms)*
PRF	*500-2300 Hz*
Polarization	*V*
Processing	*PIRAQ-1*
Products	*V,Z,NCP,SW,NCP,DCZ*
Antenna Scan Speed	*0-30°s-1*
Antenna Scan Modes	*PPI, RHI, SUR*
Truck speed	*0-81 mph*
System Height	*13 feet*
Truck Length	*21 feet*
System Weight	*11,000 lbs*

Figure1. DOW1 with wallcloud in 1995.

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2. Dual-Doppler and 2nd generation DOWs

A second DOW system, DOW2 (Fig. 2), was constructed in 1997, in order to improve on the DOW1 design, and, more importantly, to complete the first mobile dual-Doppler network for the purpose of measuring extremely high resolution vector windfields.

The DOW2 design compensated for many shortfallings in the DOW1, including a larger truck platform, with more power generation capability, more rapid hydraulic levelling systems, and better stability in high winds. The DOW2 used a surplus 2.44 m antenna

Figure 2. DOW2 (top) and DOW3 (bottom)

Table 2: DOW2, DOW3 Radar Characteristics

Tx Power (Peak)	*250 kW*
Antenna Dimension	*2.44 m Parabolic (D3 Cass)*
Beamwidth (3dB)	*0.93°*
Pulsewidth	*0.1 - 2.0 ms*
Gatelength	*12.5 - 300 (0.08 - 2 ms)*
PRF	*500-5000 Hz (+stagger)*
Polarization	*V*
Processing	*PIRAQ-2*
Products	*V,Z,NCP,SW,NCP,DCZ*
Antenna Scan Speed	*0-60°s-1*
Antenna Scan Modes	*PPI, RHI, SUR, Solar*
Truck speed	*0-74 mph*
System Height	*13 feet*
Truck Length	*27 feet*
System Weight	*25,000 lbs*

from NCAR's CP-2 radar with excellent antenna characteristics, and a 0.93° beamwidth. The spare NCAR CP-3 pedestal provided faster scanning at up to 60°s-1. NCAR's PIRAQ-2 processor permitted 83 ns sampling (12.5 m gates). The CP2 transmitter emitted 250 kW pulses for much improved sensitivity to low reflectivity and clear air phenomena. The receiver was redesigned to be compatible with mobile bistatic systems (Wurman et al 1993, Wurman 1994, 2001).

Shortly thereafter, the DOW1 was retired and replaced with the DOW3 (Fig. 2) radar. The DOW3 was similar to the DOW2, but employed some systems scavenged from the DOW1, including the pedestal, and other hardware. However, the receiving system, processing, power systems, and levelling system were all replaced with updated designs.

The capabilities of the DOW2 and DOW3 have remained relatively stable since their construction, with the important exception of new antenna control hardware and software completed in 1999. The characteristics of the DOW2 and DOW3 are shown in Table 2.

The DOW mobile dual-Doppler network has been used to retrieve vector windfields in several tornadoes (Richardson et al 2001) and single-Doppler data in others (Wurman 2001, Lee and Wurman 2001) as part of the Radar Observations of Thunderstorms and Tornadoes Experiment (ROTATE). The DOWs have measured, for the first time, the fine-scale vector windfield structure of tornadic storms, the genesis process of tornadoes, and the structure and behavior of multiple vortices within tornadoes, and other related phenomena. Vector windfields have also been retrieved in hurricanes (Zhang et al 2001).

The DOWs are deployed near supercellular thunderstorms, as illustrated in Fig. 3, to collect dual-Doppler data over a 100-200 km2 area with about 150-250 m resolution (Fig 4). In hurricanes and other phenomena both shorter (as small as 2 km) and longer baselines (as large as 70 km) have been employed.

The DOW facility has been used by a number of researchers to study a wide variety of atmospheric phenomena. While designed for severe weather intercepts, the majority of DOW deployments have been for several studies of non-severe phenomena. The DOWs

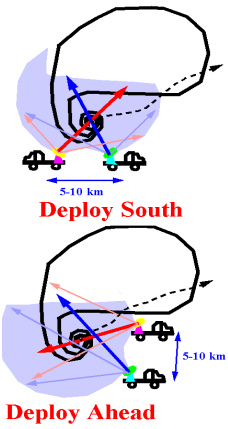

Figure 3. Deployment strategies for ROTATE. DOWs establish 5-10 km dual-Doppler baselines ahead or to right of developing or existing tornadoes. Rapid sector or 360° scans out to a range of 6-25 km capture genesis and structure.

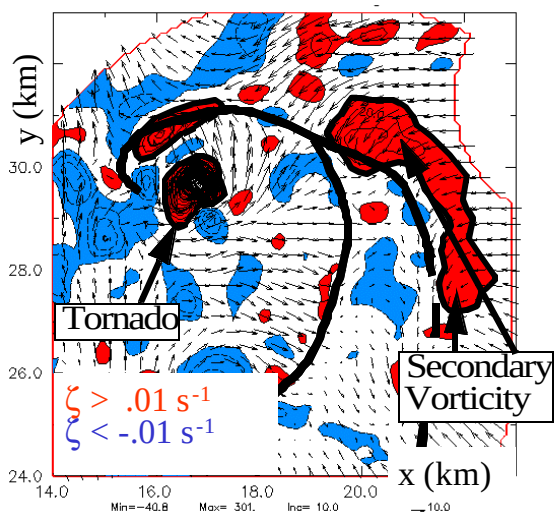

Figure 4. Horizontal Wind Vectors and Vertical Vorticity in a possibly cyclic tornado

were deployed in dual-Doppler configurations at various locations along the Pacific US coast during 1998 in the CALJET experiment and in Utah for the Intermountain Precipitation Experiment (IPEX) in 2000. One DOW was deployed in the Mesoscale Alpine Program (MAP) in Switzerland/Italy in 1999 (Fig 5.)

The DOWs formed part of a quad-Doppler network during the STEP program in 2000. A DOW was used in the FAA/RAP turbulence study in Juneau AK in 1999-2000 and in the Goodwin Creek rainfall study in 2000-1.

The DOWs have formed the core of a radar educational laboratory at OU. Since they are easy to use, and to deploy, they are uniquely accessible state-of-the-art research tools, which provide students with an exemplary opportunity to design, and perform radar meteorology experiments similar to those conducted during real field programs.

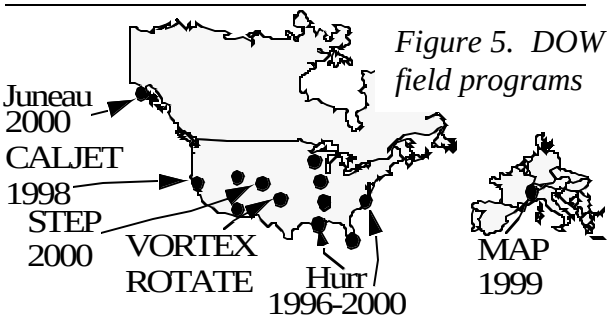

Figure 5. DOW field programs

The DOW program is a collaboration between OU and NCAR, supported by NSF and ONR.

Table 3: DOW4 Radar Characteristics

Tx Power (Peak)	*50 kW*
Antenna Dimension	*2.44 m Parabolic*
Beamwidth (3dB)	*0.93°*
Pulsewidth	*0.1 - 2.0 ms*
Gatelength	*30 - 300 m (0.2 - 2 ms)*
PRF	*500-7000 Hz (+stagger)*
Polarization	*Tx:45 Rx: H V simult*
Processing	*BINET Board*
Products	
V,Z,NCP,SW,NCP,DCZ,ZDR, rHV	
Antenna Scan Speed	*0-60°s-1*
Antenna Scan Modes	*PPI, RHI, SUR, Solar*
Truck speed	*0-78 mph*
System Height	*12.5 feet*
Truck Length	*23 feet*

3. Dual-Polarization DOW4

More DOWs with different and advanced characteristics have been or are being constructed. The dual-polarization DOW4 (Fig 6.) was constructed in OK and CO for the Athens National Observatory and has been used for precipitation studies at the University of Iowa in 2000-1 and, with the DOW2 and DOW3 as part of a multiple-DOW network in project ROTATE. The DOW4 is installed on a truck platform intermediate in size between the DOW1 and the larger DOW2,3, and is tailored for deployments along more winding and varied terrain typically found away from the mid-western USA, particularly that of Europe. Its radar characteristics are listed in Table 3.

Other institutions are constructing mobile scanning pulsed-Doppler radars with varying capabilities, following and varying the DOW design in various fashions. NSSL, TAMU and TTU are collaborating to construct two 5-cm DOW-type systems and FSU is constructing a larger 5-cm mobile radar. OU and NCAR are constructing a rapid-scan 6-1-beam Rapid-DOW (Wurman and Randall 2001).

Figure 6. DOW4 dual-polarization radar