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OFFICE OF THE FEDERAL COORDINATOR FOR
METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

FEDERAL METEOROLOGICAL HANDBOOK NO. 11

DOPPLER RADAR METEOROLOGICAL OBSERVATIONS

PART A
SYSTEM CONCEPTS, RESPONSIBILITIES, AND PROCEDURES

FCM-H11A-2009

Washington, DC
May 2009

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PREFACE

The Federal Coordinator for Meteorological Services and Supporting Research has the responsibility to maintain and publish Federal Meteorological Handbooks. This series of documents provides standards and procedures to facilitate the efficient collection, sharing, and use of meteorological information by agencies of the federal government and private industry.

The original Federal Meteorological Handbook, Number 11 (FMH-11), DOPPLER RADAR METEOROLOGICAL OBSERVATIONS, was prepared and published under the auspices of the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) at the request of the Next Generation Weather Radar (NEXRAD) Program Council and in coordination with the federal agencies that are represented on the Interdepartmental Committee for Meteorological Services and Supporting Research. The purpose of FMH-11 is to standardize, insofar as practical, the operation of the Weather Surveillance Radar-1988, Doppler (WSR-88D) systems and the procedures used by personnel of the Departments of Commerce, Defense, and Transportation. By approving publication of this handbook, those agencies have agreed to operate their WSR-88D systems accordingly. Some flexibility under certain meteorological, siting, or mission circumstances is permitted to enhance the quality and utility of some WSR-88D products.

The revision process is dependent on the evolution of WSR-88D subsystems hardware, software, and products. Part A has been revised in conjunction with recent WSR-88D software releases to ensure it provides users current operations guidance. Parts B, C, and D have been revised in a separate effort principally through the guidance of the WSR-88D Radar Operations Center (ROC). All revisions are coordinated among the NEXRAD triagencies (Department of Commerce (DOC), Department of Defense (DoD), and Department of Transportation (DOT)); thus, they possess the same authority as the initial edition of FMH-11.

The agencies should review the documents annually. The goal is to review and update the handbooks (as necessary) as part of every WSR-88D software build release. As required, the handbooks will be updated and published in electronic format, and made available on the OFCM home page at http://www.ofcm.gov/homepage/text/pubs.htm. Readers can make copies of the handbooks without a request for approval from the OFCM. A summary of changes made during updates will be annotated in the preface of each part.

In all, FMH-11 has four parts:

Part A - System Concepts, Responsibilities, and Procedures (May 2009)

Part B - Doppler Radar Theory and Meteorology (December 2005)

Part C - WSR-88D Products and Algorithms (April 2006)

Part D - WSR-88D Systems Description and Operational Applications (February 2006)

Note: Parts B – D are out of date, as of WSR-88D Software Build 7, released in 2006 and with the Open Radar Data Acquisition (ORDA) which replaced the legacy RDA. Efforts are underway to update these parts of FMH-11 to the current baseline.

Part A provides an introduction for the entire handbook including the restatement of some policy, definitions of terms, and agencies' functions and responsibilities under the WSR-88D System Concept. It provides listings of the location of systems and products the WSR-88D can generate and information on the modes of operation, volume coverage patterns, and levels of data archival. Additionally, authority for change to adaptation parameters is established. Familiarity with Part A should aid the user of other parts of FMH-11 and provide a better understanding of the overall WSR-88D system.

Summary of Major Changes:
This version of Part A replaces the one published in May 2008. This version updates the document to reflect Radar Product Generator and Radar Data Acquisition software Build 11 (release to field sites starting in May 2009). These updates include: deletion of the Severe Weather Analysis Products (No. 43 – 46); deletion of the Severe Weather Probability Product (No. 47), deletion of the Combined Shear Product (No. 87); and addition of the use of Clutter Mitigation Decision algorithm, for clutter detection and removal. Minor errors in the previous version have also been corrected.

Samuel P. Williamson
Federal Coordinator for Meteorological
Services and Supporting Research

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PART A
SYSTEM CONCEPTS, RESPONSIBILITIES, AND PROCEDURES

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DEFINITION OF TERMS

WSR-88D System. A WSR-88D system is composed of a Weather Surveillance Radar - 1988, Doppler and communications links to distribute products to various agency display systems. The functional designations are: Radar Data Acquisition, Radar Product Generator, and agency user display systems.

Agency User Display Systems. The agencies have various user display systems with dedicated and/or dial connections to WSR-88Ds. The current list of display systems is:

> **Open Principal User Processor (OPUP)**. This DoD display system is fielded in three sizes: small, medium, and large.
>
> **Advanced Weather Interactive Processing System (AWIPS)**. The National Weather Service (NWS) operates AWIPS at each Weather Forecast Office to integrate and display data and products from all sources.
>
> **Weather and Radar Processor (WARP)**. The WARP is the Federal Aviation Administration's (FAA's) computer network that places WSR-88D product data on air controllers' displays in Air Route Traffic Control Centers (ARTCCs). The WARP also collects, formats, and distributes weather information to Center Weather Service Units at FAA ARTCCs.
>
> **Integrated Terminal Weather System (ITWS)**. This FAA system integrates data from the WSR-88D, Terminal Doppler Weather Radar, Airport Surveillance Radar-9, Airport Surveillance Radar-11, Low-level Wind Shear Alert Systems, Automated Surface Observing Systems, and other NWS systems.
>
> **Medium Intensity Airport Weather System (MIAWS)**. This FAA system is at three airports that have a medium intensity of aircraft operations.
>
> **Microprocessor En Route Automated Radar Tracking System (MEARTS)**. This FAA system is located at Combined Center/Radar Approach Control outside the conterminous United States (CONUS).

External User. An external user is anyone other than a Principal User who uses WSR-88D data and products (e.g., information service companies, broadcast meteorologists, aviation interests, marine interests, industrial meteorologists, other government agencies, and universities).

National Weather Radar Network. The national weather radar network consists of WSR-88D sites dispersed throughout the CONUS.

Network Site: A DOC WSR-88D site in the CONUS that continuously collects, collates, and makes available radar data and products in support of the national weather radar network.

Non-Network Site. A non-Network Site is a non-CONUS DoD site or a non-CONUS Department of Transportation site.

Principal User. Principal users are the NWS, Air Force, Marine Corps Weather Service units, and FAA.

> **Associated Principal User.** An associated principal user is a principal user linked to a WSR-88D system with a dedicated telecommunication line.
>
> **Non-Associated Principal User.** A non-associated principal user is a principal user with access to a WSR-88D system through means of dial telecommunication.

Supplemental Site: A DoD WSR-88D site in the CONUS. It continuously collects, collates, and makes available radar data and products in support of the DoD.

CHAPTER 1

BACKGROUND

1.1 <u>Introduction</u>. The impetus for originally preparing this handbook was the development, acquisition, and deployment of the Weather Surveillance Radar - 1988, Doppler (WSR-88D). The motivation for this update is to reflect the changing operation of the WSR-88D system as it matures.

The Federal Coordinator for Meteorological Services and Supporting Research determined that the preparation of this handbook was required to support triagency use of the WSR-88D. Subsequent to coordination within the Interdepartmental Committee for Meteorological Services and Supporting Research, a Doppler Radar Meteorological Observations Working Group (WG/DRMO) was formed within the Committee for Basic Services. The WG/DRMO was charged with the responsibility for preparation of the Federal Meteorological Handbook, Number 11, FMH-11, this handbook.

The WG/DRMO was composed of personnel from the National Weather Service (NWS) within the Department of Commerce (DOC), the Air Force Weather Agency and the Marine Corps within the Department of Defense (DoD), and the Federal Aviation Administration (FAA) within the Department of Transportation (DOT). This version has been coordinated with the triagency WSR-88D focal points and triagency WSR-88D Radar Operations Center (ROC) personnel.

1.2 <u>Purpose and Scope</u>. This handbook provides information, guidance, and instruction regarding the triagency management and operation of the WSR-88D systems. The following definitions apply throughout this handbook:

Shall: means that a procedure or practice is mandatory.
Should: means that a procedure or practice is recommended.
May: means that a procedure or practice is optional.
Will: means futurity, not a requirement to be applied to a procedure or practice.

1.3 <u>Policy</u>. The WSR-88D systems shall be operated to satisfy the integrated set of federal requirements that emanated primarily from the public charters of the departments represented in the Next Generation Weather Radar (NEXRAD) Program Council (NPC) and the NEXRAD Program Management Committee (NPMC). This handbook has been developed to establish standards for the triagency operation of the WSR-88D systems and the collection, processing, and dissemination of information to meet those requirements. As a federal system, it shall be operated to meet as many requirements as possible. However, this handbook guides operations to fulfill first those fundamental requirements of the agencies that founded the program. Policy, procedures, and operational concepts, as defined in this handbook, shall be adhered to by the principal user agencies.

1.4 Changes. Suggestions for modifications and additions should be sent to the WSR-88D Radar Operations Center webmaster at http://www.roc.noaa.gov/Feedback/ for consideration for inclusion in a future update. No modification shall be adopted that adversely impacts fulfillment of the integrated requirements that drove the development of the program without the consent of the NPC. (The NPC has delegated this responsibility to the NPMC.)

CHAPTER 2

WSR-88D SYSTEM CONCEPT

2.1 <u>Overview of Agency Functions</u>. The following sections provide discussions of each principal user agency's functions with regard to WSR-88D system operations.

2.1.1 Department of Commerce. Within the DOC, the National Oceanic and Atmospheric Administration's (NOAA) NWS is the civilian weather agency of the Federal Government. As such, it must fill a broad spectrum of climatological, meteorological and hydrological requirements in its efforts to protect life and property and support the economy of the United States (U.S.). Specifically, the NWS is responsible for the detection and public warning of hazardous weather such as tornadoes, severe thunderstorms, hurricanes, floods, flash floods, winter storms, damaging tides, and any other meteorological or hydrological event with possible harmful effects. The NWS provides weather information for marine operations covering offshore, coastal, Great Lakes, and river and harbor areas for both commercial and recreational activities. The NWS also routinely provides forecasts for civilian aviation, reservoir regulation, wildland fire fighting agencies, and a variety of commercial activities. To assist in fulfilling these responsibilities, the NWS operates the national weather radar network and uses information from DoD and DOT WSR-88D systems.

2.1.2 Department of Defense. Within the DoD, the U.S. Air Force provides worldwide meteorological and aerospace environmental services to the Air Force, Army, and certain other DoD elements; and the Marine Corps Weather Service units provide environmental support to U.S. Marine Corps activities and operations. These organizations are responsible for providing and relaying severe weather warnings for the protection of DoD resources and personnel, managing flood control reservoirs (U.S. Army Corps of Engineers), providing meteorological and space environmental information to aid the decision-making process at all levels of command authority, and supporting military aerospace operations. To meet these responsibilities, DoD operates WSR-88D systems in the United States and overseas and uses information from the DOC and DOT WSR-88D systems.

2.1.3 Department of Transportation. The DOT, through the FAA, is responsible for the safe and efficient utilization of the National Airspace System. In meeting this responsibility, DOT disseminates information on the location and intensity of potentially hazardous weather conditions to pilots, air traffic controllers, air traffic flow management, and others concerned with aviation. The DOT obtains and processes data from DOC, DoD, and DOT WSR-88D systems for use by DOT personnel and DOC personnel located in DOT facilities.

2.2 <u>System Support Management</u>. Operational support for all deployed WSR-88D units is the responsibility of the triagency ROC located in Norman, Oklahoma. The ROC provides centralized radar operations support, field assistance, software maintenance, and engineering support; and depot-level support (e.g., bull gear replacement) of the WSR-88D units deployed by the three Principal Users.

2.3 <u>Memorandum of Agreement for the Interagency Operation of the WSR-88D</u>. Policies, procedures, and operational concepts, as defined in this handbook, have been agreed to by each principal user agency. Each agency shall endeavor to support, to the highest degree possible and in accordance with the terms of the Memorandum of Agreement (MOA) for Interagency Operation of the WSR-88D, the data, product, and operational requirements of the other agencies. This supportive service shall be consistent with the capabilities and mission priorities of the agency that has received the request for support. The MOA also forms the basis for the membership, leadership, and activities of the Unit Radar Committee (URC) that shall be at each WSR-88D site where more than one NEXRAD agency is connected. The current MOA is available at: http://www.roc.noaa.gov/PDFs/MOA.pdf.

2.4 <u>External User Access to WSR-88D Products and Level II Data</u>. Real-time access to products and Level II data can be achieved through two networks the NWS manages: (1) Products can be obtained through the NWS' Radar Product Central Collection Dissemination Service (RPCCDS); and (2) Level II data can be obtained through the NWS' Level II Data Collection and Distribution Network.

2.4.1 Products. The RPCCDS makes a predefined subset of all WSR-88D products available in near real time from every WSR-88D except four remote DoD non-CONUS locations (Lajes Air Base (AB), Kadena AB, Camp Humphreys, and Kunsan AB) available to external users. Users are able to connect to the RPCCDS via a dedicated connection or file transfer protocol. In addition, a predetermined set of products are provided to NOAAPORT users. Additional RPCCDS information is available at: http://www.nws.noaa.gov/tg/rpccds.html. A predetermined subset of the images available from each WSR-88D is available at: http://weather.noaa.gov/radar/national.html. Non-NEXRAD agency connections to individual radar sites for product data are not permitted.

2.4.2 Level II Data. The principal user agencies offer direct access to Level II data from operational sites on a limited basis to support government operations at sites where the required interface hardware is installed. Only certified systems will be permitted to connect to radars and only with advance triagency approval. The NWS has established a WSR-88D Level II Data Collection and Distribution Network. The network includes all NWS radars (121), 13 CONUS DoD radars, and one OCONUS FAA radar. More sites may be added at a later date. These data are available in near real time from many sources and can be used or redistributed without any restriction. Information on the network is available at: http://www.roc.noaa.gov/NWS_Level_2/.

2.5 <u>National Centers' Applications</u>. The national centers of the NWS, Air Force, and FAA have agency-specific display platforms to acquire and display real-time WSR-88D data for their agency-specific applications. Several dial ports per Radar Product Generator (RPG) are allocated for national centers' access. National centers may require information to suit a wide range of missions that assist decision making in support of critical operations and exercises. The FAA's center has access to Doppler weather radar information from a variety of sources to support its management of aviation traffic flow. The national centers are: Storm Prediction Center, National Hurricane Center, Ocean Prediction Center, Aviation Weather Center, Hydrometeorological Prediction Center, Air Force CONUS and Pacific Operational Weather Squadrons, River Forecast Centers, and the Air Traffic Control Systems Command Center.

CHAPTER 3

SITE RESPONSIBILITIES

3.1 <u>Introduction</u>. The WSR-88D system is vital to supporting the operational mission of each principal user agency. Therefore, WSR-88D systems shall be operated to satisfy the integrated needs of all three agencies. Each agency shall endeavor to support, to the maximum extent possible, the data, products, and operational requirements of the others, consistent with the capabilities and mission priorities of that agency. The units shall be operated in accordance with the procedures described in this handbook and as agreed to by the URC within the terms of the MOA for the Interagency Operation of the WSR-88D. The weather forecast office (WFO), base weather station or operational weather squadron that is the manager of the Master System Control Function (MSCF) chairs the URC (Tables 3-1 through 3-4).

WSR-88D sites are categorized as Network, Supplemental, or non-Network. Tables 3-1 through 3-4 list the metropolitan areas served by each system. In addition, the WSR-88D system four-letter International Civil Aviation Organization (ICAO) identifier, name of RDA system location, and RDA antenna elevation in feet above mean sea level (MSL) are specified for each system. Table 3-5 shows how the antenna elevation above MSL is computed.

3.2 <u>Network Site Responsibilities</u>. A WSR-88D Network Site (Table 3-1) shall:

- Operate continuously, 24 hours per day, and collect, collate and make available via telecommunications, radar data and products in support of the national weather radar network. This support shall be performed in accordance with the policies described in this handbook and such agreements as may be made among the principal users, including the MOA for Interagency Operation of the WSR-88D. A copy of the MOA may be obtained at: http://www.roc.noaa.gov/PDFs/MOA.pdf.
- Use one of the operational modes and volume coverage patterns (VCPs) agreed to by the URC.
- Set the default precipitation VCP as agreed to by the URC.
- Set the Mode Selection Function to switch the RPG Operational Mode to Clear Air (i.e., to a Clear Air VCP) and to switch the mode from Clear Air to Precipitation as agreed to by the URC.
- Generate and distribute WSR-88D products as specified by *WSR-88D Handbook*, *Volume 1*, *RPG*, *Guidance on Adaptable Parameters.* The handbook can be obtained at: http://www.roc.noaa.gov/ssb/sysdoc/Operations.asp.
- Apply appropriate clutter filtering (e.g. Clutter Mitigation Decision Algorithm (CMD)) to reduce ground clutter and anomalous propagation (AP) for the WSR-88D systems the WFOs control, including DoD and DOT systems, via the MSCF (Tables 3-1 through 3-4).

3.3 Supplemental Site Responsibilities. A WSR-88D Supplemental Site (Table 3-2) shall:

- Operate continuously, 24 hours per day, and collect, collate, and make available via telecommunications, radar data and products in support of the DoD. This support shall be performed in accordance with the policies described in this handbook and such agreements as may be made among the principal users, including the MOA for Interagency Operation of the WSR-88D. A copy of the MOA may be obtained at: http://www.roc.noaa.gov/PDFs/MOA.pdf.
- Use one of the operational modes and VCPs agreed to by the URC.
- At Vandenberg AFB, set the default precipitation VCP as agreed to by the URC.
- At Vandenberg AFB, set the Mode Selection Function to switch the RPG Operational Mode to Clear Air (i.e., to a Clear Air VCP) and to switch the mode from Clear Air to Precipitation as agreed to by the URC.
- Provide assistance to NWS WFOs and the FAA by providing access to weather radar data to reduce gaps in the national weather radar network. Ensure the provision of radar data is consistent with responsibilities stated in the MOA for Interagency Operation of the WSR-88D.
- Generate and distribute WSR-88D products as specified by *WSR-88D Handbook*, *Volume 1*, *RPG*, *Guidance on Adaptable Parameters*. The handbook can be obtained at: http://www.roc.noaa.gov/ssb/sysdoc/Operations.asp.
- Apply appropriate clutter filtering (e.g. CMD) to reduce ground clutter and AP for the WSR-88D systems the DoD controls via the MSCF (Table 3-2).
- Maintain an Implementing Agreement (IA) with the NWS WFO controlling the MSCF (where applicable) regarding the WSR-88D maintenance. The DoD maintenance organization will initiate and maintain the IA. The IA template can be obtained from the DoD WSR-88D focal point listed in Appendix B of the MOA for Interagency Operation of the WSR-88D (http://www.roc.noaa.gov/PDFs/MOA.pdf).

3.4 Non-Network Site Responsibilities.

A DOT non-CONUS Site (Table 3-3) shall:

- Operate continuously, 24 hours per day, and collect, collate, and make available via telecommunications, radar data and products in support of FAA's enroute weather radar coverage, and DoD and NWS operations. This support shall be performed in accordance with the policies described in this handbook and such agreements as may be made among the principal users, including the MOA for Interagency Operation of the WSR-88D. A copy of the MOA may be obtained at: http://www.roc.noaa.gov/PDFs/MOA.pdf.
- Use one of the operational modes and VCPs agreed to by the URC.
- Generate and distribute WSR-88D products as specified by *WSR-88D Handbook, Volume 1, RPG, Guidance on Adaptable Parameters*. The handbook can be obtained at: http://www.roc.noaa.gov/ssb/sysdoc/Operations.asp.

A DoD non-CONUS Site (Table 3-4) shall:

- Operate continuously, 24 hours per day, and collect, collate, and make available via narrowband communications, radar data and products in support of the DoD. This support shall be performed in accordance with the policies described in this handbook and such agreements as may be made among the principal users, including the MOA for Interagency Operation of the WSR-88D. A copy of the MOA may be obtained at: http://www.roc.noaa.gov/PDFs/MOA.pdf.
- Use one of the operational modes and VCPs agreed to by the URC (where applicable).
- Set the default precipitation VCP as agreed to by the URC (where applicable).
- Set the Mode Selection Function to switch the RPG Operational Mode to Clear Air (i.e., to a Clear Air VCP) and to switch the mode from Clear Air to Precipitation as agreed to by the URC (where applicable).
- Generate and distribute WSR-88D products as specified by *WSR-88D Handbook, Volume 1, RPG, Guidance on Adaptable Parameters*. The handbook can be obtained at: http://www.roc.noaa.gov/ssb/sysdoc/Operations.asp.
- Apply appropriate clutter filtering (e.g., CMD) to reduce ground clutter and AP for the WSR-88D systems the DoD controls via the MSCF (Table 3-4).
- Maintain an Implementing Agreement (IA) with the NWS WFO controlling the MSCF (where applicable) regarding the WSR-88D maintenance. The DoD maintenance organization will initiate and maintain the IA. The IA template can be obtained from the DoD WSR-88D focal point listed in Appendix B of the MOA for Interagency Operation of the WSR-88D (http://www.roc.noaa.gov/PDFs/MOA.pdf).

TABLE 3-1
NETWORK SITES

Metropolitan Area	Radar ICAO	RDA System Location	Antenna Elev. (Ft) MSL
AL, Birmingham	KBMX	Alabaster, AL	759
AL, Mobile	KMOB	Mobile, AL	289
AL, Northeast AL	KHTX	Hytop, AL	1,859
AR, Western AR	KSRX	Chaffee Ridge, AR **	737
AR, Little Rock	KLZK	North Little Rock, AR	649
AZ, Flagstaff	KFSX *	Flagstaff, AZ	7,514
AZ, Phoenix	KIWA	Phoenix, AZ	1,426
AZ, Tucson	KEMX	Tucson, AZ	5,319
AZ, Yuma	KYUX *	Yuma, AZ **	239
CA, Santa Ana Mts.	KSOX	Santa Ana Mountains, CA **	3,106
CA, Eureka	KBHX	Eureka, CA	2,516
CA, Los Angeles	KVTX	Los Angeles, CA	2,807
CA, Sacramento	KDAX	Davis, CA	144
CA, San Diego	KNKX	San Diego, CA	1,052
CA, San Francisco	KMUX	Los Gatos, CA	3,550
CA, San Joaquin	KHNX	Hanford, CA	340
CO, Denver	KFTG	Front Range Airport, CO	5,611
CO, Grand Junction	KGJX*	Grand Junction, CO	10,101
CO, Pueblo	KPUX	Pueblo, CO	5,363
FL, Jacksonville	KJAX	Jacksonville, FL	160
FL, Key West	KBYX	Boca Chica Key, FL	89
FL, Melbourne	KMLB	Melbourne, FL	116
FL, Miami	KAMX	Miami, FL	111
FL, Tallahassee	KTLH	Tallahassee, FL	177
FL, Tampa	KTBW	Ruskin, FL	122

* - Redundant Radar Data Acquisition (RDA), ** Western AR MSCF at Tulsa, OK WFO; Yuma MSCF at Phoenix, AZ WFO; Santa Ana Mtns MSCF at San Diego, CA WFO

TABLE 3-1
NETWORK SITES

Metropolitan Area	Radar ICAO	RDA System Location	Antenna Elev. (Ft) MSL
GA, Atlanta	KFFC	Peachtree City, GA	972
IA, Des Moines	KDMX	Johnston, IA	1,095
IA, Quad Cities	KDVN	Davenport, IA	851
ID, Boise	KCBX	Boise, ID	3,172
ID, Pocatello	KSFX	Springfield, ID	4,539
IL, Lincoln	KILX	Lincoln, IL	731
IL, Chicago	KLOT	Romeoville, IL	760
IN, Evansville	KVWX	Owensville, IN**	625
IN, Indianapolis	KIND	Indianapolis, IN	887
IN, Northern Indiana	KIWX	North Webster, IN	1,056
KS, Dodge City	KDDC	Dodge City, KS	2,671
KS, Goodland	KGLD	Goodland, KS	3,716
KS, Topeka	KTWX	Topeka, KS	1,415
KS, Wichita	KICT	Wichita, KS	1,400
KY, Jackson	KJKL	Jackson, KY	1,461
KY, Louisville	KLVX	Fort Knox, KY	833
KY, Paducah	KPAH	Paducah, KY	506
LA, Lake Charles	KLCH	Lake Charles, LA	137
LA, Slidell	KLIX	Slidell Airport, LA	179
LA, Shreveport	KSHV	Shreveport, LA	387
MA, Boston	KBOX	Taunton, MA	232
ME, Caribou	KCBW	Houlton, ME	860
ME, Portland	KGYX	Gray, ME	474
MI, Detroit	KDTX	White Lake, MI	1,216

** - Evansville MSCF at Paducah, KY WFO

TABLE 3-1
NETWORK SITES

Metropolitan Area	Radar ICAO	RDA System Location	Antenna Elev. (Ft) MSL
MI, Grand Rapids	KGRR	Grand Rapids, MI	875
MI, Marquette	KMQT	Negaunee, MI	1,525
MI, N. Central Lower - MI	KAPX	Gaylord, MI	1,561
MN, Duluth	KDLH	Duluth, MN	1,542
MN, Minneapolis	KMPX	Chanhassen, MN	1,101
MO, Pleasant Hill	KEAX	Pleasant Hill, MO	1,092
MO, Springfield	KSGF	Springfield, MO	1,375
MO, St. Louis	KLSX	Weldon Spring, MO	722
MS, Jackson	KDGX	Brandon, MS	609
MT, Billings	KBLX	Billings, MT	3,703
MT, Glasgow	KGGW	Glasgow, MT	2,384
MT, Great Falls	KTFX	Great Falls, MT	3,805
MT, Missoula	KMSX*	Missoula, MT	7,978
NC, Morehead City	KMHX	Newport, NC	145
NC, Raleigh/Durham	KRAX	Clayton, NC	462
NC, Wilmington	KLTX	Shallotte, NC	145
ND, Bismarck	KBIS	Bismarck, ND	1,755
ND, Grand Forks/Fargo	KMVX	Grand Forks, ND	1,083
NE, Grand Island	KUEX	Blue Hill, NE	2,057
NE, North Platte	KLNX	North Platte, NE	3,112
NE, Omaha	KOAX	Valley, NE	1,262
NM, Albuquerque	KABX	Albuquerque, NM	5,951
NV, Elko	KLRX *	Elko, NV	6,895
NV, Las Vegas	KESX	Las Vegas, NV	4,948

* - Redundant RDA

TABLE 3-1
NETWORK SITES

Metropolitan Area	Radar ICAO	RDA System Location	Antenna Elev. (Ft) MSL
NV, Reno	KRGX*	Nixon, NV	8,396
NY, Albany	KENX	East Berne, NY	1,935
NY, Binghamton	KBGM	Binghamton, NY	1,703
NY, Buffalo	KBUF	Buffalo, NY	790
NY, Brookhaven	KOKX	Upton, NY	199
OH, Cincinnati	KILN	Wilmington, OH	1,170
OH, Cleveland	KCLE	Cleveland, OH	860
OK, Norman	KTLX	Midwest City, OK	1,278
OK, Tulsa	KINX	Inola, OK	749
OR, Medford	KMAX*	Medford, OR	7,561
OR, Pendleton	KPDT	Pendleton, OR	1,580
OR, Portland	KRTX	Portland, OR	1,728
PA, State College	KCCX	State College, PA	2,486
PA, Philadelphia	KDIX	Fort Dix, NJ	230
PA, Pittsburgh	KPBZ	Coraopolis, PA	1,266
SC, Charleston	KCLX	Grays, SC	229
SC, Columbia	KCAE	West Columbia, SC	345
SC, Greer	KGSP	Greer, SC	1,069
SD, Aberdeen	KABR	Aberdeen, SD	1,383
SD, Rapid City	KUDX	New Underwood, SD	3,195
SD, Sioux Falls	KFSD	Sioux Falls, SD	1,495
TN, Knoxville/TriCities	KMRX	Morristown, TN	1,434
TN, Memphis	KNQA	Millington Naval Air Station, TN	435
TN, Nashville	KOHX	Old Hickory, TN	676

* - Redundant RDA

TABLE 3-1
NETWORK SITES

Metropolitan Area	Radar ICAO	RDA System Location	Antenna Elev. (Ft) MSL
TX, Amarillo	KAMA	Amarillo, TX	3,703
TX, Austin/San Antonio	KEWX	New Braunfels, TX	767
TX, Brownsville	KBRO	Brownsville, TX	88
TX, Corpus Christi	KCRP	Corpus Christi, TX	142
TX, Dallas/Fort Worth	KFWS	Fort Worth, TX	777
TX, El Paso	KEPZ	Santa Teresa, NM	4,218
TX, Houston/Galveston	KHGX	Dickinson, TX	115
TX, Lubbock	KLBB	Lubbock, TX	3,378
TX, Midland/Odessa	KMAF	Midland Intl. Airport	2,962
TX, San Angelo	KSJT	San Angelo, TX	2,004
UT, Cedar City	KICX *	Cedar City, UT **	10,757
UT, Salt Lake City	KMTX*	Salt Lake City, UT	6,593
VA, Sterling	KLWX	Sterling, VA	405
VA, Roanoke	KFCX	Roanoke, VA	2,965
VA, Norfolk	KAKQ	Wakefield, VA	255
VT, Burlington	KCXX	Colchester, VT	431
WA, Seattle/Tacoma	KATX	Everett, WA	642
WA, Spokane	KOTX	Spokane, WA	2,449
WI, Green Bay	KGRB	Green Bay, WI	806
WI, La Crosse	KARX	La Crosse, WI	1,357
WI, Milwaukee	KMKX	Dousman, WI	1,023
WV, Charleston	KRLX	Charleston, WV	1,213
WY, Cheyenne	KCYS	Cheyenne, WY	6,193
WY, Riverton/Lander	KRIW	Riverton, WY	5,633

* - Redundant RDA; ** - Cedar City MSCF at Salt Lake City, UT WFO

TABLE 3-2
SUPPLEMENTAL SITES

Coverage Area	Radar ICAO	RDA System Location	MSCF Location	Antenna Elev. (Ft) MSL
AL, Maxwell AFB	KMXX	Carrville, AL	WFO at Birmingham, AL	560
AL, Fort Rucker	KEOX	Echo, AL	WFO at Tallahassee, FL	537
CA, Beale AFB	KBBX	Oroville, CA	WFO at Sacramento, CA	221
CA, Edwards AFB	KEYX	Boron, CA	WFO at Las Vegas, NV	2,873
CA, Vandenberg AFB	KVBX	Orcutt, CA	Vandenberg AFB, CA	1,354
DE, Dover AFB	KDOX	Ellendale State Forrest, DE	WFO at Wakefield, VA	164
FL, Eglin AFB	KEVX	Red Bay, FL	WFO at Mobile, AL	221
GA, Moody AFB	KVAX	South Stockton, GA	WFO at Jacksonville, FL	330
GA, Robins AFB	KJGX	Jeffersonville, GA	WFO at Atlanta/Peachtree City, GA	618
KY, Fort Campbell	KHPX	Trenton, KY	WFO at Paducah, KY	624
LA, Fort Polk	KPOE	Fort Polk, LA	WFO at Lake Charles, LA	473
MS, Columbus AFB	KGWX	Greenwood Springs, MS	WFO at Jackson, MS	590
ND, Minot AFB	KMBX	Deering, ND	WFO at Bismarck, ND	1,590
NM, Cannon AFB	KFDX	Field, NM	WFO at Albuquerque, NM	4,698
NM, Holloman AFB	KHDX	Ruidoso, NM	WFO at El Paso, TX	4,270
NY, Fort Drum	KTYX	Montague, NY	WFO at Burlington, VT	1,960
OK, Altus AFB	KFDR	Frederick, OK	WFO at Norman, OK	1,315
OK, Vance AFB	KVNX	Cherokee, OK	WFO at Norman, OK	1,258
TX, Fort Hood	KGRK	Granger, TX	WFO at Fort Worth, TX	603
TX, Dyess AFB	KDYX	Moran, TX	WFO at San Angelo, TX	1,582
TX, Laughlin AFB	KDFX	Brackettville, TX	WFO at Austin/San Antonio, TX	1,196

TABLE 3-3
DOT NON-CONUS SITES

Metropolitan Area	Radar ICAO	RDA System Location	MSCF Location	Antenna Elev. (Ft) MSL
AK, Anchorage	PAHG*	Kenai, AK	WFO at Anchorage, AK	356
AK, Bethel	PABC*	Bethel, AK	WFO at Anchorage, AK	193
AK, Fairbanks	PAPD*	Fairbanks, AK	WFO at Fairbanks, AK	2,707
AK, Sitka	PACG*	Biorka Island, AK	WFO at Juneau, AK	272
AK, King Salmon	PAKC*	King Salmon, AK	WFO at Anchorage, AK	144
AK, Middleton Island	PAIH*	Middleton Island, AK	WFO at Anchorage, AK	132
AK, Nome	PAEC*	Nome, AK	WFO at Fairbanks, AK	90
HI, Kamuela/Kohala	PHKM*	Kamuela, HI	WFO at Honolulu, HI	3,966
HI, Molokai	PHMO*	Molokai, HI	WFO at Honolulu, HI	1,444
HI, South Shore	PHWA*	Naalehu, HI	WFO at Honolulu, HI	1,461
HI, South Kauai	PHKI*	South Kauai, HI	WFO at Honolulu, HI	340
PR, San Juan	TJUA*	San Juan, PR	WFO at San Juan, PR	2,958

* All sites have a redundant RDA and RPG

TABLE 3-4
DoD NON-CONUS SITES

Metropolitan Area	Radar ICAO	RDA System Location	MSCF Location	Antenna Elev. (Ft) MSL
GUAM, Andersen AFB	PGUA	Andersen AFB, GU	Guam WFO	386
JAPAN, Kadena AB	RODN	Kadena AB, JA	Hickam AFB, HI	332
PORTUGAL, Lajes AB	LPLA	Santa Barbara, Azores	Lajes AB	3,415
SOUTH KOREA, Camp Humphreys	RKSG	Camp Humphreys, ROK	Hickam AFB, HI	1521
SOUTH KOREA, Kunsan AB	RKJK	Kunsan AB, ROK	Hickam AFB, HI	192

TABLE 3-5
CALCULATION OF ANTENNA ELEVATION

Antenna **<u>Elev. (Ft)</u>** ANTENNA ELEVATION (Feet): The elevation of the center of the WSR-88D antenna is expressed in feet above mean sea level (MSL). It is the sum of the antenna's center-point height above ground level (AGL) and the RDA site's terrain elevation.

For example, the WSR-88D antenna elevation for San Diego (KNKX) is;

a.	Antenna height (AGL)	=	RDA Tower + Antenna Pedestal Height.
b.	Antenna height (AGL)	=	25.0 m + 4.7 m = 29.7 m.
c.	Antenna height (AGL)	=	29.7 m x 3.2808 ft / m = 97.4 ft
d.	RDA Site Elevation (MSL)	=	291.1 m x 3.2808 ft / m = 955.0 ft
e.	Antenna Elevation (MSL)	=	Antenna Height + RDA Site Elevation.
f.	Antenna Elevation (MSL)	=	97.4 ft + 955.0 ft = 1,052 ft MSL[Round to nearest ft].

Values for the RDA site elevation (in meters) and RDA tower height come from the ROC Site ID Database.

CHAPTER 4

OPERATIONAL MODES, VOLUME COVERAGE PATTERNS, AND PRODUCTS

4.1 Introduction. This chapter outlines the WSR-88D data processing modes, operational modes [1], volume coverage patterns [2], and the full suite of products that may be generated.

4.2 Data Processing Modes. Sites can chose the following data processing modes based on prevailing meteorological conditions and local operating policy.

4.2.1 Super Resolution. During Super Resolution processing, for the split cuts of each VCP, the RDA processes all three base data moments with 0.5° azimuthal by 0.25 km (0.13 nm) range resolution. The reflectivity data are processed to a range of 460 km (248 nm) while the Doppler data are processed to 300 km (161 nm). These Super Resolution data are sent to the RPG where they are formatted into displayable products to be used for visualization purposes only and not used by the RPG algorithms.

The RPG utilizes a Recombination Algorithm that processes the Super Resolution data and provides a data stream that emulates the data resolution and quantization of the legacy base data stream. Extensive testing has shown that RPG algorithm performance using the recombined data stream is statistically equivalent to the results achieved using data that were originally collected at the legacy resolution.

Based on available resources, at the discretion of the NEXRAD Program and in accordance with the *WSR-88D Handbook, Volume 1, RPG, Guidance on Adaptable Parameters*, Level II data distributed from the RPG may be either Super Resolution or the Recombined data stream.

4.2.2 Legacy. If a site is not in the Super Resolution processing mode, the data will be produced as a Legacy data stream (i.e., at the resolution provided before the Super Resolution capability was added). For all cuts of each VCP in Legacy mode, the RDA processes the reflectivity base data moment with 1.0° azimuthal by 1.0 km (0.54 nm) range resolution to a range of 460 km (248 nm); and the radial velocity and spectrum width base data moments with 1.0° azimuthal by 0.25 km (0.13 nm) range resolution to a range of 230 km (124 nm).

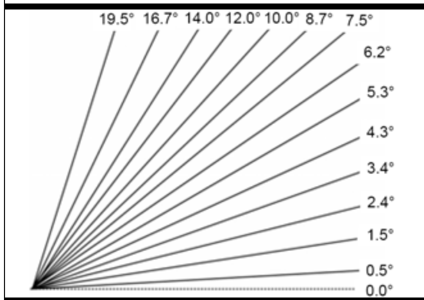
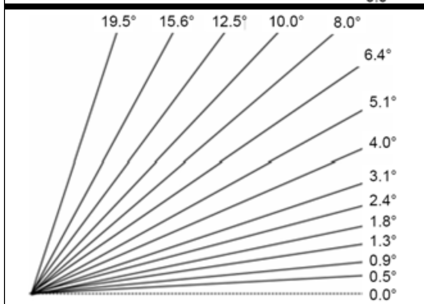
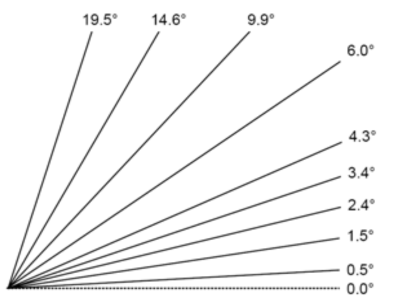
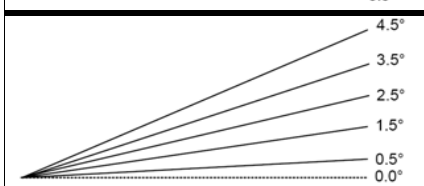
When the WSR-88D is operating in Legacy data collection mode, Level II data distributed from the RPG will be the Legacy data stream.

[1] Operational Mode -- A combination of one or more VCPs and product lists designed to better observe one or more features in a given meteorological environment.

[2] VCP -- An automated method that repetitively scans the atmosphere through a sequence of predefined elevation angles, antenna rotation rates, and pulse characteristics. A sequence of scans is called a volume scan. Table 4-1 provides the characteristics for each VCP.

TABLE 4-1
VOLUME COVERAGE PATTERN DESCRIPTIONS

Quick Reference VCP Comparison Table for RPG Operators February 2008

Slices	Tilts	VCP	Time*	Usage	Limitations
	**14**	**11**	**5 mins**	Severe and non-severe convective events. Local 11 has Rmax=80nm. Remote 11 has Rmax=94nm.	Fewer low elevation angles make this VCP less effective for long-range detection of storm features when compared to VCPs 12 and 212.
		211	**5 mins**	Widespread precipitation events with embedded, severe convective activity (e.g. MCS, hurricane). Significantly reduces range-obscured V/SW data when compared to VCP 11.	All Bins clutter suppression is NOT recommended. PRFs are not editable for SZ-2 (Split Cut) tilts.
	**14**	**12**	**4 ½ mins**	Severe convective events. Extra low elevation angles increase low-level vertical resolution when compared to VCP 11.	High antenna rotation rates slightly decrease accuracy of the base data estimates.
		212	**4½ mins**	Rapidly evolving, widespread severe convective events (e.g. squall line, MCS). Increased low-level vertical resolution compared to VCP 11. Significantly reduces range-obscured V/SW data when compared to VCP 12.	All Bins clutter suppression is NOT recommended. PRFs are not editable for SZ-2 (Split Cut) tilts. High antenna rotation rates slightly decrease accuracy of the base data estimates.
	**9**	**21**	**6 mins**	Non-severe convective precipitation events. Local 21 has Rmax=80nm. Remote 21 has Rmax=94nm.	Gaps in coverage above 5°.
		121	**6 mins**	VCP of choice for hurricanes. Widespread stratiform precipitation events. Significantly reduces range-obscured V/SW data within 230 km when compared to other VCPs.	All Bins clutter suppression is NOT recommended. High antenna rotation rates slightly decrease accuracy of the base data estimates. PRFs are not editable. Gaps in coverage above 5°.
		221	**6 mins**	Widespread precipitation events with embedded, possibly severe convective activity (e.g. MCS, hurricane). Reduces range-obscured V/SW data out to 300 km when compared to other VCPs.	All Bins clutter suppression is NOT recommended. PRFs are not editable for SZ-2 (Split Cut) tilts. Gaps in coverage above 5°.
	**5**	**31**	**10 mins**	Clear-air, snow, and light stratiform precipitation. Best sensitivity. Detailed boundary layer structure often evident.	Susceptible to velocity dealiasing failures. No coverage above 5°. Rapidly developing convective echoes aloft might be missed.
		32	**10 mins**	Clear-air, snow, and light stratiform precipitation.	No coverage above 5°. Rapidly developing convective echoes aloft might be missed.

* VCP update times are approximate.

4.3 <u>Operational Modes</u>. Two operational modes have been implemented: Clear Air and Precipitation. Each mode has one product generation list and at least two VCPs. Selection of the operational mode is closely related to the detected coverage of precipitation. The Mode Selection Function (MSF) is designed to automatically determine if precipitation is occurring within 230 km (124 nm) of the radar. The MSF examines the area of reflectivity returns at a specified intensity and compares it to the predefined threshold.

Automatic mode switching from Clear Air to Precipitation and from Precipitation to Clear Air is operator-specified based on URC agreement. Precipitation accumulation estimates are independent of the operational mode. [3]

4.3.1 Mode A -- Precipitation Mode (VCPs 11, 12, 21, 121, 211, 212, and 221). This mode should be used when significant weather echoes are present or severe weather is occurring or is anticipated. Usually, this mode will have been selected automatically due to the detection of reflectivity exceeding the predefined threshold. At times, however, such as during the early, mid-level formation of convective echoes, the RPG Human-Computer Interface (HCI) operator may choose to enter the Precipitation Mode manually.

4.3.2 Mode B – Clear Air Mode (VCPs 31 and 32). This mode may be used when there is no detectable precipitation or when precipitation intensity and areal extent are small. The RPG software will not allow a change to Clear Air Mode until precipitation exceeding the predefined thresholds has not been detected for the period specified in the Clear Air Mode Time Delay.

4.4 <u>Volume Coverage Patterns</u>. During operations, the antenna is controlled by automatic scanning programs. Volume coverage patterns are matched to an operational mode to optimize product generation for given meteorological situations; the various VCPs are further defined in Chapter 5, Part C of this Handbook. In each operational mode, scanning is continuous. Principal users are informed of the radar operational mode and the VCP in use through system status messages.

4.4.1 Volume Coverage Patterns 31 and 32. Both of these VCPs are used in the Clear Air Mode to optimize the sensitivity of the WSR-88D. The VCP 31 (long pulse) provides a better signal-to-noise ratio permitting lower reflectivity returns to be detected, while VCP 32 (short pulse) provides a higher unambiguous velocity.

[3] The Precipitation Processing Subsystem (PPS) algorithms use settings internal to the PPS that assess rainfall areas from the assembled Hybrid Scan to determine start/stop times of distinct precipitation events.

4.4.2 Volume Coverage Patterns 11 and 21. These VCPs are used in the Precipitation Mode to better sample the vertical structure of convective weather echoes and to provide better temporal resolution. The VCP 11 provides better vertical sampling of weather echoes near the antenna than VCP 21 and is usually preferred in situations where convective precipitation is within 60 nm of the antenna.

4.4.3 Volume Coverage Pattern 12. This VCP has the same number of elevation angles as VCP 11. However, denser vertical sampling at lower elevation angles provides better vertical definition of storms, improves detection capability of radars impacted by terrain blockage for better rainfall and snowfall estimates, results in more storms being identified, and provides quicker updates.

4.4.4. Volume Coverage Pattern 121. This VCP has the same elevation angles as VCP 21, but more scans. This VCP implements the Sachidananda – Zrnic Algorithm (SZ-2) processing and Multi-Pulse Repetition Frequency Dealiasing Algorithm (MPDA) to mitigate range/velocity aliasing (the Doppler Dilemma).

4.4.5. Volume Coverage Patterns 211, 212, and 221. These VCPs have the same elevation angles as VCPs 11, 12, and 21, respectively. These VCPs implement the SZ-2 Algorithm processing which is applied on the "split cuts" (generally elevation angles below 1.5^{o} (except for VCP 31 which has a split cut at 2.5^{o}). See Chapter 5, Part C, of this Handbook for additional information on split cuts. The SZ-2 Algorithm reduces range ambiguity for Doppler data.

4.5 <u>WSR-88D Product Suite</u>. Table 4-2 provides brief descriptions of every WSR-88D product. Products are initiated for generation through one of several means: through the RPG Product Generation Table, Routine Product Set lists, alert-product pairing, and through one-time requests from associated users. The specific products that constitute the baseline Product Suite for each weather mode are defined in the. *WSR-88D Handbook, Volume 1, RPG, Guidance on Adaptable Parameters.* The products listed in Table 4-2 are current as of RPG software Build 11 (May 2009 release).

TABLE 4-2
PRODUCT DESCRIPTION

PROD ID	PROD NUM	DATA LEVELS	COVERAGE (nm)	RESOLUTION (nm or see key)	PRODUCT NAME AND DESCRIPTION
GSM	2	n-a	n-a	n-a	General Status Message
R	16	8	0 – 124	0.54 x 1 °	Reflectivity.
R	17	8	0 – 248	1.1 x 1 °	Reflectivity.
R	18	8	0 – 248	2.2 x 1 °	Reflectivity.
R	19	16	0 – 124	0.54 x 1 °	Reflectivity.
R	20	16	0 – 248	1.1 x 1 °	Reflectivity.
R	21	16	0 – 248	2.2 x 1 °	Reflectivity.
V	22	8	0 – 32	0.13 x 1 °	Mean Radial Velocity.
V	23	8	0 – 62	0.27 x 1 °	Mean Radial Velocity.
V	24	8	0 – 124	0.54 x 1 °	Mean Radial Velocity.
V	25	16	0 – 32	0.13 x 1 °	Mean Radial Velocity.
V	26	16	0 – 62	0.27 x 1 °	Mean Radial Velocity.
V	27	16	0 – 124	0.54 x 1 °	Mean Radial Velocity.
SW	28	8	0 – 32	0.13 x 1 °	Spectrum Width.
SW	29	8	0 – 62	0.27 x 1 °	Spectrum Width.
SW	30	8	0 – 124	0.54 x 1 °	Spectrum Width.
USP	31	16	0 – 124	1.1 x 1 °	User Selectable Rainfall Accumulation.
DHR	32	256	0 – 124	0.54 x 1 °	Digital Hybrid Scan Reflectivity.
HSR	33	16	0 – 124	0.54 x 1 °	Hybrid Scan Reflectivity.
CFC	34	8	0 – 124	0.54 x 1 °	Clutter Filter Control. Generated when clutter suppression definition changes.
CR	35	8	0 – 124	0.54 x 0.54	Composite Reflectivity.

TABLE 4-2
PRODUCT DESCRIPTION

PROD ID	PROD NUM	DATA LEVELS	COVERAGE (nm)	RESOLUTION (nm or see key)	PRODUCT NAME AND DESCRIPTION
CR	36	8	0 – 248	2.2 x 2.2	Composite Reflectivity.
CR	37	16	0 – 124	0.54 x 0.54	Composite Reflectivity.
CR	38	16	0 – 248	2.2 x 2.2	Composite Reflectivity.
ET	41	16	0 – 124	2.2 x 2.2	Echo Tops. Min=5,000 ft, Max=70,000 ft MSL.
VWP	48	30	16 (default value)	1,000 ft (z)	VAD Wind Profile. Barbs show speeds to nearest 5 kt. Height (every 1000 ft) is plotted on z-axis and time (up to 11 volume scans) is plotted on x-axis.
RCS	50	16	0 – 124	0.54 x 0.27(z)	Cross Section -- Reflectivity. Min=0 ft, Max=70,000 ft MSL.
VCS	51	16	0 – 124	0.54 x 0.27(z)	Cross Section – Mean Radial Velocity. Min=0 ft, Max=70,000 ft MSL.
SRR	55	16	0 – 124	0.27 x 1 °	Storm Relative Mean Radial Velocity--Region. See notes for SRM (PROD ID #56), below. The presentation area is 27 nm x 27 nm centered on operator-defined location.
SRM	56	16	0 – 124	0.54 x 1 °	Storm Relative Mean Radial Velocity--Map. Derived from vector average of all identified storms or vector input by operator. Presentation area is 0 - 124 nm.
VIL	57	16	0 – 124	2.2 x 2.2	Vertically Integrated Liquid Water.
STI	58	n-a	0 – 186	n-a	Storm Tracking Information. Graphic product with 15 minute position intervals.
HI	59	5	0 – 124	n-a	Hail Index. Includes overlay to show probability and max hail size per storm.
M	60	3	0 – 124	n-a	Mesocyclone. Includes overlay for identified storms' data.

z = vertical

TABLE 4-2
PRODUCT DESCRIPTION

PROD ID	PROD NUM	DATA LEVELS	COVERAGE (nm)	RESOLUTION (nm or see key)	PRODUCT NAME AND DESCRIPTION
TVS	61	n-a	0 – 124	n-a	Tornado Vortex Signature. Includes overlay for identified storms' data.
SS	62	n-a	0 – 248	n-a	Storm Structure. Table generated each VCP.
LRA	63	8	248 x 248	2.2 x 2.2	Layer Composite Reflectivity – Average. Low Layer.
LRA	64	8	248 x 248	2.2 x 2.2	Layer Composite Reflectivity--Average. Mid Layer.
LRM	65	8	124 x 124	2.2 x 2.2	Layer Composite Reflectivity--Maximum. Low Layer.
LRM	66	8	124 x 124	2.2 x 2.2	Layer Composite Reflectivity--Maximum. Mid Layer.
APR	67	8	124 x 124	2.2 x 2.2	Layer Composite Reflectivity–AP Removed. Low Layer.
UAM	73	n-a	n-a	n-a	User Alert Message. Generated upon alert activation.
RCM	74	9	0 – 248	1/16 x 1/16 LFM	Radar Coded Message. Generated near HH:20 and HH:50 UTC. Derived from the IRM product.
FTM	75	n-a	n-a	n-a	Free Text Message. Messages can be generated at MSCF and RPG.
OHP	78	16	0 – 124	1.1 x 1 °	One-Hour Rainfall Accumulation.
THP	79	16	0 – 124	1.1 x 1 °	Three-Hour Rainfall Accumulation.
STP	80	16	0 – 124	1.1 x 1 °	Storm Total Rainfall Accumulation.
DPA	81	256	0 – 124	1/40 x 1/40 LFM	Hourly Digital Precipitation Array.
SPD	82	n-a	n–a	n-a	Supplemental Precipitation Data. Alphanumeric with rain gage values and times.
VAD	84	8	16 (default value)	n-a	Velocity Azimuth Display. Product is available for altitudes specified by VWP product (PROD ID #48).

n-a = not applicable

TABLE 4-2
PRODUCT DESCRIPTION

PROD ID	PROD NUM	DATA LEVELS	COVERAGE (nm)	RESOLUTION (nm or see key)	PRODUCT NAME AND DESCRIPTION
RCS	85	8	0 – 124	0.54 x 0.27(z)	Cross Section -- Reflectivity.
VCS	86	8	0 – 124	0.54 x 0.27(z)	Cross Section – Mean Radial Velocity.
LRA	89	8	248 x 248	2.2 x 2.2	Layer Composite Reflectivity--Average. High Layer.
LRM	90	8	124 x 124	2.2 x 2.2	Layer Composite Reflectivity--Maximum. High Layer.
DBV	93	256	lesser of 62 nm or18 kft AGL	0.54 x 1 °	Integrated Terminal Weather System Digital Base Velocity.
DR	94	256	0 – 248	0.54 x 1 °	Base Reflectivity Data Array.
CRE	95	8	0 – 124	0.54 x 0.54	Composite Reflectivity Edited for Anomalous Propagation.
CRE	96	8	0 – 248	2.2 x 2.2	Composite Reflectivity Edited for Anomalous Propagation.
CRE	97	16	0 – 124	0.54 x 0.54	Composite Reflectivity Edited for Anomalous Propagation.
CRE	98	16	0 – 248	2.2 x 2.2	Composite Reflectivity Edited for Anomalous Propagation.
DV	99	256	0 – 124	0.13 x 1 °	Base Velocity Data Array.
CLR	132	11	0 – 124	0.54 x 1 °	Clutter Likelihood Reflectivity.
CLD	133	12	0 – 124	0.54 x 1 °	Clutter Likelihood Doppler.
DVL	134	256	0 – 248	0.54 x 1 °	High Resolution Digital Vertically Integrated Liquid.
EET	135	199	0 – 186	0.54 x 1 °	High Resolution Enhanced Echo Tops.
SO	136	n-a	0 - 124	n-a	SuperOb: National Centers for Environmental Prediction Winds Model Initialization.
ULR	137	16	0 – 124	0.54 x 1 °	User Selectable Layer Composite Reflectivity (Max).
DSP	138	256	0 – 124	1.1 x 1 °	Storm Total Rainfall Accumulation (Digital Storm Product).

n-a = not applicable

TABLE 4-2
PRODUCT DESCRIPTION

PROD ID	PROD NUM	DATA LEVELS	COVERAGE (nm)	RESOLUTION (nm or see key)	PRODUCT NAME AND DESCRIPTION
MRU	139	3	0 – 124	n-a	Mesocyclone Rapid Update.
GFM	140	n-a	0 - 38	n-a	Gust Front MIGFA (Machine Intelligent Gust Front Algorithm)
MD	141	n-a	0 – 124	n-a	Mesocyclone Detection.
TRU	143	n-a	0 – 124	n-a	Tornado Vortex Signature Rapid Update.
OSW	144	16	0 – 124	0.54 x 1 °	One-Hour Snow Water Equivalent Accumulation.
OSD	145	16	0 – 124	0.54 x 1 °	One-Hour Snow Depth Accumulation.
SSW	146	16	0 – 124	0.54 x 1 °	Storm Total Snow Water Equivalent Accumulation.
SSD	147	16	0 – 124	0.54 x 1 °	Storm Total Snow Depth Accumulation.
DMD	149	n-a	0 – 124	n-a	Digital Mesocyclone Detection Data Array.
USW	150	16	0 – 124	0.54 x 1 °	User Selectable Snow Water Equivalent Accumulation.
USD	151	16	0 – 124	0.54 x 1 °	User Selectable Snow Depth Accumulation.
ASP	152	n-a	n-a	n-a	Archive III Status
SDR	153	256	0 – 248	0.13 x 0.5 °	Super Resolution Reflectivity Data Array
SDV	154	256	0 – 161	0.13 x 0.5 °	Super Resolution Radial Velocity Data Array
SDW	155	256	0 – 161	0.13 x 0.5 °	Super Resolution Spectrum Width Data Array
EDR	156	64	0 – 124	0.54 x 1 °	NEXRAD Turbulence Detection Algorithm Eddy Dissipation Rate
EDC	157	8	0 – 124	0.54 x 1 °	NEXRAD Turbulence Detection Algorithm Eddy Dissipation Confidence

n-a = not applicable
z = vertical

KEY FOR TABLE 4-2

PROD ID	PRODUCT IDENTIFIER: The official one, two, or three letter abbreviations used by the WSR-88D system and displayed on WSR-88D products.
PROD NUM	PRODUCT NUMBER: The official identification number assigned to WSR-88D products. Product numbers are recognized by the WSR-88D system software.
DATA LEVLS	DATA LEVELS: The number of gradations that display the magnitude of data in a color indexed graphical format. Some alphanumeric products have multiple categories of information (e.g., severe weather probability). The number of categories is expressed as the number of data levels.
COVERAGE	RANGE OF COVERAGE: The geographical scope of coverage for a given product. There are three types of product formats; polar, Cartesian, and grid-based. The areal extent for polar and grid-based products is indicated with a polar range limit (e.g., 460 km (248 nm)). Cartesian products' aerial extent is described by x-axis and y-axis lengths (e.g., 230 km x 230 km (124 nm x 124 nm)).
RESOLUTION	DATA RESOLUTION: Standard units of measure describe the size of the products' discrete data elements. The type of units used (e.g., nm, arc degree, grid fraction) is a function of a product's format. Product formats are: polar, Cartesian, and grid-based. The limited-area fine mesh (LFM) grid is a standard reference for the radar coded message products. **1/40 L:** Approximately 2.2 nm x 2.2 nm. The 2.2 nm length is 1/40 of the LFM grid-point separation. **1/16 L:** Approximately 5.4 nm x 5.4 nm. The 5.4 nm length is 1/16 of the LFM grid-point separation. **1/4 L:** Approximately 22 nm x 22 nm. The 22 nm length is 1/4 of the LFM grid-point separation.
PRODUCT NAME AND DESCRIPTION	The full name of product followed by pertinent information.

CHAPTER 5

ARCHIVING

5.1 <u>Introduction</u>. The WSR-88D system has the capability to provide for the archiving of data and products at four functional locations. The locations are identified as Archive Levels I, II, III, and IV, respectively. The following sections, exclusive of the final section, provide a brief description of each level and potential utilization of data archived at each level. The final section provides information pertaining to product retention at NOAA's National Climatic Data Center (NCDC).

5.2 <u>Archive Level I</u>. The Archive Level I interface is located at the RDA. Data available are the digital, time-domain output of the receiver. Information regarding synchronization, calibration, date, time, antenna position, and status is also available at this level. However, Archive Level I data are not recorded operationally. Archive Level I data are used for RDA system diagnostics and input for signal processor optimization studies.

5.3 <u>Archive Level II</u>. Archive Level II data are the digital base data output from the signal processor. The output also includes status information required to properly interpret the data (e.g., information on synchronization, calibration, date, time, antenna position, clutter and notchwidth maps, operational mode). Archive Level II data are used for many purposes including: support of operational, maintenance and developmental activities at the ROC; activities directed toward algorithm and product enhancement; research by universities; and the private sector. The only Level II data archived are those sent to the NCDC by the NWS WSR-88D Level II Central Collection and Distribution Network (Section 2.4.2).

5.4 <u>Archive Level III</u>. Archive Level III data are the output product data of the RPG. Archive Level III data are continuously transmitted from DOC WSR-88D systems to the NCDC via the AWIPS and the RPCCDS. Sites currently send products beyond the list of Level III products to the RPCCDS and NCDC (Section 2.4.1).

5.5 <u>Archive Level IV</u>. Archive Level IV data are the output product data of the RPG. The Archive Level IV interface is located at the Open Systems Principal User Processor (OPUP). All DoD sites with an OPUP will perform Archive Level IV archiving for local training, studies, accident investigation, and other purposes as required. At NWS sites, the AWIPS has an Archive Level IV-like capability.

5.6 Retention by National Climatic Data Center. Archive Level II and Archive Level III data are sent to the NCDC for permanent retention. The NCDC receives, archives, and makes these products and data available upon request. Information on the WSR-88D data in the NCDC archives can be found at: http://www.ncdc.noaa.gov/oa/radar/radarresources.html.

CHAPTER 6

ADAPTABLE PARAMETER CHANGE AUTHORITY

6.1 <u>Introduction</u>. The WSR-88D's design includes thousands of parameters that permit each WSR-88D system to be adapted to certain geographical and meteorological conditions. Since the WSR-88D is operated to satisfy the integrated requirements of the principal users and to support the national radar network, centralized control of many of the system and meteorological parameters is required to ensure a baseline operational standard. However, a subset of these parameters was designed specifically to address the local operational needs. For this reason the principal user agencies agreed to categorize a number of WSR-88D adaptable parameters into three levels of change authority (LOCA) as defined in Section 6.2. This was done, primarily, to ensure the proper LOCA use of these adaptable parameters. As defined, each of these three LOCA categories permits the modification of WSR-88D hardware and software through a controlled process. Official guidance on WSR-88D adaptable parameters is documented by the *WSR-88D Handbook, Volume 1, RPG, Guidance on Adaptable Parameters*.

6.2 <u>Levels of Change Authority</u>. The adaptable parameters have been grouped according to the level of approval that is necessary before the parameter's value can be changed. These groupings are intended to give maximum flexibility in operational use of the WSR-88D while ensuring that agency operations are not jeopardized and the system remains stable.

6.2.1 Radar Operations Center. Through the Adaptable Parameter Working Group (APWG), the ROC shall determine the general validity and range of adaptable parameter values for changes that affect the technical and scientific characteristics of WSR-88D data acquisition and algorithmic processing. In addition, the ROC shall be authorized to determine, specifically, the values for the aforementioned default adaptable parameters for WSR-88D equipment owned by the DoD, DOT, and the DOC. Since the APWG shall remain subordinate to the NPMC, the ROC LOCA shall reflect the NPMC's position on triagency policy in WSR-88D operations.

6.2.2 Unit Radar Committee. Each URC shall be authorized to change their WSR-88D system's adaptable parameter values and establish adaptation parameter change policy for the principal users within the URC. Types of changes that a URC is authorized to implement shall include the "fine-tuning" needed to meet local operational requirements, seasonal changes, and local climatological characteristics.

6.2.3 Agency. The agency is the principal user agency (DOC, DoD, or DOT) that controls the involved hardware and software. Each agency is authorized to change the range of adaptable parameter values, change default values, and establish WSR-88D adaptable parameter policy in order to meet agency-specific mission requirements and criteria. Changes that a single agency are authorized to implement may involve user passwords, meteorological algorithm parameters, and certain telecommunications settings.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

AB - Air Base
AFB - Air Force Base
AGL - Above Ground Level
AP - Anomalous Propagation
APWG - Adaptable Parameter Working Group
ARTCC - Air Route Traffic Control Center
AWIPS - Advanced Weather Interactive Processing System

CMD - Clutter Mitigation Decision Algorithm
CONUS - Conterminous United States

DOC - Department of Commerce
DoD - Department of Defense
DOT - Department of Transportation

Elev - Elevation

FAA - Federal Aviation Administration
FMH - Federal Meteorological Handbook
ft - Foot/Feet

HCI - Human Computer Interface

IA - Implementing Agreement
ICAO - International Civil Aviation Organization
ITWS - Integrated Terminal Weather System

kft - 1000s of feet

LFM - Limited Area Fine Mesh
LOCA - Level of Change Authority

m - Meter
MEARTS - Microprocessor En Route Automated Radar Tracking System
MIAWS - Medium Intensity Airport Weather System
MOA - Memorandum of Agreement
MPDA - Multi-Pulse Repetition Frequency Dealiasing Algorithm
MSCF - Master System Control Function
MSF - Mode Selection Function

MSL	-	Mean Sea Level
NCDC	-	National Climatic Data Center
NEXRAD	-	Next Generation Weather Radar
nm	-	Nautical Mile
NOAA	-	National Oceanic and Atmospheric Administration
NPC	-	NEXRAD Program Council
NPMC	-	NEXRAD Program Management Committee
NWS	-	National Weather Service
OCONUS	-	Outside Conterminous United States
OFCM	-	Office of the Federal Coordinator for Meteorological Services and Supporting Research
OPUP	-	Open System Principal User Processor
PPS	-	Precipitation Processing Subsystem
PRF	-	Pulse Repetition Frequency
RDA	-	Radar Data Acquisition
ROC	-	WSR-88D Radar Operations Center
RPCCDS	-	Radar Product Central Collection Dissemination Service
RPG	-	Radar Product Generator
SZ-2	-	Sachidananda – Zrnic Algorithm
URC	-	Unit Radar Committee
US	-	United States
UTC	-	Universal Time Coordinated
VAD	-	Velocity Azimuth Display
VCP	-	Volume Coverage Pattern
WARP	-	Weather and Radar Processor
WFO	-	Weather Forecast Office
WG/DRMO	-	Working Group for Doppler Radar Meteorological Observations
WSR-88D	-	Weather Surveillance Radar - 1988, Doppler
z	-	Vertical

APPENDIX B

GLOSSARY

Adaptable Parameter: Generally, data related to a specific WSR-88D system. These data may consist of meteorological or hydrological parameters, or of geographic boundaries, political boundaries, system configuration, telephone numbers, or similar data. Such data may be generated at either a centralized location or locally.

Associated Principal User: A principal user linked to a WSR-88D system with a dedicated telecommunication line.

Base Data: Digital fields of reflectivity, mean radial velocity, and spectrum width data **(Base Data Moments)** in spherical coordinates provided at the finest resolution available.

Batch Mode: A data collection scheme used in the middle elevation slices (elevations between 1.65^o and 6.5^o) of most VCPs where data beyond the first Doppler trip are expected, but where ground clutter contamination is generally not a major problem. The Batch Mode uses a combination of low and high pulse repetition frequencies for each radial in the elevation scan. (Section 5.3, Part C of this Handbook).

Bypass Map: The Bypass Map is a special map generated by the RDA that identifies the geographic location of clutter targets (targets with near-zero radial velocity and a narrow spectrum width). The identified targets are those present within the radar's viewing horizon at the time the map was generated. The Bypass Map is used to control the geographic application of clutter filtering.

Clutter Mitigation Decision Algorithm: An advanced science algorithm that identifies clutter on a scan-by-scan basis and automatically builds a Bypass Map each volume scan.

Conterminous United States: Those states of the United States enclosed within one common boundary. The conterminous 48 states of the United States is abbreviated 'CONUS.'

Data Resolution: The x, y, and z dimensions of the discrete 3-dimensional volume for which radar data estimates are available.

Super Resolution Data Stream: For the Split Cut elevations of each VCP, the RDA signal processor produces all three base data moments with 0.25 km (0.13 nm) range resolution x 0.5^o azimuth x 1^o elevation. For all other elevations, the base data resolution is 1 km (0.54 nm) range resolution x 1^o azimuth x 1^o elevation for reflectivity and 0.25 km (0.13 nm) range resolution x 1^o azimuth x 1^o elevation for velocity and spectrum width.

Recombined and Legacy Data Streams: For all elevations, the base data resolution is 1 km (0.54 nm) range resolution x 1^o azimuth x 1^o elevation for reflectivity and 0.25 km (0.13 nm) range resolution x 1^o azimuth x 1^o elevation for velocity and spectrum width.

Default Value: A setting or value that will be used in a given software program unless changed.

Echoes: Areas of radar reflectivity visible in the WSR-88D products that may represent meteorological or non-meteorological phenomena.

Elevation Angle: The angle the WSR-88D antenna subtends to the horizontal plane. This value can vary from 0ºE to + 60ºE.

Mesocyclone: A 3-dimensional region in a storm that rotates (usually cyclonically) and is closely correlated with severe weather.

Mode Selection Function: This function enables automatic switching between Precipitation Mode and Clear Air Mode as well as performing the mode switch manually.

NEXRAD Program Council: A NEXRAD Program triagency organization composed of senior representatives from DOC, DoD, and DOT, and the Federal Coordinator for Meteorological Services and Supporting Research.

NEXRAD Program Management Committee: A NEXRAD Program triagency organization comprised of representatives of DOC (NWS), DoD (Air Force Weather Agency), and DOT (FAA). Its responsibilities encompass all WSR-88D operational aspects (e.g., operations, maintenance, logistics, documentation, and training) to ensure that the common and unique agency concerns are addressed.

Operational Mode: A combination of one or more volume coverage patterns and product lists designed to better represent one or more features in a given meteorological environment.

Radial Velocity: The component of motion of the target toward or away from the radar.

Recombined Data: See Data Resolution in this appendix.

Reflectivity: The measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors, it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect.

Spectrum Width: A measure of dispersion of velocities within the radar sample volume.

Split Cut: A data collection scheme where the elevation slices (elevations less than 1.65^{o}) are scanned two or more times, using a different pulse repetition frequency for each full scan (Section 5.3, Part C of this Handbook).

Super Resolution Data: See Data Resolution in this appendix.

SZ-2 (Sachidananda–Zrnic Algorithm): Provides a range unfolding technique to alleviate the effects of the fundamental range-velocity ambiguity that exists with Doppler weather radars.

Tornado Vortex Signature: The radar signature of a vortex that is indicative of a tornado or tornadic circulation.

Unit Radar Committee: A coordinating committee, established by the MOA for Interagency Operation of the WSR-88D, composed of representatives of each principal user agency associated with a particular WSR-88D system.

WSR-88D