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WSR-88D SYSTEM SPECIFICATION

Prepared by the WSR-88D Radar Operations Center

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WSR-88D System Specification
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1 SCOPE

This document establishes the performance, design, development and test constraints for the Weather Surveillance Radar-1988 Doppler (WSR-88D) System. This document constitutes the System Specification, as defined by MIL-STD-490. The WSR-88D System is evolving from a proprietary hardware platform and operating system to a standards-based architecture such that improvements in data quality, operational utilization of advances in scientific algorithms and inter-operability of the WSR-88D system with other agency modernized systems (e.g. Advanced Weather Interactive Processing System (AWIPS), Meteorological Operational Capability (MOC), Weather and Radar Processor (WARP), Integrated Terminal Weather System (ITWS)) are more easily realized.

While requirements for unique equipment procured for specific systems often included a design for 20 year useful life, an acquisition philosophy that accommodates the infusion of new technology that is regularly available in the open market depends upon the use of standards-based commercial off-the-shelf (COTS) hardware that is not expected to be used for 20 years. Potential Requirements for future evolution of the WSR-88D system are identified in Annex A. The Tri-Agency Requirements (TAR) for Operational Use of Weather Radar Data contains guidance for the evolution of the WSR-88D system. The remaining sections are as follows:

Section 2 – Applicable Documents

Section 3 – Requirements

Section 4 – Quality Assurance

2 APPLICABLE DOCUMENTS

2.1 Government Documents

The following military and Federal specifications and standards are available from the sources shown.

2.1.1 Military Standards and Handbooks

MIL-STD-130	Identification and Marking of U.S. Military Property
MIL-HDBK-454	General Guidelines for Electronic Equipment
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility
MIL-STD-462	Test Standard for Measurement of Electromagnetic Interface Characteristics
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic Compatibility
MIL-STD-471A	Maintainability Verification/Demonstration/Valuation
MIL-STD-490	Specification Practices
MIL-STD-781	Reliability Testing for Engineering Development, Qualification, and Production, (Test Plan IV)
MIL-STD-810	Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
MIL-STD-961	Department of Defense Standard Practice, Defense Specifications
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MIL-STD-1130	Connections, Electrical, Solderless, Wrapped
MIL-STD-2036	General Requirements for Electronic Equipment Specifications
MIL-STD-188-124B	Grounding, Bonding, and Shielding
MIL-HDBK-217	Reliability Predictions of Electronic Equipment
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipment and Facilities
AFI 21-116	Maintenance Management of Communications Electronics
Source:	Defense Printing Service Office 700 Robbins Avenue Philadelphia, PA. 19111-5094

2.1.2 Federal Documents

FED-STD-595	Colors Used in Government Procurement
NIST Pub 500-230	NIST Pub 500-230 Application Portability Profile (APP) The U.S. Government's Open System Environmental Profile Version 3.0
OSHA-29 CFR 1910	OSHA Safety and Health Standards
FMH-11	Federal Meteorological Handbook 11 NWS Transient Susceptibility Standard (May 1978) National Weather Service Operations Manual
Source:	National Weather Service 1325 East-West Highway Silver Spring, MD 20910

AC 70/7460-IF	FAA Advisory Circular, Obstruction Marking and Lighting
DOT/FAA Order 6000.15B	Maintenance Handbook for Airway Facilities
DOT/FAA Order 6000.30B	Policy for Maintenance of the National Airspace
DOT/FAA Order 6000.40	Monitoring Policy for the Maintenance Control Center (MCC) of the NAS
DOT/FAA Order 6000.50B	Airway Facilities NAS Operations Handbook
DOT/FAA Order 6090.1A	Development and Implementation of Remote Monitoring Subsystem (RMS) within the NAS
FAA-STD-019b	Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities
Source:	Federal Aviation Administration Washington, DC 20591
	Manual of Regulations and Procedures for Federal Radio Frequency Management, National Telecommunications and Information Administration
R400-AR401	NEXRAD Algorithm Report
R400-IS301A	NEXRAD Integrated Logistics Support Plan (ILSP), May 1989
R400-IS301B	NEXRAD Integrated Logistics Support Plan (ILSP), 01 June 1998

Interface Control Documents (ICDs):

2620000	RPG/RMS ICD
2620004	RDA/RMS ICD
2620001	RPG/ASSOCIATED PUP ICD
2620006	UNIT/NON-ASSOCIATED PUP ICD
2620018	RPG/MSCF ICD
2620013	RPG/BDDS ICD
2620009	UNIT/PRINCIPLE OTHER USERS ICD
2620008	BASE DATA/USER ICD
2620002	RDA/RPG ICD

WSR-88D Specifications

MLOS Fault Isolation System 1215955B

Engineering Drawings

1213851 Plate, Identification

Source: WSR-88D Radar Operations Center (ROC)
3200 Marshall Ave
Norman, OK 73072

PUP Site Survey Instructions and Information Package, Rev 6.
Source: NEXRAD System Program Office (SPO1)
Facilities Branch
1325 East-West Highway
Silver Spring, MD 20910

Tri-Agency Requirements (TAR) for Operational Use of Weather Radar Data (May 1997)
Radar Product Generation Algorithm Survey and Analysis Report, June 1996

Source: NEXRAD Product Improvement Office
1325 East-West Highway
Silver Spring, MD 20910

FAA National Airspace Systems (NAS) Documents:

Functional Requirements for NAS System Level Specification for NAS Infrastructure

NAS-IR-51070000, Interface Requirements Document, NAS Infrastructure Management System Manager/Managed Subsystem

NAS-IC-51070000-1, Interface Control Document, NAS Infrastructure Management System Manager/Managed Subsystem using the Simple Network Management Protocol Version 1 (SNMPv1)

Source: Federal Aviation Administration
Washington, DC 20591

2.2 Non-Government Documents

The following non-Government documents are available from the sources shown.

2.2.1 American National Standards Institute (ANSI) Standards

ANSI X3.4 -1986 (R1997) Information Systems - Coded Character Sets 7-Bit American National Standard Code for Information Interchange

Source: ANSI, Inc.
1430 Broadway
New York, NY 10018
http://www.ansi.org

2.2.2 Telecommunications Industry Association/Electronics Industries (TIA/EIA) Standards

EIA-195-C Electrical and Mechanical Characteristics for Terrestrial Microwave Relay System Antennas and Passive Reflectors

TIA/EIA-222-F Structural Standards for Steel Antenna Towers and Supporting Structures

Source: http://global.ihs.com

2.2.3 Other Non-Government Documents

NFPA 70	National Electrical Code
IEEE C95.1-1991 (R1997)	Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 Ghz
HFPA 780	Standard for the Installation of Lightning Protection 1995 Edition
Source:	National Fire Protection Association Batterymarch Park Quincy, MA 02269 http://www.nfpa.org
IEEE Std 1413-1998	IEEE Standard Methodology for Reliability Prediction and Assessment for Electronic Systems Equipment, 8 Dec 1998
Source:	http://www.standards.ieee.org/
IEEE C62.41(1991)	IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
UL 1950	Safety Standards for Commercial Equipment
EN55022	Specification for Limits And Methods of Measurement of RI Characteristics of Information Technology Equipment
EN50082	Generic Immunity Standard Part 1, Residential, Light Industry
FCC, Part 15	Radio Frequency Devices

2.3 Precedence of Documents

An attempt has been made to prevent conflicts between this Specification and the referenced documents. However, in the event of a conflict between requirements, the following order of precedence (highest=a) will apply:

a. WSR-88D System Specification
b. Military Standards
c. Federal Standards
d. ANSI Standards
e. EIA Standards
f. Other

3 REQUIREMENTS

This section delineates the performance and design requirements for the WSR-88D System. Throughout this document, many performance requirements are stated as integer numbers. A minimum precision of 2 decimal places is assumed for all performance requirements given as an integer.

3.1 System Definition

The WSR-88D System comprises Doppler radars, telecommunications, computer data communications, data processing hardware and software, display and data entry equipment, documentation, and certain facilities and support capabilities required to detect, process, distribute, and display weather information in a manner which allows the Department of Commerce (DOC), the Department of Defense (DoD) and the Department of Transportation (DOT) to fulfill their mission needs.

3.1.1 General Description

A general description of the WSR-88D System and its functions is provided in the following paragraphs.

3.1.1.1 System Users

The system users include both principal users and other users.

3.1.1.1.1 Principal Users

The principal users of the WSR-88D System are operationally oriented agencies within the participating departments (DOC, DoD, and DOT) which use weather radar information to perform or support their activities. These activities include warning of hazardous weather and flash flood prediction, predicting weather conditions, ensuring safety of flight, protecting base resources, and planning military missions.

3.1.1.1.1.1 Department of Commerce

Within DOC, the National Weather Service (NWS), a component of the National Oceanic and Atmospheric Administration (NOAA), is the Federal Government's principal civilian meteorological agency. As such, it requires weather radar information to fulfill its assigned responsibilities. This information is required at National Weather Service Forecast Offices (NWSFOs), National Weather Service Offices (NWSOs), River Forecast Centers (RFCs), the Center for Environmental Prediction (NCEP), the Tropical Prediction Center (TPC), and the Storm Prediction Center (SPC).

3.1.1.1.1.2 Department of Defense

In the case of DoD, Air Force Weather (AFW) is the principal user agency which provides meteorological services to the Air Force, the Army, and certain other DoD elements. The Naval Meteorological Oceanography Command (NMOC) is the principal meteorological agency which supports the Navy, Marine Corps, and other elements of DoD. Air Force Weather requires weather radar information at its Base Weather Stations (BWSs), regional hubs, and at the Air Force Global Weather Central (AFGWC). NMOC requires weather radar information at its Naval Oceanography Command Detachments (NOCDs).

3.1.1.1.1.3 Department of Transportation

In the case of DOT, the Federal Aviation Administration (FAA), as the principal civilian agency for ensuring air traffic safety, requires weather radar information. This information is required for Air Traffic at Air Route Traffic Control Centers (ARTCCs), Terminal Radar Control facilities (TRACONs), airport towers, Automated Flight Service Stations (AFSSs), and the FAA's Air Traffic Control System Command Center (ATCSSCC). Airway Facilities requires this information at the National Operations Control Center (NOCC), Operational Control Centers (OCCs), and at Service Operations Center Work Centers (SOC/WCs).

3.1.1.1.2 Other Users

Other users of the WSR-88D System include Federal Government agencies other than the principal users; state and local government agencies; and private sector users such as airline companies, consulting meteorologists, the media, and university laboratories. Selected weather radar information will be made available to these users according to policy established by NEXRAD Program Management Committee (PMC).

3.1.1.2 Product Types

To support the common needs of the principal and other users for weather radar information, the WSR-88D System will generate products which can be used for distribution and presentation to operational personnel. These include base data, base products, derived products, alphanumeric products, and derived data array products (Defined in Appendix B).

3.1.1.2.1 Base Data

Base data consist of the Doppler moments at the highest resolution available from the signal processor (at least reflectivity, mean radial velocity and spectrum width). The base products consist of reflectivity, mean radial velocity, and radial velocity spectrum width (standard deviation) estimates presented in a format suitable for display on a color graphic display. The derived products provide processed radar data, concentrated to provide large volumes and varieties of data in a form suitable for display on color graphic displays and, to the extent possible, requiring minimum interpretive effort. The alphanumeric products provide processed radar data for users without a graphic display capability. The derived data array products provide data in a non-displayable format for transmission to systems external to the WSR-88D System for further processing.

3.1.1.2.2 Radar Products

Product generation will be automated to the extent feasible. However, at selected sites, an interactive display and data entry capability will be available for human analysis of radar data and assistance in the generation of certain radar products.

3.1.1.3 Product Distribution

The WSR-88D System will distribute products to the operational facilities (Defined in Appendix B) of the principal users and have an access capability so that other users can obtain selected products.

3.1.1.3.1 Principal User Product Distribution

3.1.1.3.1.1 NWS Local Sites

In the case of NWS, operational personnel at NWSFOs and NWSOs will automatically be provided products from a preselected WSR-88D. Certain NWSFOs may also regularly be provided products from one or more additional preselected WSR-88D Systems since their geographic area of responsibility is usually larger than for NWSOs. NWSFOs and NWSOs may choose products from the preselected WSR-88D(s) for regular receipt or on-demand call-up, subject only to their communications bandwidth limitations. In addition, NWSFOs and NWSOs will be able to obtain a limited number of products from any other WSR-88D in the United States on a dial request basis.

3.1.1.3.1.2 NWS National and Regional Sites

In the case of NWS, regional facilities and national facilities (Defined in Appendix B) will be provided selected products based on their needs. For each RFC, precipitation related products will be made available from each WSR-88D within its area of responsibility. Each RFC may choose products from any WSR-88D within its area of responsibility via dial-up requests. For the NWS national centers (NCEP, the TPC, and SPC), relatively low resolution products will be routinely made available from each relevant WSR-88D. In addition, the national centers will be able to request higher resolution products from any WSR-88D within the conterminous United States when needed.

3.1.1.3.1.3 DoD Local Sites

In the case of DoD, operational personnel at BWSs and NOCDs will automatically be provided products from a preselected WSR-88D. The BWSs and NOCDs may choose any product from the preselected WSR-88D for regular receipt or on-demand call-up, subject only to their communications bandwidth limitations. In addition, BWSs and NOCDs will be able to obtain a limited number of products from any other WSR-88D on a request basis.

3.1.1.3.1.4 DoD National Facility and Regional Centers

The only DoD national facility which requires WSR-88D products is AFGWC. It, like the NWS national centers, will routinely have available low resolution products and will be able to request more detailed products from any WSR-88D. The Air Force Weather regional hubs will receive products from pre-selected WSR-88D Systems.

3.1.1.3.1.5 DOT Facilities

In the case of the FAA, the NEXRAD WSR-88D System will provide products to all ARTCCs. The Center Weather Service Unit (CWSU) in each ARTCC will be provided with selected products from every WSR-88D within, or with extensive coverage within, its area boundary. (However, the further processing of the data received at the CWSU and its distribution to controllers within the ARTCC and to personnel at other FAA operational facilities is the responsibility of the FAA.) If one or more WSR-88Ds provide coverage for each of a selected set of major airport terminals, certain base data products and other RPG-derived products will be sent from those RPGs to the FAA facility at that airport/terminal.

3.1.1.3.2 Other User Products

Other users will have access to selected products, according to policy established by the NEXRAD Program Management Committee (PMC).

3.1.1.4 Principal User Processing and Display

Each of the principal users of the WSR-88D System will require a processing and display capability at operational facilities. This capability will be used by operational personnel for the selection, analysis, and further annotation and distribution of products. The processing and display capabilities will support the routine display of selected current products, the call-up of other products (both current and earlier versions), the annotation of products and their further distribution to external display systems, and the archiving of selected products.

3.1.1.5 Radar Siting

The WSR-88D radar (antenna) sites must meet the area and point coverage of the principal users. These sites are within the conterminous States; in Alaska, Hawaii, and Puerto Rico; and at selected overseas A number of these sites are in the vicinity of selected airports provide airport and terminal coverage. Some radar sites are collocated a principal user site.

3.1.1.6 Support Facilities

The WSR-88D system support environment includes support facilities (Defined in Appendix B) to assure satisfactory equipment operation and depot maintenance; provide training for operational and maintenance personnel; and support development, test, and evaluation activities.

3.1.1.6.1 Maintenance and Supply Depots

A centralized maintenance facility, the National Reconditioning Center (NRC), and supply depot, the National Logistics Support Center (NLSC), supports all WSR-88D equipment. These depots contain WSR-88D hardware, including radar, data processing, and display and data entry equipment configured as at an operational site. In addition, other support hardware and software required for the maintenance function and related documentation are located at the NRC. Spare parts and consumable supplies are located at the NLSC.

3.1.1.6.2 Maintenance Training Facilities

WSR-88D maintenance training facilities are located at existing principal user's training sites. Each facility contains WSR-88D equipment, including radar, data processing, and display and data entry hardware, and appropriate test software, dedicated to the hardware maintenance training function.

3.1.1.6.3 Operational Training Facilities

WSR-88D system operational training facilities are located at existing principal users' training sites. Each training facility possesses the equipment necessary for operational training including a data playback capability.

3.1.1.6.4 Radar Operations Center

The WSR-88D Radar Operations Center (ROC) provides support to the WSR-88D System. This facility provides operational support, test and evaluation activities and life cycle support. The ROC also manages the development of hardware enhancements and retrofits, technical documentation, and software changes. To support test and evaluation activities, the ROC has data recording, data playback, and data analysis capabilities. Radar data sets, recorded in climatologically different geographical areas and under different meteorological conditions, are provided to the ROC to support test and evaluation of the data processing, distribution, and display portions of the WSR-88D System. To support maintenance, enhancement, and distribution of the WSR-88D System operational software, support software (such as assemblers, compilers, operating systems, test aids, and adaptation data generation software) is available. Support hardware (such as simulation equipment, data storage devices, and printers) is available to support the software maintenance and enhancement functions.

3.1.1.7 Functional Areas

An overview of the WSR-88D System functional areas, together with an identification of the functions of each area, is provided in Figure 3-1. Functional area requirements are presented in more detail in Section 3.7 of this document. The WSR-88D System Specification has been defined in terms of the functional areas listed below. Accordingly, a system design may be selected that allocates functions to equipment items and computer programs in a manner different than implied by the functional area breakdown, provided all of the system requirements are met. Specifically, conclusions should not be drawn, unless explicitly stated, regarding the relationship between a physical location (site) and the requirements of an individual functional area.

a. System Requirements
b. Radar Data Acquisition
c. Radar Product Generation
d. Principal User Processing
e. Facilities
f. Support

FUNCTIONAL AREAS

RADAR DATA ACQUISITION	RADAR PRODUCT GENERATION	PRINCIPAL USER PROCESSOR	FACILITIES	SUPPORT
Antenna Control	Product Generation	Display & Data Entry	Buildings	Off-Line Diagnostics
Transmit	Product Storage	Product Request	Towers	Support Software
Receive	Product Distribution	Product Display	Real Property Installed Equipment (RPIE)	Adaptation Data Maintenance
Signal Processing	Display & Data Entry	Local Product Storage		Map Generation
Ground Clutter Suppression	Control	Product Annotation & Distribution		Computer Performance Monitoring
Control	Status Monitoring & Error Detection	Control		Test Data Generation
Monitoring & Error Detection	Archiving	Status Monitoring		Test Software
Display	Hydrometeorological Processing	Archiving		Configuration Management
Calibration	Base Data Ingest			
Archiving	Base Data Distribution			
Base Data Output				

Figure 1 FUNCTIONAL AREA OVERVIEW

3.1.1.7.1 Radar Data Acquisition

The Radar Data Acquisition (RDA) functional area includes the Doppler radars which are located at the radar sites. This functional area also includes hardware and software required to perform the signal processing, clutter suppression, base data distribution, equipment and software control, status monitoring and error detection (both local and through the FAA Remote Monitoring System (RMS) (Defined in Appendix B.), display, calibration, and archiving functions related to radar operation. It also includes any hardware and software, including communications equipment, needed for wideband links that may be required for transmission of data between non-collocated RDA and RPG.

3.1.1.7.2 Radar Product Generation

The Radar Product Generation (RPG) functional area includes all hardware and software required for real time generation, storage, and distribution of products (to the PUP and other dedicated and dial up interfaces) for operational use. It also includes hardware and software required for base data ingest from the RDA, control, status monitoring and error detection (both local and through the FAA RMS, archiving, and hydrometeorological processing. To the extent required, this functional area includes display and data entry hardware and software provided for human participation in the generation of the products. It also includes any hardware and software, including communications equipment, needed for wideband links that may be required for transmission of data between non-collocated RDA and RPG.

3.1.1.7.3 Principal User Processing

The Principal User Processing (PUP) functional area includes all hardware and software required for the request, reception, display, local storage, and local annotation and distribution of products by operational personnel of the principal user agencies. It also includes the hardware and software required for local control, status monitoring, and archiving.

3.1.1.7.4 Facilities

The Facilities functional area includes buildings, towers, and Real Property Installed Equipment (RPIE) such as power generation and air conditioning equipment.

3.1.1.7.5 Support

The Support functional area includes an off-line diagnostics capability, support software, adaptation data maintenance, map generation, computer performance monitoring, test data generation, test software, and Configuration Management (CM). The support software includes capabilities required for the development, test, maintenance, and enhancement of the operational software.
The NEXRAD Integrated Logistics Support Plan (ILSP) outlines the logistics, maintenance depot equipment, spares, maintenance support equipment, and infrastructure to support the WSR-88D systems. The ILSP also describes and assigns responsibility for maintenance and operational training.

3.1.2 Missions

DOC, DOD, and DOT have major weather related missions and responsibilities that require weather radar information.

3.1.2.1 Department of Commerce Missions

DOC, through the National Weather Service (NWS), is the principal civilian meteorological agency of the Federal Government. Specifically, DOC is responsible for detection of hazardous weather such as severe thunderstorms, tornadoes, excessive rainfalls, and winter weather events; and warning the public. It is also responsible for providing essential weather information to other activities such as civilian aviation, marine, agricultural and forestry operations, and the entire river and flood prediction program. DOC operates many weather radars and uses information from some radars operated by DOD and DOT to meet these responsibilities.

3.1.2.2 Department of Defense Missions

Within DOD, the Air Force Weather Agency (AFWA) provides worldwide meteorological and aerospace environmental services to the Air Force, Army, and certain other DOD elements; the Naval Meteorological and Oceanography Command (NMOC) supports the Navy, Marine Corps, and some other elements of DOD. These organizations are responsible for providing and relaying severe weather warnings for the protection of DOD resources and personnel, providing weather information to aid the decision making process at specific locations, and supporting military aviation. To meet these responsibilities, DOD operates weather radars in the United States and overseas and uses information from these and from DOC and DOT WSR-88D systems in the United States.

3.1.2.3 Department of Transportation Missions

DOT, through its Federal Aviation Administration (FAA), is responsible for the safe and efficient utilization of United States airspace. In meeting these responsibilities, the FAA provides information on the location and intensity of potentially hazardous weather conditions to air traffic personnel, flight service specialists, airline dispatchers, pilots, and others concerned with aviation. There has been an increased emphasis on providing real time hazardous weather information. DOT has a number of programs planned to exploit the WSR-88D data. DOT presently obtains its information from other equipment, to include its own air traffic control radars (not designed for weather detection), FAA terminal and en route weather radars, DOD and NWS radars via remote displays, and from other FAA and NWS products, and NWS personnel located at FAA facilities.

3.1.2.4 System Mission

The mission of the WSR-88D System is the acquisition, processing, and distribution of weather radar information to aid in reducing loss of life, injuries, and damage to property. The radar system addresses the common needs among three Federal departments (DOC, DoD, and DOT). The WSR-88D System is expected to provide real-time information on the location, intensity, and movement of both routine and hazardous weather phenomena. These phenomena, although not mutually exclusive, are: precipitation, wind and wind shear, tornadoes, fronts and fine lines, tropical cyclones, mesocyclones, thunderstorms, turbulence, icing conditions, hail, and freezing/melting level.

The WSR-88D System provides routine information useful for monitoring and assessing general weather conditions such as rainfall amounts and distribution. To meet the minimum objectives of the principal users, the WSR-88D System must acquire, process, and display data in a readily interpretable fashion. Although the WSR-88D System is intended to be a standalone system, it must also interface with certain existing principal user display and standard communications systems. This will be accomplished by providing a standard set of products over a standard communications interface.

3.1.3 System Diagrams

In addition to the functional area overview (Figure 3-1) already presented, the following diagrams are also presented:

Figure 3-2 shows four possible WSR-88D example configurations. Example 1 consists of the NWS or DoD Collocated RDA and RPG, the Collocated PUP (applies to NWS RPGs only), external interfaces, and agency WSR-88D PUPs. Example 2 consists of the NWS Remote RDA, the NWS RPG and its collocated PUP, external interfaces, and agency WSR-88D PUPs. Example 3 consists of the NWS Remote Redundant RDA, the NWS RPG and its collocated PUP, external interfaces, and agency WSR-88D PUPs. Example 4 consists of the FAA Remote Redundant RDA and RPG, external interfaces, and agency WSR-88D PUPs. Examples 2 and 3 indicate that the RDA and RPG are physically separated by some distance that requires Microwave Line of Site (MLOS) or commercial/private telco service. In examples 1 and 4, the RDA(s) and respective RPG(s) are in physical proximity under 500 ft. The tri-agency WSR-88D PUPs and systems connected to other data interfaces in all 4 examples may be located in the same weather facility as the RPG or at respective agencies remote locations.

Table 3-1 presents a NEXRAD principal user organization overview.

3.1.4 User Interfaces

Figure 3-2 shows the major interfaces of the WSR-88D.

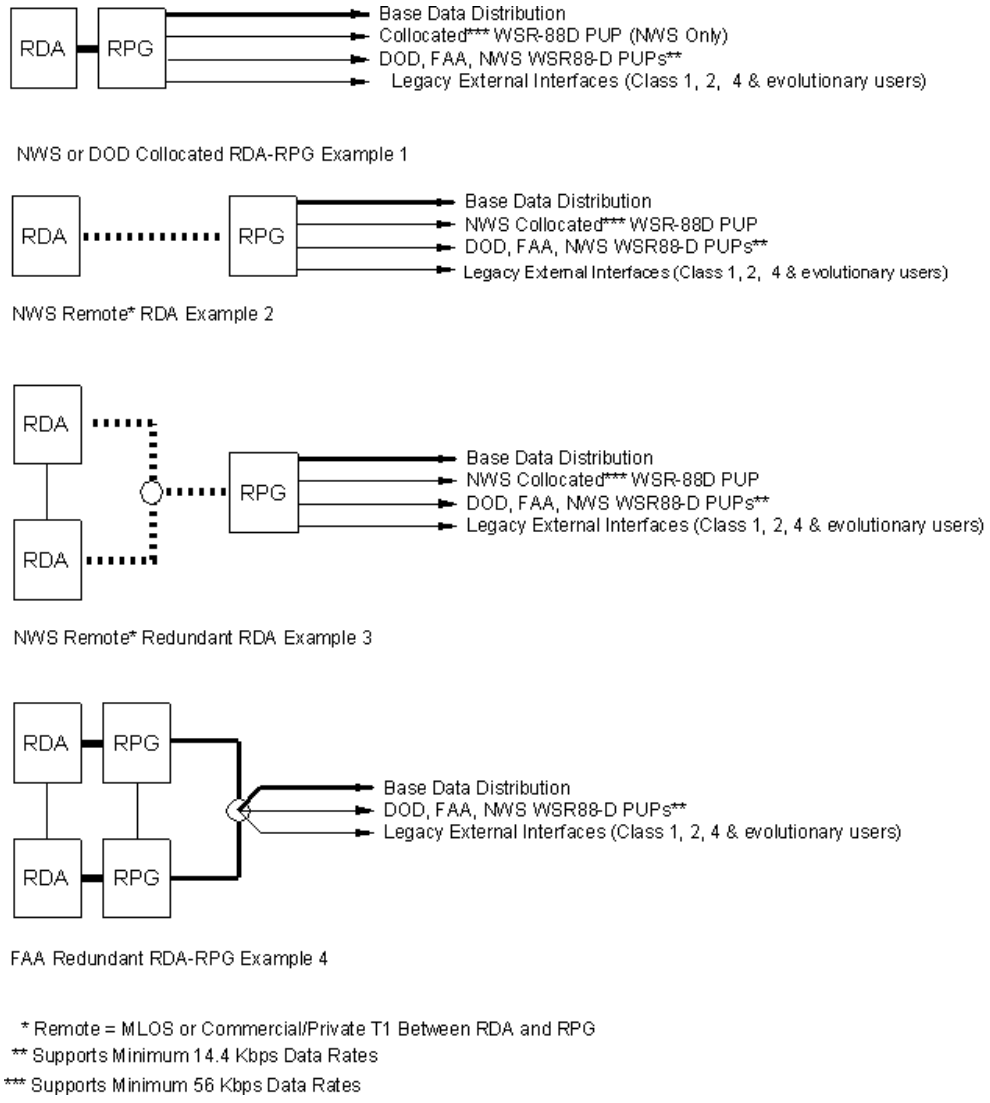


Figure 2 WSR-88D EXAMPLE CONFIGURATIONS

Table 3-1 NEXRAD PRINCIPAL USER ORGANIZATION OVERVIEW

FACILITY	RELEVANT RESPONSIBILITY	NEED FOR/USE OF NEXRAD INFORMATION
• NCEP	Issue weather analysis and forecast guidance	Overview information for generation of radar summary products; detailed rainfall information; and high resolution data for mesoscale models.
• SPC	Issue severe convective storm and tornado watches	Low resolution information in storm areas.
• TPC	Issue hurricane watches and warnings	Low resolution information in hurricane areas.
• RFCs	Derive flood forecasts.	High resolution area/precipitation estimates covering river basins.
• NWSFOs/NWSOs	Issue severe weather, flood, and flash flood warnings for local area.	High resolution information on hazardous weather in or approaching local area.
DoD • BWSs	Issue weather warnings and advisories for AF base area.	High resolution information on hazardous weather in or approaching base area.
• AFGWC	Issue weather warnings and advisories where no BWS operating.	High resolution information on hazardous weather where no BWS operating; Low resolution overview information elsewhere.
• NOCDs	Relay weather warnings and advisories in Navy base/station area.	High resolution information on hazardous weather in or approaching base area
FAA • ARTCCs/CWSUs	Disseminate hazardous weather information internally and to other FAA users (e.g., ARTCC, TRACON, and Tower) in ARTCC area of responsibility.	High resolution on hazardous weather in or approaching ARTCC area of responsibility
• ATCSCC	Interface with each ARTCC to establish air traffic flow patterns, enhance flight safety, and minimize delays.	Low resolution overview information on a national basis.
• AFSSs	Provide hazardous weather information within air-to-ground coverage area; provide En route Flight Advisory Service for area of responsibility (if applicable); provide preflight briefings on a national basis.	High resolution information on hazardous weather in or approaching FSS area of responsibility; low resolution information on a national basis.
• TRACONS	Provide hazardous weather information to controllers and pilots.	High resolution current information on hazardous weather in terminal airspace (e.g., gust fronts, down drafts, wind shear, and turbulence), especially on final approach and take-off.

3.2 System Characteristics

This section contains the performance, physical, reliability, maintainability, availability, environmental, and transportability requirements for the WSR-88D System.

3.2.1 Performance Characteristics

This section contains the performance requirements. The WSR-88D can be operated manually or is capable of operation in a fully automatic mode. Any performance limitations associated with a fully automated operation are subject to NEXRAD Configuration Control Board (CCB) approval.

3.2.1.1 WSR-88D Full Load

The full load requirements of the Radar Data Acquisition, Radar Product Generation, and Principal User Processing functional areas are defined in this section. The full load defines the total number of functions and activities to be performed concurrently within each functional area while meeting all required response time and throughput requirements (Sections 3.2.1.3 and 3.2.1.4) without product generation load-shedding, loss of any radar data, or loss of control/status messages. This does not preclude load-shedding of products to be distributed if the capacity of the distribution interfaces is exceeded. The column labeled "Full Load" in Table 3-4 represents the system configuration that must meet the full load requirements in this section. The full load requirements are the following:

a. The WSR-88D shall (1) perform the control and monitoring functions of the RDA functional area, as defined in Section 3.7.2

b. The WSR-88D shall (2) monitor and transmit RDA performance data.

c. In the volume scan time specified in paragraph 3.7.2.2.1.2, the WSR-88D shall (3) provide base data from the RDA to the RPG in accordance with the unique elevation angles described for each scan strategy.

d. The WSR-88D shall (4) process RDA control commands from the RPG.

e. The WSR-88D shall (5) monitor and control all activities performed by the RPG.

f. The WSR-88D shall (6) generate the full load product mix defined in Table E-1a.

g. The WSR-88D RPG shall (7) output products selected from the full products column of Table E-1a to drive eight associated PUP (or Legacy Class 1 user) interfaces and one Collocated PUP interface to their full capacity. Requirements for interface capacity are defined in Section 3.7.1.8.

h. The WSR-88D RPG shall (8) output products selected from the products column of Table E-1a to twelve Legacy Class 2 user interfaces (or PUP with a dial connection). Requirements for interface capacity are defined n Section 3.7.1.8.

i. Deleted per ECP 0141

j. The WSR-88D RPG shall (10) process a mix of peak requests (see Section 3.2.1.2) from eight associated PUPs or Legacy Class 1 users and the collocated PUP.

k. The WSR-88D shall (11) satisfy all processing requirements defined in Section 3.7.3 for the RPG functional area.

l. The WSR-88D shall (12) display products on each display at the collocated PUP.

m. The WSR-88D PUP shall (13) control all activities performed by the PUP functional area, as defined in Section 3.7.4.

n. Each associated PUP shall (14) receive all products from a fully driven interface to its RPG. Requirements for interface capacity are defined in Section 3.7.1.8.

o. Each PUP with a dial connection shall (15) receive products selected from the products column of Table E-1a from an RPG.

p. The WSR-88D shall (16) display products on each display at a PUP.

q. The WSR-88D shall (17) satisfy all processing requirements defined in Section 3.7.4 for the PUP functional area.

r. The WSR-88D shall (18) process a mix of product requests (selected from the products column of Table E-1a) from twelve Legacy Class 2 users (or PUP with a dial connection).

s. The WSR-88D shall (19) output product(s) (defined in FMH-11 for Other Users) to four Legacy Class 4 interfaces. Requirements for interface capacity are defined in Section 3.7.1.8.

t. The WSR-88D PUP shall (21) output products selected from the products column of Table E-1a to one Other User interface (Class 3 interface). Requirements for interface capacity are defined in Section 3.7.1.8.

u. The WSR-88D shall (22) provide the full load archiving as shown in FMH-11 for the RPG and Table E-1a for the PUP.

v. The WSR-88D shall (23) output products (the product mix identical to the product mix for the collocated PUP) from an RPG to one LAN interface. Requirements for interface capacity are defined in Section 3.7.1.8.

w. The WSR-88D shall (24) output the unaltered base data stream to four Base Data Distribution Interfaces (this is in addition to the RDA/RPG data stream).

3.2.1.2 Peak Request Rates

The RPG shall (1) handle up to 4 product requests (3 existing products and 1 product requiring generation) per second. Each PUP shall (2) generate 1 display request per second as defined in Table 3-2. The peak request rate-mix of requested types is defined as those products selected from the products column of Table E-1a and listed in FMH-11 (see product distribution full load requirements in previous section). The requests shall (3) be capable of being repeated every second if the response to the request is less than one second. If the response to the request is greater than one second, a request shall (4) be repeated at a frequency consistent with the response time required for the request type (see Table 3-3).

Table 3-2 PEAK REQUEST RATES

Display Requests: 1 Per Second

Product Selection (locally stored)
Background Map Selection/Deselection
Off-center/Preset Center
Display of Cursor Coordinates
Cursor Home
Test Pattern Selection/Deselection
Time Lapse Display

3.2.1.3 Response Time Requirements

Table 3-3 summarizes the response time requirements for the WSR-88D system. All response times (except for Startup and Restart) shall (1) be met while the system is processing a full load as defined in Section 3.2.1.1.

System response time requirements shall (2) be met 90% or greater of all measurements for a statistically significant sample of the response time parameter are equal to or less than the defined requirement. Requirements referencing Table 3-3 are in the following sections. Unless specifically stated, display functionality requirements do not apply to the RPG.

Table 3-3 SYSTEM RESPONSE TIME REQUIREMENTS

FUNCTION	RDA	RPG	PUP
Product Selection (locally stored)	-	-	3 sec.
Product Selection (one-time basis)	-	Note 1	Note 1
Product Deselection	-	-	100 msec.
Product Turn-on/Turn-off	-	-	100 msec.
Background Map Selection/Deselection	-	-	1 sec.
Background Map Turn-on	-	-	500 msec.
Background Map Turn-off	-	-	100 msec.
Off-center/Preset Center	-	-	3 sec.
Resolution Change (locally stored)	-	-	3 sec.
Resolution Change (one-time basis)	-	Note 1	Note 1
Display Annotation	-	-	200 msec.
Display of Cursor Coordinates	-	-	1 sec.
Cursor Home	-	-	1 sec.
Test Pattern Selection/Deselection	-	-	1 sec.
Status Message Output / Display	-	10 sec.	10 sec.
Alarm Output	2.5 sec.	2.5 sec.	-
Local Display of Alarm	5 sec.	5 sec.	5 sec.
Alert Message Output (Note 5)	-	2.5 sec.	-
Alert Message Display (Note 5)	-	-	5 sec.
Power Fail Recovery	-	1.5 min	30 sec.
Magnification	-	-	3 sec.
Time Lapse Display - First Image	-	-	Note 2
Time Lapse Display - Successive Images (Note 3)	-	-	1/3-10 sec.
Time Lapse Display - Image Replacement	-	-	100 msec.
Master Cursor Function	-	-	100 msec.
Hard Copy Generation	-	2 min.	2 min.
Cold Startup	15 min.	3 min.	2 min.
Warm Startup	10 sec.	-	-
Restart	Note 4	1.5 min	30 sec.
Engine Generator On-line	25 Sec	-	-
FAA Redundant Channel Switchover	15 Sec	-	-

Note 1: Total WSR-88D response times are defined for each product in Table E-1b, assuming a 14.4 kbps, Class 1 line to an associated PUP. The PUP is allocated 3 seconds of the total for display of the product.

Note 2: For products preselected for time lapse display, the response time will not be greater than 3 seconds. For all other products, the response time will not be greater than 3 seconds + 1.25 seconds per image in the display sequence.

Note 3: When successive images are displayed with a response time less than 1 second, the displayed product resolution may be reduced to not less than 256 x 256 pixels. However, the product shall (5) fill a 512 x 512 pixel display area.

Note 4: The RDA Restart time is a function of outage time and the state of the RDA, but will in no case exceed the RDA Cold Startup time.

Note 5: Alert message output response time is from detection to transmission of the alert message to the PUP distribution queue. Delay in product distribution queue not included. The PUP alert message display response time is from reception of the message to completion of the display.

3.2.1.3.1 Product and Background Map Display

Products and background maps selected for display shall (1) be completely displayed within the response time required (see Table 3-3). Products and background maps deselected shall (2) be deleted from the display within the response time required (see Table 3-3). The functional requirements for the product display and background map selection capabilities are stated in Section 3.7.4 for the PUP functional area. Product data and background maps shall (3) be capable of being turned on and turned off within the response times defined (see Table 3-3).

3.2.1.3.2 Off-Center/Preset Center

An off-center or preset center request action shall (1) be completed within the response time required (see Table 3-3). During the processing time required to accomplish the action, the display image may be static or wholly blanked for up to the total period required to complete the action but not longer than the response time requirement. The functional requirements for the off-center/preset center capability are stated in Section 3.7.4 for the PUP functional area.

3.2.1.3.3 Resolution Change

A resolution change shall (1) be completed within the response time required (see Table 3-3). During the processing time required to accomplish the action the display image may be static for up to the total period required to complete the action, but not longer than the response time requirement. The functional requirements for the resolution change capability are stated in Section 3.7.4 for the PUP functional area.

3.2.1.3.4 Display Annotation

The response to any operator input action which causes insertion or deletion of data on a display shall (1) be completed within the response time required (see Table 3-3).
The response time shall (2) include the time to update a preview area and the preview area cursor symbol, or the time to annotate a display area selected by a cursor.

3.2.1.3.5 Display of Cursor Coordinates

The present value of the master cursor coordinates shall (1) be updated within the response time required (see Table 3-3), after the cursor has stopped.

3.2.1.3.6 Cursor Home

The cursor symbol shall (1) be positioned at an adaptation controlled position on the display within the response time required (see Table 3-3), following the requesting action.

3.2.1.3.7 Test Pattern Selection/Deselection

Following the test pattern selection action, the test pattern shall (1) be displayed within the response time required (see Table 3-3).
Following the test pattern deselection action, the operational data displayed prior to the test pattern selection, including updated data occurring during the period the test pattern was displayed, shall (2) be displayed within the response time required (see Table 3-3).

3.2.1.3.8 Status Message Display

Display of status messages at the station configured as the Master System Control Function (MSCF), or the PUP shall (1) be completed within the time indicated in Table 3-3 to include the time from generation of status message (within the functional area) or reception of status message from another functional area to completion of display.

Transmission of status messages from the RPG to the Class 1/Collocated PUP and the FAA RMS interface shall (2) be completed within the response time indicated in Table 3-3 to include the time from generation of status message (within the RPG) or reception of status message from the RDA, but not including delay in the communication queue.

3.2.1.3.9 Alarm/Alert Output/Display

The following alarm response times shall (1) be within the times indicated in Table 3-3:

a. Time from the detection of an alarm condition (within the functional area) or reception of alarm from another functional area to the activation of a local alarm (display on the RDA MSCF position, the RPG MSCF position, and the PUP display).

b. Time from the detection of an alarm condition or reception of alarm from another functional area to the transmission of the alarm to the appropriate functional area (RPG/Class 1 PUP/Collocated PUP) and the FAA RMS interface (delay in communication queue not included).

The alert message response times shall (2) be within the times indicated in Table 3-3.
All products automatically generated when alert criteria are met shall (3) meet the appropriate response times for one-time product requests as shown in Table E-1b.

3.2.1.3.10 Power Fail Recovery

When normal power levels have returned following a power interruption, the WSR-88D System shall (1) automatically resume normal operation (with all functions available to users and all previously displayed data displayed) within the response time required (see Table 3-3). The functional requirements for the power failure recovery capability, including limitations, are stated in Section 3.7.1.4 for the system requirements.

3.2.1.3.11 Magnification

Data selected for display, using the magnification function shall (1) be completely displayed within the response time required in Table 3-3. During the processing time required to accomplish the action, the display image may be static or wholly blanked for up to the total period required to complete the action but not longer than the response time requirement. The functional requirements for the magnification capability are stated in Section 3.7.4 for the PUP functional area.

3.2.1.3.12 Time Lapse Display

It shall (1) be possible to time lapse any sequence of base or derived products currently in the local data base while meeting the response times shown in Table 3-3. The functional requirements for the time lapse capability are stated in Section 3.7.4 for the PUP functional area.

3.2.1.3.13 Master Cursor Function

The update time for positioning each slave cursor shall (1) be within the response time required (see Table 3-3). The functional requirements for the master cursor function are stated in Section 3.7.4 for the PUP functional area.

3.2.1.3.14 Hard Copy Generation

The time from the request for hard copy output until it is available shall (1) be within the response time required in Table 3-3.

3.2.1.3.15 Startup/Restart

The entire cold startup procedure shall (1) be capable of being completed within the time specified in Table 3-3 while minimizing to the extent feasible the number and complexity of operator actions. The warm startup procedure shall (2) be capable of being performed by one person within the time specified in Table 3-3 with the response time measured from the initiation of the warm startup control command (from the MSCF or through the FAA RMS interface until the RDA is operational, the RDA to RPG interface is re-established and valid data transfer to the RPG has begun. The restart procedure shall (3) be capable of being performed by one person within the time specified in Table 3-3 with the response time measured from the initiation of the restart control command (from the MSCF or through the FAA RMS interface or from the detection of an error condition requiring an RDA restart) until the RDA is operational, the RDA to RPG interface is re-established, and valid data transfer to the RPG has begun.

3.2.1.3.16 Engine Generator Online

In the event of primary power failure or manual selection of backup power, the backup engine generator shall (1) become operational and on-line within the response time required in Table 3-3.

3.2.1.3.17 FAA Redundant Channel Switchover

The redundant channel switchover shall (1) be capable of being performed by one person within the time specified in Table 3-3 with the response time measured from the initiation of the command (from the MSCF or through the FAA RMS interface until data transfer from the RDA to the RPG has begun.

3.2.1.4 Unit Throughput

Products generated on a routine basis by the RPG shall (1) be displayed at the RPG and PUPs within the throughput time requirements defined in Table E-1b. All throughput time measurements shall (2) be taken while the WSR-88D System is performing under a full load condition. The WSR-88D throughput time requirements will be met if 90% or greater of all measurements for a statistically significant sample of the throughput parameter are equal to or less than the defined requirement.

3.2.1.5 Configuration

The WSR-88D shall (1) provide the minimum operational configuration as indicated in Tables 3-4a, 3-4b, 3-4c, and 3-4d for each functional area. Performance requirements for the Full Load configuration listed in the table are detailed in Section 3.2.1.1. Functionally, the following configurations shall (2) be possible without modification (facilities excluded) of the WSR-88D equipment:

a. Collocated RDA, RPG, PUP (PUP not located in RDA/RPG equipment area)
b. Separate RDA; collocated RPG/PUP
c. Collocated RDA/RPG; separate PUP
d. Collocated redundant, RDA/RPG (Section 3.2.1.5.1); separate PUP
e. Separate redundant RDA (Section 3.2.1.5.2); Collocated RPG/PUP

3.2.1.5.1 FAA Redundant Configuration

The driving principle behind the FAA redundant configuration is increased availability. A capability for a collocated RDA/RPG in a fully redundant configuration shall (1) be provided. All RDA and RPG functional area equipment, but excluding the antenna, pedestal, tower, telco service, and backup power generator, shall (2) be redundant. The point for recombining the redundant channels shall (3) be before telco service access.

A single environmentally controlled area shall (4) be provided to house both redundant channels. The equipment shall (5) be arranged to facilitate convenient and efficient maintenance. One MSCF display/control position shall (6) be provided in the redundant configuration. The back-up power generator and the air conditioning equipment shall (7) be sized and configured to support one channel at full operation and the second channel at full power without high voltage being applied to the klystron.

3.2.1.5.2 NWS Redundant Configuration

A capability for a configuration comprised of a redundant RDA (see Section 3.2.5 for availability requirements) and a single-channel RPG which is collocated with a PUP shall (1) be provided. All RDA functional area equipment excluding MLOS system or telco service (as applicable), antenna, pedestal, tower, and backup power generator, shall (2) be redundant. The point for recombining the redundant channels shall (3) be the output for the base data distribution function.

A single, environmentally controlled area shall (4) be provided to house both redundant RDA channels. The equipment shall (5) be arranged to facilitate convenient and efficient maintenance. The MSCF and its associated display/control positions shall (6) be capable of full status reporting, alarms, and control of both RDA channels.

A selection capability shall (7) be provided at the Remote RDA maintenance terminal to bring either channel to standby (controlled shutdown state, Section 3.7.3.5.5) or full operation, regardless of the state of the other channel. A communications link with a defined protocol may be used for this purpose. The back-up power generator and the air conditioning equipment shall (8) be sized and configured to support this configuration.

Table 3-4a WSR-88D RDA CONFIGURATIONS

	Operational Configurations	
FUNCTIONAL AREA FEATURE	Minimum	Full Load Test
Base Data Interface to the RPG	1	1
[Deleted by ECP 0151, SCN-02]	1	0
Archive Level I Interface	1	0
Archive Level II Capability	1	1
Remote RDA Control Interface	1	1
FAA RMS Interface	0	1

Table 3-4b WSR-88D RPG CONFIGURATIONS

	Operational Configurations	
FUNCTIONAL AREA FEATURE	Minimum	Full Load Test
Base Data Interface to the RDA	1	1
Dedicated Ports to Associated PUPs / Class 1 Interfaces	0	8
Dial-in Ports from PUPs / Class 2 Interfaces	4	12
Ports for Other Users (combined ded & dial) / Class 4 Interfaces	0	4
Archival Capability (Level III)	0	1
Base Data Distribution Interfaces	0	4
Dedicated Port for Remote MSCF terminal	0	0
Alphanumeric Hardcopy Device (MSCF Control)	0	1
Remote Monitoring System (RMS) Interface	0	1
Remote RPG Control Interface	0	0
Total Class 1, 2, 4 Ports that must be supported without expansion is a minimum of 30.		

Table 3-4c WSR-88D NON-COLLOCATED PUP CONFIGURATIONS

	Operational Configurations	
FUNCTIONAL AREA FEATURE	Minimum	Full Load Test
Dedicated Ports to Associated RPG / Class 1 Interfaces (not a Collocated PUP)	0	1
Dial-out Ports to RPG / Class 2 Interfaces	1	1
Ports to Other Users (combined dedicated & dial) / Class 4 Interfaces	0	1
Archival Capability	1	1
Graphics Displays per Position	2	2
Alphanumeric Display per Position	1	1
Hardcopy Devices per Position	0	1
Total Class 1,2, 4 Ports that must be supported without expansion is a minimum of 8.		

Table 3-4d WSR-88D COLLOCATED PUP CONFIGURATIONS

	Operational Configurations	
FUNCTIONAL AREA FEATURE	Minimum	Full Load Test
Hard Connection to RPG	1	1
Dial-out Ports to RPG / Class 2 Interfaces	1	1
Ports to Other Users (combined dedicated & dial) / Class 4 Interfaces	0	0
Archival Capability	0	0
Graphics Displays per Position	2	2
Alphanumeric Display per Position	1	1
Hardcopy Devices per Position	1	1
Total Class 1, 2, 4 Ports that must be supported without expansion is a minimum of 8.		

3.2.1.6 Data Processing Reserve

The equipment performing the RPG functions shall (1) have a processing reserve such that when processing the full load requirements (defined in Section 3.2.1.1) the utilization of each of the processing, addressable memory (available to software not including the operating system), and direct access mass storage functions, averaged over a volume scan time period, does not exceed the following:

RESOURCE	UTILIZATION
Processing	30%
Addressable memory	30%
Mass Storage	30%

This reserve is based upon the anticipated increase, over the first several years of operation, of resource requirements as indicated in the Radar Product Generation Algorithm Survey and Analysis Report, June 1996.

3.2.1.7 Expandability

WSR-88D Systems shall (1) be incrementally expandable by field modification. The expansion capability is in reference to the WSR-88D equipment to meet the full load, as defined in Section 3.2.1.1, including the reserve as defined in Section 3.2.1.6.

3.2.1.7.1 RPG Expandability

The RPG functional area shall (1) be expandable to at least the following:

a. Processing Capacity: 3 times
b. Addressable Memory: 3 times
c. Direct Access Mass Storage Devices: 3 times
d. Archival Storage Devices: 2 times
e. Communications Interfaces: 46 total Class 1, 2, 4 interfaces
f. Base Data Distribution Interfaces: 4 times

3.2.1.7.2 PUP (Collocated and Non-Collocated) Expandability

The PUP functional area shall (1) be expandable to at least the following:

a. Processing Capacity: 2 times
b. Addressable Memory: 2 times
c. Direct Access Mass Storage Devices: 2 times
d. Archival Storage Devices: 2 times
e. Communication Interfaces: 10 total Class 1, 2, 4 interfaces

3.2.1.7.3 RDA Expandability

The RDA functional area shall (1) be expandable to incorporate additional computer processing, memory, communications, and data storage capacities.

3.2.2 Physical Characteristics

Section 3.7.5 further defines physical characteristic limitations consistent with existing access capabilities. The WSR-88D shall (1) operate within the limits of the existing facilities.

3.2.3 Reliability

This section defines the hardware reliability requirements for the WSR-88D System. There are no explicitly stated reliability requirements for system software.

3.2.3.1 Hardware Reliability

The method determining the hardware reliability shall (1) conform to IEEE Std 1413-1998.

3.2.4 Maintainability

This section defines the hardware maintainability requirements for the WSR-88D System. This applies to the relevant failures defined in Section 3.2.5.1.1. It is assumed that all specified values have sufficient significant figures required by the availability requirements in Section 3.2.5.

3.2.4.1 Hardware Maintainability

The WSR-88D System shall (1) have a Mean Time To Repair (MTTR) of 0.5 hours. The MTTR is defined as the total elapsed time (clock hours) for corrective maintenance divided by the total number of corrective maintenance actions during a given period of time. The times that are included in the calculation of MTTR are as follows:

a. Localization - The time required to locate a failure without using support equipment.
b. Preparation- The time to obtain, set up, interconnect, and warm up support equipment and/or tools.
c. Isolation- The time required to locate a failure using support equipment.
d. Disassembly- The time required to disassemble equipment to gain access to the Line Replaceable Unit (LRU) that is to be replaced.
e. Interchange- The time required to remove the defective LRU and install the replacement.
f. Reassembly- The time required to close and reassemble the equipment after the LRU replacement has been made.
g. Alignment- The time required to perform alignment and/or adjustment made necessary by the repair action.
Checkout - The time required to perform those minimum checks necessary to verify correction and equipment serviceability.

Mean Active Maintenance Downtime (MAMD) is defined as the total elapsed time (clock hours) for corrective maintenance and preventive maintenance divided by the total number of corrective maintenance and preventive maintenance actions during a given period of time. The MAMD is not specified. Instead, the Total Preventive Maintenance (TPM) downtime per year is specified.

The WSR-88D System shall (2) have a Total Preventive Maintenance (TPM) time not to exceed 23 hours each year. The Maximum Time To Repair (MAXTTR) is the maximum corrective maintenance downtime within which 90% of all corrective maintenance actions can be accomplished.

For the WSR-88D System the following MAXTTR limits shall (3) be imposed on the functional areas identified:

RDA	2 hours MAXTTR
RPG	1 hour MAXTTR
PUP	1 hour MAXTTR

3.2.5 Availability

There are two types of availability requirements stated for the WSR-88D System. These two types of availability are Inherent Availability and Achieved Availability. Inherent and Achieved Availability apply to system hardware only.

3.2.5.1 Hardware Availability

3.2.5.1.1 Relevant Failures for Hardware Availability Calculation

Inherent and Achieved Availability shall (1) be based on failures categorized as "relevant". Relevant failures are everything that is not cited as non-relevant in this section. A failure is defined as any hardware malfunction which degrades the performance of a configuration item below its specified value. A non-relevant failure is a failure which results from factors external to the subject configuration item or group of configuration items. Non-relevant failures are limited to those failures which are due to the following causes:

a. Accidents

b. Operator errors

c. Failures caused by test instrumentation / monitoring equipment that is not part of the system.

d. Maintenance induced failures, unless attributable to equipment design.

e. Software failures.

3.2.5.1.2 Inherent Availability

Inherent Availability (Ai) is defined as the probability that, when used under stated conditions in an ideal support environment without consideration for preventive action, a system will provide the functional area capabilities stated in Table 3-5. Each functional area must provide all of the capabilities listed in the corresponding section of the table in order to be classified as available. An ideal support environment exists when the stipulated tools, parts, skilled manpower, manuals, support equipment and other support items required are available. Inherent Availability excludes whatever preventive maintenance downtime, supply downtime, and administrative downtime may be required.

The hardware components of the RDA functional areas shall (1) have an Ai of at least 0.9953. The hardware components of the RPG functional areas shall (2) have an Ai of at least 0.9996. The hardware components of the PUP functional areas shall (3) have an Ai of at least 0.9990. The relationship between Ai and reliability and maintainability is given by the following formula:

$$Ai = \frac{MTBF}{MTBF + MTTR} = \frac{\text{Total Time - TCM}}{\text{Total Time}}$$

Where: MTBF = Mean Time Between Failures
[upper test (θ_0) per MIL-STD-781 C]

MTTR = Mean Time To Repair
TCM = Total Corrective Maintenance Time

The FAA redundant configuration has a separate availability requirement (Availability B) for the combined RDA and RPG functional areas. The hardware components of the combined RDA/RPG functional areas for the FAA configuration shall (4) have an Inherent Availability of at least 0.9985. If the Availability B requirement is met through providing a redundant configuration, failures of redundant equipment that incur no loss of system capability (that is repairs made while redundant components are functional and the system is operationally capable) are not counted. Mean Time Between Visits (Defined in Appendix B), (MTBV) is substituted for MTBF in the formula for Inherent Availability and MTTR includes only repairs of components whose failure results in loss of system capability.

3.2.5.1.3 Achieved Availability

Achieved Availability (Aa) is defined as the probability that, when used under stated conditions in an ideal support environment, a system will provide the functional area capabilities stated in Table 3-5. Each functional area must provide all of the capabilities listed in the corresponding section of the table in order to be classified as available. This differs from Inherent Availability only in its inclusion of consideration for preventive action. Achieved Availability excludes supply downtime and administrative downtime.

The hardware components of the RDA functional areas shall (1) have an Aa of at least 0.993.
The hardware components of the RPG functional areas shall (2) have an Aa of at least 0.998.
The hardware components of the PUP functional areas shall (3) have an Aa of at least 0.999.
The relationship between Aa and reliability and maintainability is given by the following formula:

$$Aa = \frac{MTBMA}{MTBMA + MAMD} = \frac{\text{Total Time - TCM - TPM}}{\text{Total Time}}$$

Where: MTBMA = Mean Time Between Maintenance Actions
MAMD = Mean Active Maintenance Downtime
TCM = Total Corrective Maintenance Time
TPM = Total Preventive Maintenance Time

The FAA redundant configuration has a separate availability requirement (Availability B) for the combined RDA and RPG functional areas. The hardware components of the combined RDA/RPG functional areas for the FAA configuration shall (4) have an Aa of at least 0.996. If the Availability B requirement is met through providing a redundant configuration, only the actual system downtime is counted against availability. Any corrective and preventive maintenance that can be accomplished while redundant components are functional and the system is operationally capable is not assessed against Aa.

Table 3-5 FUNCTIONALITY FOR HARDWARE AVAILABILITY REQUIREMENTS

RDA Functional Area	
Transmit/Receive	a. Control Antenna b. Generate pulses c. Receive echo returns d. Separate reflectivity and phase (analog) data
Signal Processing (Reflectivity)	a. Provide analog-to-digital conversion for reflectivity data. b. Generate digitized reflectivity estimates c. Clutter filtering
Signal Processing (velocity and spectrum width)	a. Provide analog-to-digital conversion for phase data b. Generate digitized mean radial velocity and spectrum width estimates c. Clutter filtering
Archive Level I	a. Format data for recording on appropriate medium b. Support future connection of appropriate device
Archive Level II (DELETED PER ECP 0151, SCN-02)	a. Control recording device b. Record all Base Data and RDA status messages (DELETED PER ECP0151, SCN-02)
RPG Functional Area	
Processing I	a. Base product generation b. Base product distribution
Processing II & III	a. Signature recognition b. Tracking c. Product generation (other than base products) d. On-line product storage e. Product distribution (other than base products) f. Control/status monitoring g. Accept request/reply commands
Archive Level III	a. Format data for recording b. Control recording device c. Record selected products and system status messages
PUP Functional Area	
Collocated / non-collocated PUP	a. Display base products b. Display derived products c. Display alphanumeric products d. Request & receive products from dedicated RPG e. Request & receive products from dial-up RPG f. Annotate products g. Enter adaptation data h. Control/status monitoring
Archive Level IV	a. Format data for recording b. Control recording device c. Record selected products and system status messages

3.2.6 Environmental Conditions

The WSR-88D System must be capable of operating in and withstanding the environmental conditions specified in the following sections. The term operating criteria defines the conditions under which the system must operate and meet all functional and performance specifications. Non-operating criteria (including transportation and storage) defines conditions which the system will withstand without damage.

3.2.6.1 Temperature and Humidity

All equipment within the shelter or user agency facility shall (1) meet the indoor environment temperature and humidity requirements for operating and non-operating conditions (Table 3-6).

Table 3-6 TEMPERATURE AND HUMIDITY

OUTDOOR ENVIRONMENT			
CONDITION	TEMPERATURE		HUMIDITY
	Minimum	Maximum	
Operating	-40°C	+49°C	15 - 95%
Nonoperating	-62°C	+60°C	15 - 95%

INDOOR ENVIRONMENT			
CONDITION	TEMPERATURE		HUMIDITY
	Minimum	Maximum	
Operating	+10°C	+35°C	20 - 80%
Nonoperating	-35°C	+60°C	15 - 95%

All equipment within the radome shall (2) meet the outdoor environment temperature and humidity requirements for operating and Non-operating conditions (Table 3-6). For internal radome air temperatures above +25 degrees C, forced air ventilation shall (3) be provided to keep the radome interior within 5 degrees C of the exterior ambient air temperature.

3.2.6.2 Pressure and Altitude

Equipment located at a radar site shall (1) be capable of operating at altitudes up to 3300 meters above mean sea level. Equipment located at a user site shall (2) be capable of operating at altitudes up to 2100 meters above mean sea level (MSL).

3.2.6.3 Solar Radiation

Exposed (Exposed equipment is that equipment not normally located in a controlled environment, including radomes, towers, shelters, etc.) WSR-88D equipment shall (1) be capable of withstanding without failure the following intensities of ultraviolet, visible, and infrared radiation:

Table 3-7 RADIATION INTENSITIES

Portion	Wavelength± (Microns)	Intensities (Wm^{-2})[(Wft^{-2})]	Percent of Total
Ultraviolet	< 0.38	75.35 [7] or less	7 or less
Visible	0.38 - 0.78	538.20 [50] or less	48 or less
Infrared	> 0.78	775.0 [72] or less	69 or less
Total Intensity = 1,119 ± 10.76 Wm^{-2}[104 ± 1 Wft^{-2}]			

(Wm^{-2}) = Watts per square meter
Wft^{-2} = Watts per square foot

3.2.6.4 Rainfall

Exposed WSR-88D equipment shall (1) be operable and sustain no physical damage or significant degradation in performance when subjected to wind and rain under the following conditions:

a. Operational An instantaneous rain rate equivalent to 300 mm per hour with a maximum wind speed of 18 ms^{-1}

b. Non-operational

(1) A 1-hour average rain rate of 130 mm per hour (with an instantaneous rate of 400 mm per hour) with a wind speed of 33 ms^{-1},

(2) A 12-hour average rain rate of 30 mm per hour with a maximum wind speed of 26 ms^{-1}, and

(3) A 24-hour average rain rate of 18 mm per hour with a maximum wind speed of 21 ms^{-1}

3.2.6.5 Fungus

Exposed WSR-88D equipment shall (1) be compliant with Guideline 4 (Fungus-Inert Materials) of MIL-HDBK-454.

3.2.6.6 Salt Fog

Exposed WSR-88D equipment shall (1) be capable of continuous operation in a salt laden atmosphere without degradation of material surfaces or performance.

3.2.6.7 Sand and Dust

All system capabilities shall (1) be met when exposed WSR-88D equipment has been subjected to the effects of blowing fine sand and dust particles with wind speeds up to 18 ms^{-1}, and particle concentration of 0.177 grams per cubic meter with particle sizes up to 150 micrometers in diameter.

3.2.6.8 Wind

The RDA shall (1) provide a pointing accuracy in both azimuth and elevation of ±1/3 degrees rms in a steady wind of 25 ms^{-1}, and ±1 degree rms in a steady wind of 50 ms^{-1}. Exposed WSR-88D equipment shall (2) be capable of withstanding, without physical damage for both operational and Non-operational conditions, a steady wind or gust up to 60 ms^{-1}. All wind speeds of Section 3.2.6 are measured at the maximum height of the tower.

3.2.6.9 Snow and Ice Load

Exposed WSR-88D Systems shall (1) sustain no physical damage when subjected to 235 kilograms per square meter of snow and ice loading.

3.2.6.10 Lightning (Transient Susceptibility)

All WSR-88D equipment shall (1) be compliant with IEEE Recommended Practice on surge Voltages in Low-Voltage AC Power Circuits.

3.2.6.11 Lightning Protection

The lightning protection devices at FAA WSR-88D sites shall (1) be installed in accordance with NFPA 780-1995 (Standard for the Installation of Lightning Protection Systems) established "Rolling Sphere Concept" and FAA-STD-019b (Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities).

3.2.6.12 Electromagnetic Compatibility (EMC), Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI)

For Developed Items, the WSR-88D System shall (1) comply with all recommended general requirements (Part 1) and all recommended specific requirements as Class A3 (USAF requirements), as covered in MIL-STD-461, as detailed in sections 3.2.6.11.1 through 3.2.6.11.4. For COTS equipment, the WSR-88D System shall (2) comply with FCC, Part 15, Class A emission standard.

3.2.6.12.1 Emissions (Conducted)

The emissions (conducted) requirements for developed items are as follows:

Table 3-8 EMISSION (CONDUCTED)

	Applicable Specification	Range of Requirements
A.C Power (50/60HZ)	CE03	15 KHz - 50 MHZ
	CE07	±50% of nom. RMS volt
D.C Power & Control Lines	CE03	15 KHz - 50 MHZ
	CE07	+50%, -150% of nom. volt
Antenna Terminals		
Receivers	CE06	(NB) 34 dBµV (BB) 40 dBµV/MHZ
Transmitters (Key up)	CE06	(NB) 34 dBµV (BB) 40 dBµV/MHZ
Transmitters (Key down)	CE06	80 dB down from f_o

3.2.6.12.2 Emissions (Radiated)

The emissions (radiated) requirements for developed items are as follows:

Table 3-9 EMISSION (RADIATED)

	Applicable Specification	Range of Requirements
All WSR-88D Radar PUP and RDA Equipment	RE02	(NB) 14 KHz - 10 GHz (BB) 14 KHz - 1 GHz

3.2.6.12.3 Susceptibility (Conducted)

The susceptibility (conducted) requirements for developed items are as follows:

Table 3-10 SUSCEPTIBILITY (CONDUCTED)

	Applicable Specification	Range of Requirements
All Power lines	CS101	30 Hz - 50 KHZ
	CS102	50 KHz - 400 MHZ
	CS106	Spikes & Transient
Antenna Terminals	CS103	Intermodulation, 2-signal
	CS104	Residual of undesired signals
	CS105	Cross Modulation
	CS107	Squelch (if any) Test 1 90 db/μv/MHZ Signal-Signal method Test 2 2-Signal Method

3.2.6.12.4 Susceptibility (Radiated)

The susceptibility (radiated) requirements for developed items are as follows:

Table 3-11 SUSCEPTIBILITY (RADIATED)

	Applicable Specification	Range of Requirements
Spikes	RS102	Spike Transient
Power Frequency	RS102	Inductive Transient
Electrical Field	RS103	14 KHz - 10 GHz

3.2.6.12.5 3.2.6.12.5 Reference Test Data

For developed items, Magnetic field radiated emissions, RE 101, and magnetic field radiated susceptibility, RS 101, tests shall (1) be performed in accordance with MIL-STD-462.

3.2.7 Transportability

All items of equipment comprising the WSR-88D System shall (1) be capable of being transported via common surface, air, or sea carrier in its packed-for-shipment configuration, excluding the WSR-88D radar antenna. Size, weight, and physical characteristics shall (2) not exceed the limits imposed for commercial equipment by any particular common carrier available. Transportation methods for the WSR-88D radar antenna shall (3) be subject to government approval on a case by case basis.

3.3 Design and Construction Requirements

The design and construction of the WSR-88D System will be accomplished in accordance with the requirements identified below:

a. For new equipment designs, the general equipment requirements contained or referenced in MIL-HDBK-454 for the design (except for human engineering, maintainability, reliability, climatic service conditions, electronic countermeasure vulnerability, and encapsulation and embedment); parts; materials; processes; nomenclature, identification marking, and labels; and workmanship shall (1) apply.

b. For Commercial-Off-the-Shelf (COTS) equipment, applicable commercial standards such as ASTM, ANSI, shall (2) apply. MIL-STD-2036 may also be used for guidance.

The requirements in this section should not preclude consideration of Non-Developmental Items (NDI), including COTS. Deviations from these requirements to permit an economical use of NDI shall (3) be subject to approval on a case by case basis, evaluating the risk of non-compliance.

3.3.1 Materials, Processes, and Parts

The selection of materials, processes, and parts to be used in WSR-88D System equipment will conform to the requirements specified in the following sections. Consistent with the limitations imposed by COTS equipment usage, at least two sources shall (1) exist for all parts used in the WSR-88D System.

3.3.1.1 Trade Practices and Nonspecified Processes and Materials

Where the design, quality, or function of the system or any part thereof is not controlled by the requirements of this document, such design, quality, or function shall (1) comply with applicable ASTM and National Electrical Code standards and requirements.

3.3.1.2 Selection of Electrical and Mechanical Parts

The selection of electrical and mechanical parts will satisfy the following requirements:

a. The specified performance of the system shall (1) be obtained without the special selection of any part(s).

b. The system shall (2) comply with this document when any part meeting the part manufacturer's specification is used.

c. Parts whose characteristics are more restrictive than those specified by the part manufacturer shall (3) not be used.

d. The use of parts shall (4) not be dependent upon characteristics not specified by the part(s) manufacturer.

e. Specified system performance shall (5) be obtained by installing acceptable parts at random as received from the part manufacturer without subsequent replacement or interchanging thereof.

3.3.1.3 Part Limits and Ratings (Electrical and Mechanical)

The part manufacturer's specifications and limits for any part shall (1) not be exceeded when the system is subjected to and operated under the conditions specified in Section 3.2.6 and in accordance with all other requirements of this document. Derating of parts shall (2) be accomplished as necessary to assure the required reliability within the specified operating conditions.

3.3.1.4 Mechanical Design

Unless basic component size and/or maintenance accessibility prohibit, all major equipment used in the WSR-88D System (e.g., computers and storage devices) shall (1) be designed for a standard 19 inch rack mounting. All parts shall (2) be securely mounted and attached and shall (3) withstand the rigors of transportation, operation, and maintenance without damage.

The WSR-88D System design will facilitate ease of maintenance. Specifically, the system design:

a. shall (4) allow localization of malfunctions to a defective LRU without disassembly or removal (extender boards allowed).

b. shall (5) allow routine operation or maintenance without the removal of structural members.

c. shall (6) allow direct access to LRUs, test points, and maintenance adjustments without disassembly or removal (extender boards allowed).

3.3.1.5 Toxic, Hazardous Substances, and Ozone Depleting Chemicals

See Section 3.7.5.3, Environment, for requirements.

3.3.1.6 Recycled, Recovered, or Environmentally Preferable Materials

Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs. See Section 3.7.5.3, Environment, for requirements.

3.3.1.7 Use of Corrosion Resistant Parts

Parts and materials used throughout the WSR-88D equipment should be resistant to corrosion to prevent deterioration through the equipment life cycle with minimum maintenance.

3.3.2 Electromagnetic Radiation

System requirements for electromagnetic radiation in Section 3.2.6.12 and Section 3.7.5 and its subsections will be satisfied.

3.3.3 Nameplates and Product Markings

All WSR-88D equipment repairable items shall (1) have a unique serial number. Additionally, nameplates shall (2) be required for major WSR-88D configuration items as specified in Drawing #1213851, Plate, Identification, updated for any changes in manufacturers identified. LRUs shall (3) contain reference designators in accordance with IEEE Standard 200-1975.

3.3.4 Workmanship

The minimum standard of workmanship to be applied during fabrication of non-COTS equipment shall (1) be compliant with Guideline 9 of MIL-HDBK-454. MIL-STD-2036 may be used as a guideline for NDI including COTS.

3.3.5 Interchangeability

Each type of LRU shall (1) be physically, mechanically, structurally, and electrically interchangeable in and between all WSR-88D equipment procured under this document without modification and without causing any unit to deviate from the requirements of this document.

3.3.6 Safety

The WSR-88D System shall (1) be compliant in all respects with OSHA Safety and Health Standards (29 CFR 1910) and with American National Standards Institute Standard ANSI C95.11982. In addition, the following requirements of MIL-HDBK-454 will be satisfied. Specifically, the WSR-88D system:

a. shall (2) comply with Guideline 1 for Safety (Personnel Hazard).

b. shall (3) comply with Guideline 3 for Flammability.

c. shall (4) comply with Guideline 45 for Corona and Electrical Breakdown Prevention.

3.3.7 Human Performance/Human Engineering

The WSR-88D System equipment will be designed to ensure human factors principles are applied for those aspects of the equipment requiring both operator and maintenance personnel interface. The objectives of the operator and maintainer require different aspects of human factors principles to be applied.

For the WSR-88D maintainer, the requirements of Section 5.9 of MIL-STD-1472D shall (1) apply to the WSR-88D developed item equipment design. For the WSR-88D operator, the requirements of Section 5.15 of MIL-STD-1472D shall (2) apply for the User-computer interface characteristics associated with WSR-88D developed item equipment design.

3.3.7.1 Acoustic Noise Requirements

Acoustic noise requirements for equipment accessed by maintenance personnel only and for equipment in areas occupied by operational personnel are defined in the following sections.

3.3.7.1.1 Equipment Accessed by Maintenance Personnel Only

The acoustic noise level of WSR-88D equipment which is normally accessed by maintenance personnel only shall (1) not exceed condition A of the tabulation of noise limits defined in Section 3.3.7.1.3. Acoustic noise level requirements apply to operating free-standing equipment, with all internal fans necessary for proper air flow and cooling operating normally. Acoustic noise level measurements shall (2) be performed on operating equipment.

The measurements shall (3) be taken a distance of 1.0 meters from the cabinet sides and 1.5 meters up from the floor. Measurements shall (4) be taken on the air inlet and air exhaust sides of cabinets wherever air is drawn in or exhausted via the sides of cabinets. Measurements shall (5) be performed in an environment where ambient noise levels do not constitute more than 5 percent of the noise generated by the equipment at any frequency.

3.3.7.1.2 Equipment in Areas Occupied by Operational Personnel

The acoustic noise level of RPG and PUP equipment installed in areas occupied by operational personnel shall (1) not exceed condition B of the tabulation of noise limits defined below. This shall (2) include all RPG functional area equipment and all PUP functional area equipment. Optional noise suppression devices (acoustic panels, baffles, etc.) may be used to satisfy this requirement. Individual measurement sets may be used for the RPG and PUP. Acoustic noise level requirements apply to operating equipment with all internal fans necessary for proper air flow and cooling operating normally.

Acoustic noise level measurements shall (3) be performed on operating equipment in an environment where ambient noise levels do not constitute more than 5 percent of the noise generated by the equipment at any frequency. Measurements shall (4) be performed 0.8 meters from the front, rear, and each side of the equipment (not the noise suppression device) at a height of 1.2 meters.

3.3.7.1.3 Acoustic Noise Limits

The following tabulation provides the noise limits for WSR-88D equipment expressed in decibels (dB) with a reference of 0.0002 dynes per square centimeter.

Table 3-12 ACOUSTIC NOISE LIMITS

	FREQUENCY BANDS (HZ)								
CONDITION	20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	4800-9600	9600-20000
A	100	89	82	76	73	70	68	67	66
B	79	68	60.2	52	48	45	43	42	41

3.3.7.2 Heating Requirements

At selected sites, a modular heating capability in the radome shall (1) be provided. One of three levels of heat shall (2) be provided to correspond to three geographic temperature zones, the coldest being 40 degrees Celsius. Resistive and/or infrared electric heating shall (3) be provided to produce:

a. An acceptable working environment for maintenance personnel to work on the azimuth and elevation bearing and drive areas of the pedestal

b. A minimum temperature of 5 degrees Celsius on the internal pedestal components in the vicinity of the azimuth and elevation drives for safety concerns of skin-to-metal contact.

c. Automatic activation of radome heating when the ambient air temperature within the radome drops below 0 degrees Fahrenheit to eliminate pedestal electronics failures due to low temperatures.

The heating mode shall (4) be automatically activated via thermostat located in each radome heating unit. Total power consumption for this heating capability shall (5) not exceed 30 kW. Backup power support for the radome heat capability is not required.

3.3.8 Computer Software

The software architecture should use recognized standards for services when available and appropriate to facilitate system evolution and technology infusion. Additional guidance is contained in the Application Portability Profile (APP), NIST Special Publication 500-230. Requirements for use of the software standards are listed in the following sections. Requirements for communications standards are in Section 3.7.1.8, Interface Requirements. Requirements for the graphical user interface are in Section 3.3.7, Human Performance/Human Engineering.

3.3.8.1 Software Portability

To support portability and maintainability of the software, the selection of operating systems and programming languages will be made on the following requirements (assuming availability on chosen hardware platforms).

a. Kernel services are part of the operating system and perform essential operating system tasks, such as handling disk input and output and managing internal memory. They also provide functions that may be called by a user process to interact with the hardware in some fashion. The Systems Application Program Interfaces are standardized operating system services provided to a high-order language, in this case the C programming language. Kernel Services shall (1) comply with current Portable Operating System Interface (POSIX) standards.

b. The shell is a program that provides the user interface between the operating system and the user. The utilities or Unix and shell commands provide the mechanism for operations at the operator level such as comparing, printing, and displaying file contents, editing files, pattern searching, evaluating expressions and logging messages. The shell and utilities shall(2) comply with current POSIX standards for shell and utilities.

c. Real-time extensions provide programs with a collection of services designed to support predictable responses to asynchronous events. Real-time embedded systems usually have different requirements than systems which are not real-time or embedded. When using real-time extensions they shall (3) comply with current POSIX standards for real-time extensions, as far as practical.

d. Software code written in a particular computer language shall (3) maintain compatibility with the current software and shall (4) follow the current industry standard for that computer language as long as compatibility with the current software can be maintained.

e. Firmware is software code stored in ROM, PROM, or EPROM. Firmware is hardware specific and, in general, not portable. The choice of hardware will determine the firmware language and standards compliance.

3.3.8.2 Database Requirements

New development for the WSR-88D requiring the use of a relational database shall (1) conform to FIPS PUB 127-2 for the database management system. The database management services include:

a. Data Definition - The capability to create, alter and delete database elements

b. Data Manipulation - The capability to insert, select, update and delete database elements

c. Data Query - The capability to specify search conditions consisting of a combination of select lists, predicates, and comparison operators.

d. Data Integrity - The capability to perform data locking, transaction control, referential constraints for data integrity, and synchronous writing of data.

3.3.8.3 Extensibility

The functionality and capability of the WSR-88D will evolve as the needs of the NEXRAD agencies change. Extensibility (or flexibility) is the ease in which the WSR-88D System can be modified to provide new capabilities to meet these needs.

3.3.8.3.1 Application Programming Interface (API)

Applications related to WSR-88D (RPG) product generation shall (1) be implemented using an application programming interface (API) that facilitates ease of implementation and modification.

3.3.8.3.2 Software Modularity

The architecture of the WSR-88D software (RPG only for Open Build 1) shall (1) be modular in the sense that changes in system capabilities/requirements in one area can be implemented with minimal impact on system capabilities in another area. The software design (RPG only for Open Build 1) shall (2) implement software in a manner which maximizes reusability within the WSR-88D system.

3.3.8.4 Expandability

The software shall (1) accommodate the capacity to add or delete hardware components to support varying requirements for computer resources (see expandability requirements in Section 3.2.1.7).

3.3.9 Firmware

Firmware is defined to consist of those programs or microprograms that reside in the class of memory that cannot be dynamically modified by the computer during its processing. The class of memory includes read-only memory (ROM), programmable read-only memory (PROM), or writeable control store (WCS). Documentation of the firmware memory should be included in the hardware development specification, where applicable. Documentation of the firmware program should be included in the software development specification and product specification, (as appropriate).

3.3.10 Flexibility and Scalability Requirements

The system architecture shall (1) support the addition of hardware components to accommodate the expandability requirements in Section 3.2.1.7.

3.4 Logistics

The WSR-88D System shall (1) be designed so that it can remain fully operational, when supported in accordance with the NEXRAD Integrated Logistics Support Plan (ILSP), throughout its specified useful life period. The logistics concept is summarized in this section. The logistics system for NEXRAD coordinates the hardware configuration, to include the identification of those hardware components that are line replaceable units (LRU), with the availability and maintainability requirements. The NEXRAD logistics system is based on existing NEXRAD agency logistic systems and augments those existing systems to the maximum extent possible. The logistics system includes both periodic and corrective maintenance actions.

3.4.1 Maintenance/Logistics Concept

The general WSR-88D maintenance approach is to monitor system performance locally and remotely at the RDA, RPG, and PUP level, to localize the failures through the use of software and hardware maintenance features, and to replace the failed LRU from onsite spares, whenever available. The actual repair of a replaced item will be managed by the NRC for depot repairables, or at a designated on-site repair area for those items that are coded for local repair or disposal. The WSR-88D maintenance practices, which will augment the maintenance practices of the principal users, require that the individual who performs on-equipment, onsite maintenance (removal and replacement of the LRU) will also perform any off-equipment, onsite maintenance (repair of the faulty LRU). If a failed LRU is not repaired onsite, it will be coded for offsite repair and sent to a repair depot. The concept of removal and replacement will be implemented, and maximum use will be made of depot level repair, consistent with the Life-Cycle Cost (LCC) analysis.

3.4.1.1 Calibration

Calibration will be conducted to maintain operational equipment performance parameters and characteristics to specification tolerances. To the degree warranted by good engineering practices, development of performance diagnostic techniques using external support equipment will be oriented toward providing measurements more precisely than the tolerances of the operating equipment/performance parameters to be measured.

3.4.1.2 Maintenance Environment

Equipment will be located at fixed worldwide locations. For DOD, onsite maintenance will be accomplished in accordance with AFI 21-116. For FAA, on-site maintenance will be accomplished in accordance with DOT/FAA Order 6000.15B, 6000.30B, 6000.40, 6000.50, and 6090.1A. For NWS, on-site maintenance will conform with Weather Service Operations Manual (WSOM) Chapter H-50, Equipment Maintenance Program, and WSOM Chapter H-98, Engineering Directives Subsystem. Off-site maintenance will be performed by a designated NEXRAD agency organization. That organization will arrange for service engineering modifications.

3.4.1.3 Depot Maintenance

The NRC is the single central depot to support all LRUs not repaired on-site.

3.4.1.4 Supportability

WSR-88D system support will be consistent with: a single Operational Support Facility which provides engineering, operations support, and software systems maintenance; a single depot which provides central repair and reprocurement services; and a separate supply depot for each principal user.

3.4.2 Personnel Skill Level

There are primarily two types of personnel which will have hands-on access to the WSR-88D equipment; maintenance personnel and operations personnel.

3.4.2.1 Maintenance Personnel

The WSR-88D shall (1) be designed to allow the system to be maintained by the personnel of the NEXRAD agencies having the skills and training stated below. The skill of these personnel varies. For those sites staffed by DOD, maintenance personnel will consist of skill level 5 (journeyman) airmen or equivalent. Individual qualifications of DoD maintenance personnel vary from graduates of basic electronic and systems technical schools with several years experience to new graduates of these schools. NWS and FAA will, in general, use skilled maintenance personnel that have been trained in the proper maintenance procedures for the WSR-88D. See Section 3.5.1 for maintenance training.

3.4.2.2 Operations Personnel

The operational users of the WSR-88D equipment are varied across the three agencies but are primarily targeted towards meteorologically oriented personnel. Skill levels range from meteorologists to hydrologists, meteorological technicians, weather forecasters and weather observers. See Section 3.5.2 for operations training.

3.4.3 Supply

Site spares and initial depot spare parts are provided. The site spares consists of line (lowest) replaceable units (LRUs). Provisioning documentation consisting of provisioning parts list, numerical parts list, long lead-time item list, and item identification/item logistics data records are provided. A single principal user (the NWS) will be responsible for ordering all non-consumable WSR-88D supplies. This agency will redistribute supplies to the other NEXRAD agencies utilizing normal supply systems where possible. Spare parts should be made available in sufficient time to replenish inventories without impacting system operation.

3.5 Training

The WSR-88D System is supported by operations and maintenance training, enabling Government personnel to operate and maintain the WSR-88D equipment.

3.5.1 Maintenance Training

All maintenance personnel will complete the training directed by their agency before being responsible for maintenance of the WSR-88D equipment.

3.5.2 Operations Training

All operators of the WSR-88D equipment will complete the training directed by their agency before being responsible for operation of the WSR-88D equipment.

3.6 Intentionally Left Blank

FUNCTIONAL AREAS

3.7 Functional Area Characteristics

Characteristics are specified herein for the WSR-88D functional areas, consisting of the following:

a. System Requirements

b. Radar Data Acquisition

c. Radar Product Generation

d. Principal User Processing

e. Facilities

f. Support

SYSTEM REQUIREMENTS SECTION

3.7.1 System Requirements

System requirements include those requirements not specific to an individual functional area or common to more than one functional area. These requirements are necessary to meet system performance and operational characteristics. An attempt is made to identify as many of these requirements as possible, however system evolution and equipment design may identify additional requirements unforeseen at this time. The identification of a requirement as a system requirement precludes that required function from being forced into a functional area that may not prove optimal as the system design takes shape.

3.7.1.1 Data Quality

The following sections define the range unfolding and velocity dealiasing requirements.

3.7.1.1.1 Range Unfolding

The WSR-88D shall (1) provide mean radial velocity and spectrum width data processing with the accuracies specified in Section 3.7.2.2.3.1 over the unambiguous range interval of at least 115 km as defined by the following equation:

$$R \text{ (Unambiguous Range)} = \frac{cT_s}{2}$$

where: T_s = Doppler Pulse Repetition Time (PRT)
c = Speed of Light

A technique shall (2) be provided to present the mean radial velocity and spectrum width data at the correct range (range unfolding) to a minimum range of 230 km. See Section 3.7.2.2.1.1 for unambiguous range coverage. Data significantly contaminated due to overlaid weather echoes or ground clutter shall (3) be identified.

3.7.1.1.2 Velocity Dealiasing

Velocity dealiasing to extend the measurement of the mean radial velocity interval to at least twice the Nyquist velocity shall (1) be provided in the WSR-88D System. The Nyquist velocity (V_a) shall (2) be at least 11 ms^{-1}, as given by the following equation:

$$V_a = \pm \frac{\lambda}{4T_s}$$

where: λ = wavelength
T_s = Doppler Pulse Repetition Time (PRT)

3.7.1.2 Pulse Repetition Frequency Selection

A technique shall (1) be provided for automated selection on a volume scan basis from a minimum of five different Pulse Repetition Frequencies (PRFs) meeting the operational constraints on unambiguous range interval (Section 3.7.1.1.1) and on Nyquist velocity (Section 3.7.1.1.2). The PRF selected shall (2) be the one calculated to result in minimum echo area obscuration (relative power is within 5 dB) at the lowest elevation scan. This PRF shall (3) be used during the next volume scan.

There shall (4) be a manual override for this capability. The set of PRFs available for selection shall (5) be adjustable, on a site specific basis, over a range of at least ±1%. This will permit the selection of PRFs to allow certain types of receiver interference suppression circuitry to be effective.

3.7.1.3 Archive Level II

The Archive Level II data shall (1) be the digital base data output of the signal processor, status information, and metadata (which includes: RDA performance/maintenance data, volscan data, clutter filter bypass map data, notchwidth map data , and RDA adaptation data).

3.7.1.3.1 Archive Level II Interface Connection

The WSR-88D System shall (1) provide interface connections to allow Archive Level II data to be collected. Synchronization, calibration, and other data required to properly interpret the archive data, including date, time, antenna position, status, etc., shall (2) be available at the Archive Level II interface connections.

3.7.1.3.2 Archive Level II Equipment

The Archive Level II function shall (1) include a permanent and easily transportable recording/archiving medium. The archive medium shall (2) be write-protectable. The Archive Level II equipment shall (3) also have a playback capability.

The WSR-88D System shall (4) also have the capability to ingest previously recorded data from the Archive Level II system. Starting and stopping of recording and playback of the Archive Level II equipment shall (5) be controllable from the Master System Control Function.

3.7.1.4 Power Failure Recovery

The RDA and RPG shall (1) retain all required data necessary for full load operation for any number of outages per 24 hour period with no single outage exceeding 15 seconds and the total duration of outages for a 24 hour period not exceeding five minutes with the interval between outages not less than 0.1 second. All unit adaptation and control information shall (2) be stored in such a manner that required response times can be met for a restart up to at least one hour after power interruption, and that all PUPs can be returned to the state existing immediately prior to the outage.

3.7.1.5 Overload Control

The recovery from an overload condition (known as load shedding) shall (1) be performed automatically for each resource. Load shedding shall (2) be performed in a manner so as not to allow a rapid cycling between overload and non-overload conditions.

3.7.1.5.1 Processing Overload Control

When a processing overload condition occurs, allocation of resources shall (1) be performed dynamically, if possible, to alleviate the overload condition. The goal of dynamic resource allocation should be to, without operational impact, balance processor loads caused by excessive demand or processor failure. If dynamic resource allocation is not possible, processing tasks within each processor shall (2) be load-shed by a defined priority. Within each processor, processing tasks shall (3) be reactivated following elimination of the overload condition in the reverse of the shedding order.

3.7.1.6 Master System Control Function (MSCF)

3.7.1.6.1 General Requirements

The WSR-88D system shall (1) include the Master System Control Function (MSCF). The MSCF provides operator/maintenance access to all RDA and RPG control, status monitoring, and error detection functions defined in the subsections below. The MSCF shall (2) include a human/machine interface (control position) in the form of a graphical user interface for data entry and display. Requirements for the graphical user interface are in Section 3.3.7. A subset of the MSCF monitor and control capabilities shall (3) be made available at the FAA remote monitoring subsystem (RMS) interface as indicated throughout this document. Required characteristics of this interface are detailed in Section 3.7.1.8.

The MSCF capabilities shall (4) be accessible from a single display/control position within the RPG and a single display/control position within the RDA and the FAA RMS interfaces. The control capabilities shall (5) be only available through either of the display/control positions or the FAA RMS interface at any given time. This means that the subset of MSCF control capabilities that are provided to the FAA RMS interface, are either being controlled through the FAA RMS interface or one of the MSCF control positions at any one time. The capability shall (6) be provided for a user with the proper privileges at an MSCF control position (or through the FAA RMS interface) to take control from the FAA RMS interface (or the MSCF control position).

Status and monitoring information shall (7) be simultaneously available at the display/control positions and the FAA RMS interface. The MSCF display/control position shall (8) be capable of being located remotely from the remaining RPG and RDA equipment via a dedicated communications line. The dedicated communications line to a remotely located Master System Control Function display/control positions shall (9) have a data rate of no less than 9600 bits per second.

3.7.1.6.1.1 System Security/Access Control

Provisions will be made to limit the access to selected classes of control functions through privilege levels, passwords, or other suitable means as described in this section.

To prevent unauthorized access to the MSCF or selected classes of its control functions, a privilege hierarchy shall (1) be provided. The selected classes of control functions which require additional security will include but are not limited to the following: System Administration, Adaptation Data Control, and Maintenance. Password protection shall (2) be provided in the MSCF to identify all users and deter system access beyond allowed requests. An invalid password entry shall (3) result in an error message response.

Three consecutive invalid password entries on the same product user port shall (4) result in immediate disconnect and shall (5) prevent further access to that port until corrective action is made by the system operator. Site adaptable passwords for each product port and each user shall (6) be required to access any data from that port.

3.7.1.6.1.2 Operator Commands

All operator commands shall (1) be validated. Whenever an operator provides an invalid command, an appropriate English language error message shall (2) be provided to the operator. No combination of errors in operator input shall (3) require a restart (see Section 3.7.3.4.2 and Section 3.7.2.8.2) for recovery.

3.7.1.6.2 Overload Status and Control

Notification shall (1) be provided of a condition of resource utilization overload of any part of the WSR-88D System. The capability shall (2) also be provided to the MSCF and the FAA RMS Interface to adjust, by means of adaptation data, the thresholds for these notifications. Through the MSCF, the capability shall (3) be provided, by means of adaptation data, to define the priority for load-shedding processing tasks (within each processor) when a processing overload situation occurs.

Through the MSCF, the capability shall (4) be provided, by means of adaptation data, to define the priority for load-shedding products. Recovery from product load-shedding shall (5) be in the reverse of the shedding order. The capability shall (6) exist for the operator to specify an on-line storage retention time for each product type.

3.7.1.6.3 Status Monitoring

The capability shall (1) be provided to detect, record, and display all status and error messages. Requirements for the storage of status messages on transferable media are in Section 3.7.3.6, Archive Level III. Such messages can be displayed through graphical symbols, text messages or other means. Any text messages displayed shall (2) be in descriptive English language. However, for the recording of each status and error message, a descriptive English language message shall (3) be provided.

A record of each message shall (4) be automatically stored in non-volatile memory for at least 24 hours. An interface shall (5) be provided for a hardcopy device for printing of status and error messages.

3.7.1.6.3.1 Radar Status Monitoring

The capability shall (1) be provided for radar equipment monitoring, reporting, and displaying of status of radar functions to the MSCF. The capability shall (2) be provided to request and output selected or all of the RDA monitored parameters. The capability shall (3) be included to monitor the performance of selected functions on a non-interfering basis with the processing of on-line data and perform sufficient tests to ascertain that no degradation in operation has occurred.

The following parameters, at a minimum, shall (4) be monitored:

a. Average Transmitter Power (at transmitter output and the antenna pedestal)
b. Receiver Calibration
c. Waveguide Arcing
d. Pulse Repetition Frequency (PRF)
e. Memory Checks
f. Signal Processor Performance
g. A/D Converter Performance
h. Timing Controls
i. Over/Under Voltages
j. Over/Under Currents
k. Over Temperature
l. Air Flow Failures
m. Pedestal Oil Level
n. Radar Data Output
o. Backup Power
p. Protective Circuitry Parameters (as defined in Section 3.7.2.4.5.1)

Alarms shall (5) be provided for RDA conditions which might result in further equipment problems or failures if the indicated condition is not corrected. This shall (6) include the case when the automatic radar calibration function can no longer maintain performance parameters within specification limits. All alarms shall (7) result in alarm messages being sent to the MSCF, with further dissemination as defined in Section 3.7.3.5.

3.7.1.6.3.2 System Status Monitoring

Through the MSCF, the capability shall (1) be provided to display the status of the RDA, the RPG (including components of the local area network), and each communications interface. This status shall (2) include operational modes, conditions, and parameters, as well as error conditions. Alarm messages received shall (3) be considered status messages for the purposes of further dissemination.

Status shall (4) be provided to the MSCF and the FAA RMS interface: (a) when requested; (b) periodically, as specified; and (c) when there is a change in the status of the RDA, the RPG, or any of the WSR-88D communications interfaces. The capability shall (5) be provided to turn on or turn off display of selected status and error messages. This capability shall (6) be provided individually for the RPG itself, each of its major subcomponents (e.g., a communications server, product server, control workstation), the RDA, and each of the communications interfaces.

The capability shall (7) be provided to selectively display the record of status and error messages by functional areas or other subsets based on operator-selected keywords. The capability shall (8) be provided to display previously archived RPG status and error messages.

3.7.1.6.4 System Control

MSCF capabilities will provide for operation of the WSR-88D System. These capabilities are accessible through the FAA RMS interface. These capabilities include, but are not limited to, the following:

a. RPG Startup
b. RPG Restart
c. RDA Restart and Warm Startup
d. RDA Cold Startup
e. User Interface Connection Control
f. Controlled Shutdown
g. Mode Control
h. RPG Reconfiguration
i. Archive Level II and Archive Level III Control
j. Product Generation Control
k. Product Storage Control
l. Adaptation Control
m. RDA Backup Power Control
n. User Interface Configuration
o. RPG and RDA Redundant Channel Control
p. Product Distribution and Data Ingest Control
q. Volume Coverage Pattern Control
r. Clutter Suppression Control
s. System Administration
t. Stop/Start Base Data Transmission
u. Spot Blanking Control
v. RDA Maintenance

See Sections 3.7.2.8 and 3.7.3.4 for more detailed requirements.

3.7.1.6.4.1 RPG Startup

The MSCF shall (1) provide the capability to manually initiate the RPG startup function.

3.7.1.6.4.2 RPG Restart

The MSCF shall (1) provide the capability to manually initiate the RPG restart function. The MSCF shall (2) provide the capability to manually initiate restart of any RPG subcomponent.

3.7.1.6.4.3 RDA Restart and Warm Startup

The MSCF shall (1) provide the capability to manually initiate the RDA restart and warm startup functions. The warm startup capability shall (2) enable the RDA to resume operation from the warm startup state. The restart capability shall (3) initiate an RDA restart.

3.7.1.6.4.4 RDA Cold Startup

The RDA cold startup procedure shall (1) be initiated through the MSCF. Through the MSCF, the operator shall (2) be able to initiate sending data to the RPG, if it was inhibited during the cold startup procedure, without repeating any of the cold startup procedure.

3.7.1.6.4.5 User Interface Connection Control

The MSCF shall (1) provide the capability to manually connect, terminate, or prevent connection with any and all user interfaces (listed in Section 3.7.1.8) within its WSR-88D System.

3.7.1.6.4.6 Controlled Shutdown

The MSCF shall (1) provide the capability to shutdown in a controlled manner the following parts of the system:

a. The RDA
b. The communications links.
c. The RPG, or its subcomponents.

The capability shall (2) exist to shut down the entire RPG functional area with a single command, or to shut down individual subcomponents with a single command. Shutdown of the RPG, or individual subcomponents of the RPG, shall (3) have no effect on the operation of the RDA if the MSCF is active.

3.7.1.6.4.7 Mode Control

3.7.1.6.4.7.1 RDA Mode Control

The MSCF shall (1) provide the capability to manually change RDA Modes by selecting various RDA parameter sets. The parameter sets which shall (2) be selected are the following:

a. Mode Control: Operational/Maintenance

b. Operational Modes: A, B, and others specified in Appendix I

Selection of Mode B, for clear air observations, shall (3) require a manual action through the MSCF.

3.7.1.6.4.7.2 RPG Mode Control

The MSCF shall (1) provide the capability to switch the RPG between its two modes, test and operational.

3.7.1.6.4.8 RPG Reconfiguration

The MSCF shall (1) provide the capability to manually control the shifting of loads between RPG processors, if the RPG has more than one processor.
At redundant sites, the MSCF shall (2) provide the capability to manually reallocate RPG resources. For Open Build 1 this means reallocation of major subcomponents (e.g., a communications server, product server, control workstation).

3.7.1.6.4.9 Archive Level II and Archive Level III Control

The MSCF shall (1) provide the capability to activate, deactivate, and monitor the status of the data archive function. The MSCF shall (2) also provide the capability to select the product types to be routinely archived and their frequency of archiving. Additionally, the MSCF shall (3) provide the operator the capability to routinely archive status and error messages and operational parameters.

The MSCF shall (4) also provide the capability to pause and resume archive recording. The MSCF shall (5) be capable of displaying operator selected status and error messages previously recorded on archive media. The MSCF shall (6) provide the capability to activate and deactivate the Archive Level II function and to replay Archive Level II data.

3.7.1.6.4.10 Product Generation Control

The MSCF shall (1) provide the capability, by means of adaptation data, to select the set of products to be routinely generated. In addition, the capability shall (2) be provided for the MSCF to specify, on a per product basis, specific product parameters (e.g., center az/ran, layer heights, elevation angle/slice) and the frequency at which the product is generated. The MSCF shall (3) provide the capability to select the product for generation for each alert category (see Appendix J).

3.7.1.6.4.11 Product Storage Control

The MSCF shall (1) provide the capability, by means of adaptation data, for defining and changing the product mix, frequency, and retention time (up to a maximum of 1 hour for base data and six hours for all NEXRAD products) for products to be retained in the on-line RPG storage.

3.7.1.6.4.12 Adaptation Control

The MSCF shall (1) provide the capability to display and modify all RPG and RDA adaptation parameter values. The MSCF shall (2) provide the capability to select the use of the baseline RPG and/or RDA adaptation data.

3.7.1.6.4.13 RDA Backup Power Control

The MSCF shall (1) provide the capability to initiate with a single command a systematic, controlled power transfer between commercial and backup generator power for all WSR-88D equipment at the radar site.

3.7.1.6.4.14 Interface Configuration

The MSCF shall (1) provide the capability to configure or reconfigure, by means of adaptation data, any product distribution and ingest interface to connect to any of the WSR-88D communication classes available.

3.7.1.6.4.15 RDA and RPG Redundant Channel Control

The MSCF shall (1) provide the capability to control the state of the FAA redundant channels as defined in Section 3.2.1.5.1. The MSCF shall (2) provide the capability to control the state of the NWS redundant channels defined in Section 3.2.1.5.2. The MSCF shall (3) provide the capability to change active channels with a single command. When active channels are switched, either automatically or by command, there shall (4) be no change in operating characteristics (i.e., no manual input of status, adaptation data, or rain gage data to the new channel).

3.7.1.6.4.16 Product Distribution and Data Ingest Control

The MSCF shall (1) provide the capability to specify and change, through adaptation data, which products will be available and their frequency of availability to Legacy Class 2 and 4 users. The MSCF shall (2) provide the capability to select, through adaptation data, the distribution method to be used for each Legacy Class 4 user port. The available distribution methods shall (3) include as a minimum: a predefined single set of products, a predefined set of products routinely, and a limited selection of products on a one-time request basis.

3.7.1.6.4.17 Volume Coverage Pattern Control

The MSCF shall (1) provide the capability for selecting a single scanning strategy to be employed at any given time from the set of defined (local and remote) scan strategies (Note: "Local" scan strategies are stored at the RDA. "Remote" scan strategies are stored at the RPG). The MSCF shall (2) provide a manual override of the defined strategies for maintenance actions. A manual override for automated Pulse Repetition Frequency (PRF) selection capability shall (3) be provided through the MSCF.

The capability shall (4) be provided to select one of the predetermined Doppler PRFs through the MSCF when the manual override capability has been selected. The MSCF shall (5) provide the capability to modify VCP parameters by elevation scan where appropriate. The parameters shall (6) include, but are not limited to Doppler PRF selection, SNR threshold values (as defined in Section 3.7.2.6), sector definition, and velocity measurement increment.

3.7.1.6.4.18 Clutter Suppression Control

Through the MSCF, the capability shall (1) be provided, at a minimum, to:

a. Define clutter suppression regions;

b. Modify the bypass clutter filter map;

c. Select the operational bypass map;

d. Initiate generation of a new bypass clutter filter map.

The definition of clutter suppression regions shall (2) include the capability to select the elevation angle(s), minimum and maximum ranges and azimuths, notch width selection, and type of suppression. The notch width selection shall (3) be one of the three levels of Doppler clutter suppression capability from Table 3-17.

The capability shall (4) be provided to modify, through adaptation data, the selections in a, b, and c above. The bypass clutter filter map shall (5) consist of a site-specific elevation angle independent clutter suppression map which specifies the ranges and azimuths to be used for clutter suppression. This map applies to both Doppler and reflectivity clutter suppression.

3.7.1.6.4.19 System Administration

The MSCF shall (1) provide status and control for system fault management, performance accounting, system security, and configuration management.

3.7.1.6.4.20 Stop/Start Base Data Transmission

The MSCF shall (1) provide the capability to start or stop the transmission of base data from the RDA to the RPG. Parameters of this command shall (2) allow selection of any combination of base data, reflectivity, mean radial velocity, and/or spectrum width data.

3.7.1.6.4.21 Spot Blanking Control

There shall (1) be the capability of invoking or prohibiting spot blanking through the MSCF.

3.7.1.6.4.22 RDA Maintenance

The MSCF shall (1) provide the capability to manually override the RF emission interlock when an antenna stoppage occurs for a period of 30 seconds or more. The interlock is defined in Section 3.7.2.4.1. The MSCF shall (2) provide the capability to manually override of the automatic calibration function defined in Section 3.7.2.11.

3.7.1.7 Remote System Access

The capability shall (1) be provided (at selected sites) for dial-up access to the WSR-88D MSCF monitor and control capabilities. The capability shall(2) be provided (at selected sites) for dial-up access to the WSR-88D RDA control capabilities. The characteristics of these interfaces are in Section 3.7.1.8.2, External Interfaces.

3.7.1.8 Interface Requirements

The meteorological and hydrological products of the WSR-88D are accessible by both internal and external user display systems. Requirements for the distribution of WSR-88D products are in Section, 3.7.3.3, Product Distribution. Access to products includes, but is not limited to base data, base products, and derived products. The internal user product display system is the WSR-88D PUP workstation, and it provides secondary access to base products and derived products for external user display systems. This section states the required characteristics of internal and external interfaces; capabilities provided at the interfaces are covered elsewhere. Characteristics not specified or referenced in this section are left for system design. Requirements for the number and type of interfaces to be supported by functional area are in Section 3.2.1.5, Configuration and Section 3.2.1.1, WSR-88D Full Load. Expandability requirements are in Section 3.2.1.7.

3.7.1.8.1 Internal Interfaces

The RPG shall (1) have dedicated and dial modems compatible for complete inter-operability with WSR-88D PUPs.

3.7.1.8.1.1 Dedicated PUP Connections

For most WSR-88D System, the RPG shall (1) include one or more WSR-88D dedicated PUP connection(s). Transfer of data shall (2) be at a minimum data rate of 14.4 Kbps.
For selected WSR-88D Systems, the RPG shall (3) include a Collocated PUP connection.
The dedicated interface from an RPG to a Collocated PUP shall (4) exchange data at no less than 56,000 bits per second, full duplex.

For a Collocated PUP within 1.2 Km of the RPG, the connection shall (5) employ the RS232-RS422 converter hardware implementation of the RS449 standard communications interface. For a Collocated PUP greater than 1.2 Km from the RPG, the connection shall (6) employ RS232 or CCITT V.35 paragraph 10 implementation of the RS449 standard communications interface. In all other respects, the dedicated WSR-88D PUP interfaces shall (7) conform to the requirements specified in paragraph 3.7.1.8.2.1 for external Legacy Class 1 interface.

3.7.1.8.1.2 Dial-up PUP Connections

All WSR-88D systems include dial interface as an alternative means of connection for the WSR-88D dedicated PUPs described above. The dial PUP interface shall (1) conform to the requirements specified in paragraph 3.7.1.8.2.2 for external Legacy Class 2 interface.

3.7.1.8.2 External Interfaces Requirements

3.7.1.8.2.1 Legacy Class 1

Legacy Class 1 users shall (1) have full time dedicated access to WSR-88D System products. Example Class 1 interfaces include the WSR-88D dedicated PUP, AWIPS, WARP, ITWS, and WFO Advanced. These interfaces shall (2) transfer data at a minimum rate of 14.4 Kbps, unless otherwise specified. The defining ICD for this interface is number 2620001. These users shall (3) be capable of processing all message types in Table II of this ICD, except for the Sign On Message.

3.7.1.8.2.2 Legacy Class 2

Class 2 users shall (1) have dial access to WSR-88D System products. Example Class 2 interfaces include the WSR-88D dial PUP, PUPIE (See Appendix G), AWIPS, WFO Advanced, and SSM (See Appendix G) The defining ICD for this interface is number 2620007. In addition, these users shall (2) be capable of processing all message types described in Section 3.5 in this ICD.

This interface shall (3) transfer data at a minimum rate of 14.4 Kbps. This interface shall (4) conform to the security and privacy requirements specified in paragraph 3.7.1.6.1.1 for system access. The specific products available to the Class 2 user are defined within the WSR-88D system.

3.7.1.8.2.3 Legacy Class 4

Class 4 users shall (1) have either full time dedicated access or dial up access to WSR-88D System products. The primary Class 4 interfaces are to the NEXRAD Information Dissemination Service (NIDS) Providers. Examples of such interface systems are PcPUP (See Appendix G) and WinPUP (See Appendix G) Class 4 interface shall (2) transfer data at a minimum rate of 14.4 Kbps. The defining ICD for this interface is number 2620009.

In addition, these users shall (3) be capable of processing all message types described in Section 3.5 in this ICD. The dial Legacy Class 4 interface shall (4) conform to the security and privacy requirements specified in Section 3.7.1.6.1.1 for system access.

3.7.1.8.2.4 Base Data Distribution Interface

Base Data Distribution users shall (1) have dedicated access to the WSR-88D base data stream. This interface shall (2) transfer data at a rate sufficient to capture the real-time data stream. This interface shall (3) conform to the Base Data Distribution ICD.

3.7.1.8.2.5 FAA Remote Monitoring Subsystem (RMS)

The FAA Remote Monitoring Subsystem interface provides dedicated access to all system status and control capabilities as stated in this specification. The system shall (1) accept transfer of data that effectively controls the system at a rate in accordance with RPG/RMS ICD 2620000 and RDA/RMS ICD 2620004. The format of status and control messages and other characteristics shall (2) be in accordance with RPG/RMS ICD 2620000 and RDA/RMS ICD 2620004.

3.7.1.8.2.6 Remote Access Interfaces

The Remote RDA Control Interface shall (1) provide dial up access to the RDA control capabilities. The Remote RPG Control Interface shall (2) provide dial up access to the MSCF capabilities. These interfaces shall (3) transfer data at a rate to effectively control the system but not less than 9.6 Kbps. These interfaces shall (4) conform to the security and privacy requirements specified in Section 3.7.1.6.1.1 for system access.

3.7.1.9 Diagnostic Techniques

Fault isolation to the LRU without component removal shall (1) be incorporated into the system design. This shall (2) be achieved through the use of Built-In Test Equipment (BITE), automatic alarms, indicator lights, and computer diagnostic and system diagnostic software. The equipment shall (3) be designed to minimize the use of special support equipment.

Easily accessible test points shall (4) be provided to facilitate the use of external test equipment. The BITE system shall (5) provide remote performance monitoring, parameter measurements, and equipment adjustments sending performance information to the appropriate maintenance control section of the unit responsible for maintaining the system.

RADAR DATA ACQUISITION (RDA) SEGMENT

3.7.2 Radar Data Acquisition Functional Area

The Radar Data Acquisition (RDA) functional area provides the capability to acquire, perform signal processing on, and transfer weather radar data to the Radar Product Generation (RPG) functional area.

3.7.2.1 General Requirements

3.7.2.1.1 Monitor/Control

The RDA shall (1) include an antenna, pedestal, radome, transmitter, receiver, signal processing capability, control capability, monitoring and error detection capability, and an interfacing capability/maintenance position. These capabilities shall (2) provide for the detection and measurement of weather phenomena to the extent defined in Section 3.7.2.2, while meeting the reliability, maintainability, and availability requirements defined in Sections 3.2.3, 3.2.4, and 3.2.5, and while operating within the environmental conditions defined in Section 3.2.6. RDA monitoring and control functional capabilities (defined in Sections 3.7.1.6 and 3.7.2.9) shall (3) be included in the RDA to support both operations and maintenance activities. The RDA shall (4) be designed for unattended operation.

3.7.2.1.2 Operational Modes

The RDA shall (1) be capable of operation in at least two modes, designated Mode A and Mode B. Mode A is for precipitation detection, tracking, and measurement. Mode B is for clear air observations. Except where noted, all requirements of Section 3.7.2 shall (2) apply to both Modes A and B. Switching from Mode B shall (3) be accomplished automatically through the Precipitation Detection Function described in Appendix D. Criteria for automatic mode switching are provided in Appendix I.

3.7.2.1.3 Long Pulse

A long pulse capability shall (1) be provided for Mode B. Radar system parameter changes allowed for this long pulse capability shall (2) be:

a. a 3 dB pulse volume depth less than 750 meters
b. A Nyquist velocity greater than 11 ms^{-1}
c. reflectivity measurement out to a minimum range of 460 km
d. a longer system dwell time to allow attainment of the requirements of Section 3.7.2.2.3.1.

3.7.2.1.4 Short Pulse

Radar system performance characteristics for short pulse shall (1) be:

a. a 3 dB pulse volume depth less than 250 meters
b. A Nyquist velocity greater than 11 ms^{-1}
c. reflectivity measurement out to a minimum range of 460 km

3.7.2.1.5 RDA Power Failure Recovery Requirements

The RDA shall (1) operate using commercial power as specified in Section 3.7.5.2.1. In the event that primary power feeds to the RDA fails or degrades below acceptable limits, the RDA shall (2) switch to auxiliary power automatically. Acquisition of radar data during the switch between either primary or backup power feed is required when the WSR-88D system is equipped with a Transitional Power Source. Following a power outage of less than or equal to 15 seconds while acquiring base data, the RDA shall (3) resume acquisition at the interrupted elevation scan as soon as the antenna and transmitter have returned to stable operational conditions.

The elevation scan which was in progress at the point of power outage shall (4) be restarted with a full collection of base data, and, thereafter, the remaining portions of the volume coverage shall (5) be completed. For power outages in excess of 15 seconds, the volume coverage shall (6) be restarted.

3.7.2.2 Performance Characteristics

The RDA shall (1) consist of a coherent Doppler radar capable of operating within a Radar Spectrum Engineering Criteria (RSEC) allocation bandwidth within the 2.7-3.0 GHz frequency band. The RDA shall (2) be capable of continuous, preprogrammed surveillance to provide, at a minimum, reflectivity, mean radial velocity, and spectrum width base data (Defined in Appendix B). Base data shall (3) meet the requirements defined in this section.

3.7.2.2.1 Coverage

The following sections define the range, volume coverage and spot blanking requirements.

3.7.2.2.1.1 Base Data Coverage

The WSR-88D collects base data for each elevation angle of the operational volume coverage pattern. The horizontal resolution and unambiguous range coverage are defined by the volume coverage pattern definition subject to the following requirements.

3.7.2.2.1.1.1 Base Reflectivity

The RDA shall (1) provide quantitative reflectivity estimates over an unambiguous range of 1 km to a minimum of 460 km (or up to a height of 70,000 ft MSL if this height occurs prior to reaching 460 km in horizontal range). The quantitative reflectivity estimates from 2 km to a minimum of 230 km shall (2) meet the accuracies specified in Section 3.7.2.2.3.2. The same signal processing scheme shall (3) be used to provide all reflectivity estimates.

3.7.2.2.1.1.2 Base Velocity and Spectrum Width

The RDA shall (1) provide quantitative mean radial velocity and spectrum width estimates from 1 km to the unambiguous range of the employed pulse repetition frequency. The quantitative velocity estimates from 1 km to the unambiguous range of the employed pulse repetition frequency shall (2) meet the accuracies specified in Section 3.7.2.2.3.1. The range unfolding and velocity dealiasing requirements are specified in Sections 3.7.1.1.1 and 3.7.1.1.2 respectively.

3.7.2.2.1.2 Volume Coverage

The RDA shall (1) provide the capability for a volume coverage defined by a rotated triangular section extending in range from the antenna to the specified range, 360 degrees in azimuth relative to the antenna's rotational axis, and from -1 degree to 45 degrees in elevation relative to the antenna's rotational axis and the horizontal plane at the antenna.
However, there is no requirement for coverage above 70,000 feet Mean Sea Level (MSL).

3.7.2.2.1.2.1 Scanning Strategy 1

The capability of at least 20 unique automatic antenna scanning strategies shall (1) be provided. One scanning strategy shall (2) provide, for a volume scan time of five minutes, a sample of the coverage volume. This sample shall (3) consist of 14 unique elevation scan levels, from zero degrees to +20 degrees in elevation, with at least the lowest six degrees of elevation having no gaps between the one-way pattern 3 dB points of adjacent elevation scans. This scan strategy is designated Scan Strategy 1.

3.7.2.2.1.2.2 Scanning Strategy 2

Another scanning strategy shall (1) provide a sample of the coverage volume of nine unique elevation angles from zero degrees to +20 degrees in elevation, for a volume scan time of six minutes. The lowest four degrees of elevation shall (2) have no gaps between the one-way pattern 3 dB points of adjacent elevation scans. This scan strategy is designated Scan Strategy 2.

3.7.2.2.1.2.3 Scanning Strategy 3

Another scanning strategy shall (1) provide a sample of the coverage volume of five unique elevation angles from zero degrees to +5 degrees in elevation, for a volume scan time of ten minutes. Two versions of this scanning strategy shall (2) be available, one employing short pulse and the other employing long pulse. This scan strategy is designated Scan Strategy 3.

3.7.2.2.1.2.4 Scanning Rate

The scanning rate may vary with elevation, but should be consistent with reasonable dwell times (T_D) for the required system performance for reflectivity and radial velocity data. Additional scan strategies are specified in Appendix I.

3.7.2.2.1.3 Spot Blanking

The RDA shall (1) provide the capability to inhibit transmission of radiated power for up to five (5) separate areas within any volume coverage pattern. Blanking is defined as a reduction in power of the radiated beam. These selectable areas shall (2) be capable of being defined by an upper and lower elevation angle and a beginning and ending azimuth angle with a selection resolution of one degree. These data shall (3) be capable of being entered only through controlled adaptation parameters at the RDA.

The design of the spot blanking shall (4) not impose any undue physical or electronic constraints on the transmitter and receiver assemblies of the RDA. Spot Blanking shall (5) be done in such a manner as to minimize any disruption to the meteorological content of the radar data, as well as any clutter suppression invoked at the time, to the data outside of the area selected for blanking.

3.7.2.2.2 Sample Interval

The following sections define the azimuth and range sample interval requirements.

3.7.2.2.2.1 Azimuth Sample Interval

The RDA shall (1) provide an azimuth sample interval of greater than 0.953 degrees and less than 1.0555 degrees.

3.7.2.2.2.2 Range Sample Interval

The RDA shall (1) provide a range sample interval of not greater than 1 km, from 1 km to 460 km, including the effects of range averaging, for reflectivity measurements. The RDA shall (2) provide a range sample interval of not greater than 250 meters for mean radial velocity and spectrum width measurements from a range of 1 km to 230 km.

3.7.2.2.3 Accuracy and Precision

The following sections define range accuracy and precision requirements for mean radial velocity, spectrum width, reflectivity.
The RDA shall (1) provide the capability of operating over a range of dwell times compatible with nominal scan rates of from 0.5 rpm to 3.2 rpm.

3.7.2.2.3.1 Mean Radial Velocity and Spectrum Width

For the range of possible dwell times (T_D), the RDA shall (1) provide estimates of mean radial velocity (V) and spectrum width (W) with the following accuracy and precision:

Table 3-14 MEAN RADIAL VELOCITY AND SPECTRUM WIDTH

	Accuracy	Precision (Note 2)
Mean Radial Velocity	For a true spectrum width (Note 1) of 4 ms^{-1} the standard deviation in the estimate of the mean radial velocity will be less than or equal to 1.0 ms^{-1} including quantization errors, for signal-to-noise ratio (SNR) greater than 8 dB.	0.50 ms^{-1}
Spectrum Width	For a true spectrum width (Note 1) of 4 ms^{-1} the standard deviation in the estimate of the spectrum width will be less than or equal to 1.0 ms^{-1} including quantization errors, for SNR greater than 10 dB.	0.50 ms^{-1}

Note 1: True spectrum width is defined as one standard deviation of the meteorological phenomenon spectrum width within a sampled volume for which the indicated accuracy applies. Stated accuracy values apply for Nyquist velocities of the system. (Gaussian spectrum assumed.)

Note 2: Precision is defined as the quantization, the smallest resolvable increment.

Note 3. Significant biases introduced by the computational technique should be minimized. (Formerly Shall (4). Relocated Per ECP 0151, SCN-02)

During short pulse operations, spectrum widths of 1 to at least 10 ms^{-1} shall (2) be calculated. Spectrum widths larger than 10 ms^{-1} shall (3) be displayed as being 10 ms^{-1}.
Deleted Requirement

3.7.2.2.3.2 Reflectivity (Z)

For the reflectivity provided by the RDA, from 2 to 230km, the estimates shall (1) be averaged over 1 km range bins. These reflectivity estimates shall (2) meet the following accuracy and precision requirements:

Table 3-15 REFLECTIVITY (Z)

	Accuracy	Precision (Note 2)
Reflectivity(Z)	For a true spectrum width of 4 ms^{-1} the standard deviation in the estimate of the reflectivity will be less than or equal to 1 dB at SNR $\geq$ 10 dB (including only the error due to meteorological signal fluctuations).	1 dB

Note 1: Accuracy is defined as one standard deviation (SD) of the estimate, including effects of precision.

Note 2: Precision is defined as the quantization, the smallest resolvable increment.

Automatic calibration shall (3) reduce system hardware drift errors to less than 1 dB.

3.7.2.2.3.3 Range

The error in range placement of base data output from the RDA due to timing instabilities shall (1) be less than 50 meters.

3.7.2.2.4 Minimum Detection Capability and Dynamic Range

The RDA minimum detection capability shall (1) provide at least a 0 dB signal to noise ratio for a -7.5 dBZ_e target at 50 km. The effective dynamic range of the RDA shall (2) be at least 93 dB for both reflectivity and velocity data. The RDA shall (3) not make use of RF Sensitivity Time Control (STC).

3.7.2.3 Antenna

3.7.2.3.1 Antenna Assembly

The antenna assembly shall (1) include items such as a mounting pedestal, drive mechanism(s), rotary joint, transmit and receive feed horn, reflector, radome and other items needed to comply with the mechanical and electrical requirements described in this document. The antenna shall (2) be designed to be mounted inside a radome atop a tower. The tower is available in 5 meter height increments with a maximum height of 30 meters. The antenna shall (3) meet all requirements herein while operating under the environmental conditions defined in Section 3.2.6.

3.7.2.3.2 Antenna Performance

The antenna performance requirements are derived from the RDA performance requirements contained in Section 3.7.2.2 and the following specific requirements:

a. The antenna type shall (1) be single pencil beam.
b. The antenna pattern shall (2) provide a median gain of ≤ -10 dBi.
c. The antenna shall (3) provide a half power beamwidth in azimuth and elevation of ≤ 1 degree.
d. Sidelobe Levels:
   (1) In any plane, the first sidelobe shall (4) be less than or equal to -25 dB relative to the peak of the beam.
   (2) In the region between ±2 and ±10 degrees, the sidelobe level shall (5) lie below the straight line connecting -25 dB at ± 2 degrees and 34 dB at ±10 degrees.
   (3) Between ±10 degrees and ±180 degrees, the sidelobe envelope shall (6) be less than or equal to -40 dB relative to the peak of the beam.
   (4) Beyond ±10 degrees, the peak of an individual sidelobe may be averaged with the peak of the two nearest side-lobes, one on either side; or with the peaks of the four nearest side-lobes, two on either side, provided that the level of no individual sidelobe exceeds the - 40 dB level by more than 6 dB and that the combined angular extent of all peaks exceeding -40 dB does not exceed 30 degrees.
e. Cross Polarization Radiation:
   (1) In any plane, the cross polarization radiation shall (7) be at or below the level specified for the sidelobe and back-lobe levels of the co-polarized radiation within the angular regions applicable to these lobes.
   (2) Within the main lobe angular region, the cross polarization component shall (8) be at least 25 dB below the peak of the main beam of the co-polarized radiation.
f. Beam location reporting error shall (9) be ≤ 0.15 degrees.
g. The antenna shall (10) provide linear horizontal polarization.

3.7.2.3.3 Antenna Design

The antenna assembly shall (1) be designed to facilitate removal and replacement of any portion except the antenna reflector, radome, and the pedestal. The antenna assembly shall (2) be constructed to be disassembled and reassembled for maintenance and repair at the top of the antenna tower using tools supplied. The antenna assembly design shall (3) include provisions for routine inspection of critical internal pedestal and drive mechanism parts without disassembly. The design shall (4) allow any maintenance activity to be completed within the repair times defined in Section 3.2.4 (Maintainability).

3.7.2.3.4 Radome

The RDA shall (1) include a rigid radome. The radome shall (2) protect the antenna and pedestal from hazards, hazardous weather, direct wind forces (to reduce antenna structural requirements), and severe weather conditions (to ensure severe weather performance and operation during heavy snow conditions). The radome shall (3) have a surface which precludes rain sheeting and facilitates the prevention of icing and snow buildup. The radome shall (4) incorporate venting. Means for closing the radome vents shall (5) be provided.

3.7.2.3.4.1 Radome Service Conditions

The radome shall (1) withstand all of the environmental conditions defined in Section 3.2.6.

3.7.2.3.4.2 Radome Radiation Considerations

The radome design shall (1) minimize the effect of radome attenuation, beam distortion, polarization degradation, and sidelobe perturbations due to the radome. These effects shall (2) be minimized for any look angle through the radome used in the operational scanning sequences. The effects of the radome shall (3) be included in meeting the RDA performance requirements. The procedures for performing antenna measurements shall (4) be based on the applicable details of Section 50 of MIL-STD-469.

3.7.2.3.5 Pedestal and Antenna

The pedestal and antenna shall (1) meet the requirements of the following sections.

3.7.2.3.5.1 Pedestal Requirements

The following pedestal requirements will be met:

a. The pedestal type shall (1) be elevation over azimuth.

b. The pedestal shall (2) provide continuous 360 degree rotation in azimuth (both directions) and from at least -1 degree to +60 degrees in elevation.

c. The pedestal shall (3) provide a variable rotation rate between zero degrees per second and 30 degrees per second.

d. The pedestal shall (4) provide an acceleration of at least 15 degrees per second squared (both azimuth and elevation).

e. The pedestal shall (5) provide a deceleration of at least 15 degrees per second squared (both azimuth and elevation)

f. The absolute value of the positioning error, including effects of angular encoding precision, shall (6) be less than or equal to 0.2 degrees (both azimuth and elevation).

g. The angular encoding precision shall (7) be less than or equal to 0.1 degrees (both azimuth and elevation).

3.7.2.3.5.2 Antenna Mounting

The antenna pedestal shall (1) be designed for installation within the radome.

3.7.2.3.5.3 Antenna Scanning Control

A programmable control of antenna scanning shall (1) be provided. Any changes to the tilt sequencing and scan rates of the set of scan strategies shall (2) only be accomplished through changes issued in adaptation data released by the WSR-88D ROC.

3.7.2.4 Transmitter

The WSR-88D radar equipment shall (1) be governed by the requirements set forth in Section 5.3, Radar Spectrum Engineering Criteria (RSEC) of the Manual of Regulations and Procedures for Federal Radio Frequency Management. (These requirements apply to promote an efficient use of the RF spectrum and are not intended to restrict new design approaches required for attaining performance goals). RSEC provisions of Subsection 5.3.3 (Criteria D, subparagraphs 2, 3, 4, 6, and 7) are applicable to all WSR-88D Systems operating anywhere in the 2.7 - 3.0 GHz band. In addition, WSR-88D Systems designated as operating in high density areas shall (2) be subject to the RSEC provisions of Subsection 5.3.3, subparagraphs 9, 9a, and 9b.

3.7.2.4.1 Transmitter Interlock

An interlock shall (1) be provided which automatically halts RF emissions when an antenna stoppage occurs for a period of thirty seconds or more. Means shall (2) be provided for manually overriding this interlock at the maintenance position. RF emissions shall (3) be halted five minutes (±10 seconds) from the time that the interlock override is initiated by the maintainer .

3.7.2.4.2 Transmitter Recovery Time

The time for the transmitter to recover from primary power feed interruptions and outages shall (1) be based on the required klystron heater warm-up time. The recovery time, after heater voltage is restored, shall (2) be as listed in Table 3-16.

Table 3-16 TRANSMITTER RECOVERY TIMES

HEATER OFF TIME (MINUTES)	RECOVERY TIME
less than 0.5	None
From 0.5 to 5.0	Equal to heater off time
Greater than 5.0	12.0 Minutes

3.7.2.4.3 Redundant Transmitter

Any redundant transmitter configuration (3.2.5, 3.2.1.5.1, and 3.2.1.5.2) shall (1) include a four port waveguide switch and a high power RF dummy load. The waveguide switch shall (2) be configured to permit maintenance of one transmitter while the second transmitter is fully operational into the antenna. There is no requirement for both transmitters to be operating at the same time while on backup power.

Transmitter RF emissions shall (3) be disabled if the waveguide switch is not positively engaged. The high power RF dummy load shall (4) be capable of operating continuously at full transmitter power without liquid or forced air cooling. The redundant transmitters shall (5) operate at different frequencies separated by a minimum of 30 MHZ. Each transmitter at FAA sites shall (6) communicate with the FAA RMS in accordance with the NEXRAD RDA/RMS ICD.

3.7.2.4.4 Pulse Repetition Frequency

The RDA design tradeoffs between the maximum unambiguous range, velocity estimation requirements, and volumetric scanning rate shall (1) determine the set of PRFs for the transmitter. Requirements for the automatic control of PRF are in Section 3.7.1.2.

3.7.2.4.5 Transmitter Maintenance Control and Protection

The design includes the following transmitter control and protection circuits.

3.7.2.4.5.1 Protective Circuitry

Protective circuitry shall (1) be provided to adequately protect major transmitter components from damage. This circuitry shall (2) include, but not be limited to, sensing, control and visual indication (with memory) at the RDA maintenance position of malfunctions in the following parameters. Status messages for these parameters shall (3) be sent to the MSCF and the FAA RMS interface:

a. Modulator Module Failure
b. Waveguide Arcing
c. HV OverCurrent
d. Modulator Overload
e. Waveguide Air Pressure
f. Waveguide Air Humidity
g. RF Output Tube Temperature
h. Coolant Flow
i. High Voltage Standing Wave Ratio

3.7.2.4.5.2 Maintenance Controls

Principal maintenance and tuning controls shall (1) be provided on the interior front panel of the transmitter/modulator so that optimum operation may be obtained in a minimum of time. The capability shall (2) be provided to select the pulse-width and PRF for maintenance purposes. The capability shall (3) be provided for manual control of the RDA for maintenance purposes. Transmitter control and status shall (4) be provided to FAA RMS in accordance with the NEXRAD RDA/RMS ICD.

3.7.2.5 Receiver

The receiver unit shall (1) be a stable, sensitive, wide dynamic range receiver providing a flexibility to implement a variety of interference rejection filters. The radar equipment emissions shall (2) conform with requirements established in the Manual of Regulations and Procedures for Federal Radio Frequency Management, RSEC Subsection 5.3.3 (Criteria D), subparagraphs 2, 3, 4, 6 and 7. In addition, the radar shall (3) be capable of complying with subparagraphs 9 and 9c when operating in designated high density areas.

3.7.2.6 Signal Processing Capability

Doppler radar output data shall (1) be processed to provide, at a minimum, estimates of reflectivity, mean radial velocity, and spectrum width in accordance with the requirements defined in Section 3.7.2.2. In addition, the processor shall (2) be capable of estimating reflectivity and velocity at SNRs down to and including -3 dB. The Z, V, and W estimates shall (3) be discarded when the corresponding SNR is less than a set threshold value.

Independent threshold values shall (4) be used for the three estimates (Z, V, W). The capability shall (5) be provided to use a separate set of threshold values for each scan strategy and each scan rate used. All threshold values shall (6) be adaptable at the MSCF in increments of 0.125 dB, over a range of SNR's of at least -12 dB to +20 dB. Outbound radial velocities shall (7) be defined as positive velocities. Inbound radial velocities shall (8) be defined as negative velocities.

3.7.2.7 Ground Clutter Suppression

The objective of the ground clutter suppression capability is to improve the measurement of weather return parameters in the presence of clutter. Clutter suppression is defined as the ratio of clutter input to clutter output, normalized to filter noise gain. Clutter suppression performance is described by the improvement in the ability to measure weather return parameters from a Gaussian random process weather model in the presence of two different clutter models. Clutter model A is a Gaussian random process with a Gaussian spectrum centered at zero mean velocity. The clutter root mean square (rms) spectrum width is the rms of 0.1 ms^{-1} plus the rms spectrum width resulting from the antenna rotation rate at the lowest two elevation angles. Clutter Model B represents a scattering echo from a point target and consists of a complex wave form with an amplitude envelope which is an approximation of the two-way antenna pattern.

3.7.2.7.1 Ground Clutter Suppression Requirements

The RDA shall (1) provide ground clutter suppression capability of at least 30 dB in the reflectivity channel. The RDA shall (2) provide ground clutter suppression capability for the Doppler channel which meets the requirements shown in Table 3-17 for mean radial velocity (V) and spectrum width (W). In areas where the clutter suppression is not applied, there shall (3) be no degradation in the weather return parameter measurement accuracy with respect to sections 3.7.2.2.3.1 and 3.7.2.2.3.2.

For testing purposes, the following shall (4) apply:

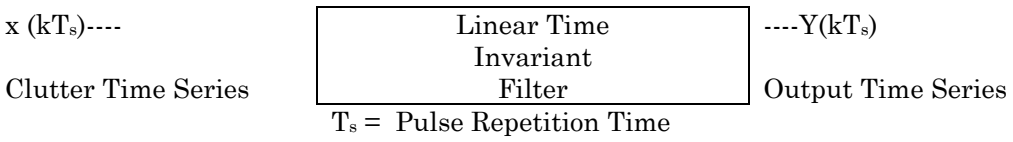
a. Ground clutter suppression performance is measured at a nominal frequency of 2.8 GHz.

b. Ground clutter suppression requirements are met when implemented for the lowest two elevation scans on both scan strategies 1 and 2 (see Appendix I).

Table 3-17 CLUTTER SUPPRESSION REQUIREMENTS FOR MEAN RADIAL VELOCITY AND SPECTRUM WIDTH ESTIMATES

	Required Ground Clutter Suppression Capability (I) in dB (Spectrum Width = 4 ms^{-1})	
Minimum Usable Mean Radial Velocity, V_{min} in ms^{-1} (see Section 3.7.2.7.2)	Clutter Model A	Clutter Model B
2	20	20
3	28	30
4	50	50

If clutter suppression is accomplished by a linear time invariant filter followed by a conventional weather return parameter estimation process such as a pulse pair algorithm, the clutter rejection performance is the ratio of filter input power to filter output power for each of the two clutter models, as illustrated in Figure 3-3. The window time duration shall (5) correspond to the appropriate weather parameter estimation interval.



Clutter Model	Algorithm for Computing Clutter Suppression Capability: I
A	$I = 10 \log_{10} [<\|x(kT_s)\|^2>/<\|y(kT_s)\|^2>]$
B	$I = 10 \log_{10} [\max<\|x(kT_s)\|^2>/\max<\|y(kT_s)\|^2>]$

< > represents the value of the time average over a moving window as the antenna scans past a point target. The scan rate assumed should be that used on the lowest two elevations.

| | represents absolute value.

Figure 3-3 Clutter Suppression Capability Characterization for Linear Time Invariant Clutter Filtering

3.7.2.7.2 Clutter-related Estimate Errors

In the presence of clutter, weather return parameter estimate errors are due to the following two components:

a. An error results from undesired effects on the weather returns due to the introduction of the clutter suppression device. Bias error contributions by the clutter suppression device to the reflectivity estimates shall (1) be less than or equal to the values given in Table 3-18. This bias is measured with an input signal-to-clutter ratio (SCR) of at least 30 dB. It applies for all mean radial velocities (V) and shall (2) be systematic, i.e., predictable from mean radial velocity and spectrum width parameters of the Gaussian random process weather model. Bias and standard deviation contributions by the clutter suppression device to the mean radial velocity and spectrum width estimates shall (3) each be less than 2 ms^{-1} for mean radial velocities greater than or equal to the minimum usable mean radial velocity, Vmin, for the following conditions:

   (1) Clutter suppression capability selected from Table 3-17.

   (2) Input SNR of at least 20 dB.

   (3) Input signal-to-clutter ratio of at least 30 dB.

   (4) A spectrum width of 4 ms^{-1}.

b. An additional error results from the clutter residue (which is a function of the signal-to-clutter ratio at the output of the filter). With the clutter suppression device operating and a spectrum width equal to or greater than 4 ms^{-1}, the expected bias error in the reflectivity estimate due to the clutter residue shall (4) be less than 1.0 dB for an output signal-to-clutter ratio of 10 dB.

   (1) The contribution of the clutter residue to the bias error for the mean radial velocity estimate shall (5) be equal to or less than 1 $ms^{-1}$for the following conditions:

      (a) Output signal-to-clutter ratio of 11 dB.
      (b) Clutter model A (see Section 3.7.2.7).
      (c) V = (V_a/2) (where V_a is the Nyquist velocity).
      (d) W = 4 ms^{-1}.

   (2) The contribution of the clutter residue to the bias error for the spectrum width estimate shall (6) be equal to or less than 1 $ms^{-1}$for the following conditions:

      (a) Output signal-to-clutter ratio of 15 dB.
      (b) Clutter model A.
      (c) V = (V_a/2).
      (d) W = 4 ms^{-1}.

Table 3-18 MAXIMUM ALLOWABLE BIAS IN REFLECTIVITY ESTIMATES DUE TO THE CLUTTER SUPPRESSION DEVICE

Weather Spectrum Width (W) (ms^{-1})	Maximum Allowable Bias in Reflectivity Estimate (dB)
1	10
2	2
≥ 3	1

3.7.2.8 Control Functions

The RDA includes all hardware and software necessary for operational control and monitoring of the RDA functional area. The RDA control capability supports performing cold startup, restart, warm startup and control commands as described in this section. The RDA control capability shall (1) also support the running of off-line diagnostics as defined in Section 3.7.6.1.

3.7.2.8.1 Cold Startup

Cold startup is a series of procedures intended to bring the radar from an idle state (i.e., no software loaded, no hardware initialized) to the warm startup state (i.e. Standby); an Operator must manually intervene and start the process by issuing the command that causes the radar to load, initialize, and start the RDA application software and initialize the radar hardware. The radar enters a Startup sequence which includes (but not limited to) establishing the communications link with the RPG, commanding the pedestal to the park position, establishing the controlling channel, initializing the maintenance display interface, and performing initial radar calibrations. Upon completion of cold startup procedures, the radar will be in the Standby state if previously commanded to perform a normal shut-down using the Terminate command.

The cold startup function of the RDA functional area shall (1) provide the capability to start up the RDA either initially or after a failure requiring maintenance action to be taken at the RDA. The cold startup function shall (2) provide all control signals and other information related to the start of operation. Immediately following the completion of cold startup, it shall (3) be possible to allow or inhibit data transfer from the RDA to the RPG functional area.

Following the cold startup, data available within the RDA shall (4) be provided to the MSCF and the FAA RMS interface for test and adjustment purposes. It shall (5) be possible to initiate sending data to the RPG, if it was inhibited prior to or following the completion of the cold startup procedure, without repeating any of the cold startup procedure.

3.7.2.8.2 Restart and Warm Startup

Warm Startup. Warm startup is a series of procedures that begins with the radar in Standby, Playback, or Offline Operate states, and the Operator issuing an Operate command to bring the radar to the Operate state. During warm startup, the radar channel is checked to make sure it is the controlling channel and the pedestal is initialized; the end result of warm startup, the radar is in Operate state.

Restart. The purpose of a restart is to return the radar to a normal operational state. A restart can begin manually with the Operator at the maintenance position or MSCF issuing a Restart command, or automatically when a hardware or software condition causes the processor to reboot, when one of

the RDA software tasks pauses, under certain error conditions (i.e. timeouts), and upon prime power recovery following a power failure. During the restart process, the operating system is reloaded and a cold startup is performed. At the completion of the restart process, the RDA will be returned to the state present at the time the restart was initiated (if initiated from the RPG), or to a default state (if initiated from the RDA).

The restart function (including the warm startup function when necessary) shall (1) provide the capability to restart the RDA as a result of a restart action, the detection of a transient error condition, or a manual or automatic equipment substitution action if redundant or standby equipment is provided. A restart action shall (2) place the RDA into a standby state, then reinitialize the RDA applications software, and then place the RDA into an operational state. An RDA restart shall (3) include an RDA warm startup procedure, if the radar was previously in a state other than standby.

The restart and warm startup procedures shall (4) be automatic except when manual control by the Operator is desired. The warm startup function shall (5) provide both local control (RDA) and remote control. All unit adaptation and control information shall (6) be stored in such a manner that required response times can be met for a restart up to at least one hour after power interruption.

3.7.2.8.3 Controlled Shutdown

A controlled shutdown of the RDA shall (1) return it to a state from which an RDA cold startup may be performed. An RDA shutdown shall (2) terminate the receipt by the RPG of data from the RDA. A controlled shutdown of the RDA shall (3) also result in notification of the shutdown to all users. A controlled shutdown shall (4) not affect system capabilities related to sending existing products to the users.

3.7.2.8.4 Control Commands

Control commands shall (1) be accepted from the RPG MSCF, RDA MSCF, or FAA RMS. See Sections 3.7.1.6 and 3.7.3.4 for additional requirements related to RDA control commands.

3.7.2.9 Monitoring and Error Detection Capability

The capability shall (1) be provided to send RDA status, including a positive indication that the RDA is operating within all specification parameters, to the MSCF and the FAA RMS interface. The RDA equipment shall (2) include built-in test equipment to provide a combination of on-line and off-line status monitoring and self test to support system operation and fault isolation to the degree required to meet the maintenance concept as described in Section 3.4.1. All alarms shall (3) drive indicators on individual units, where appropriate, and at the maintenance position in the RDA.

3.7.2.10 Display Functions

The RDA shall (1) include a capability to display radar data status and performance information for purposes of system monitoring, maintenance, and adjustment. The design shall (2) include displays, meters, and indicators as necessary for maintenance. The RDA shall (3) support a local Real Time Display of base data.

3.7.2.11 Calibration

The RDA shall (1), during each volumetric scan sequence, automatically perform the calibration measurements defined in this section and automatically correct the measurement of base data in the subsequent volume scan. The calibration data and parameters shall (2) be included in the RDA status data which accompanies base data for applications by the users at all levels of data processing. RDA performance data shall (3) be incorporated into the digital information message traffic provided to the MSCF and the FAA RMS, and shall (3a) be displayable at the RDA maintenance interface.

The calibration measurements include but are not limited to the following:

a. A measurement of the average transmitted power level shall (4) be monitored.

b. A calibration of the RDA reflectivity channel from the channel's first active device through the signal processor shall (5) be monitored. This calibration shall (6) be timed to correspond to regions of space devoid of both ground clutter and weather echoes. The calibration shall (7) be performed over the entire linear range of performance. The calibration signals shall (8) undergo the same averaging as the weather echoes.

c. The mean radial velocity and spectrum width processing performance shall (9) be monitored. This monitoring function shall (10) be timed to correspond to regions of space devoid of both ground clutter and weather echoes. This monitoring function shall (11) include at least one known value of mean radial velocity and spectrum width at one range cell. The system shall (12) be capable of expansion to monitor new hardware in receiver channel, to include a second receiver for dual polarization and processing parameters from a digital receiver.

3.7.2.12 Setup Mode

The RDA shall (1) include the capability to measure and monitor the following parameters:

a. Transmitter frequency

b. Peak transmitted power

c. Transmitted pulse shape

d. Transmitted pulse width

e. Pulse repetition interval

f. Receiver calibration over entire dynamic range

g. Mean radial velocity and spectrum width computation over entire Nyquist interval

h. Complex spectrum in at least one range cell that is controllable over the entire system PRF with the number of samples being variable from 32 to 512 in power of 2 increments.

The measurements and status of these parameters shall (2), when available to the RDA application software, be sent to the MSCF and the FAA RMS interface.

3.7.2.13 Archive Level I Interface Connections

The RDA shall (1) provide interface connections to allow Archive Level I data to be obtained. The Archive Level I data shall (2) be the output of the receiver (digital time-domain data). Synchronization, calibration, and other data required to properly interpret the archive data, including date, time, antenna position, etc., shall (3) be available at the Archive Level I interface connection.

RADAR PRODUCT GENERATION (RPG) SEGMENT

3.7.3 Radar Product Generation Functional Area

The Radar Product Generation (RPG) functional area uses base data received from the Radar Data Acquisition (RDA) functional area to generate a set of products which contains information on meteorological phenomena including, but not limited to, the following:

a. Precipitation

b. Wind and Wind Shear

c. Tornadoes

d. Fronts and Fine Lines

e. Tropical Cyclones

f. Mesocyclones

g. Thunderstorms

h. Turbulence

i. Icing Conditions

j. Hail

k. Freezing/Melting Level

The products are then distributed to the users (see Figure 3-2). The RPG shall (1) be capable of accepting, storing, and processing base data for differing numbers of elevation scans and scan rates, including those scan strategies defined in Appendix I. The RPG shall (2) provide for real-time distribution of base data to multiple users. It shall (3) be possible to perform RPG functions in either a fully automated mode or manually through the MSCF or through commands received from the FAA RMS interface.

In a fully automated mode (with/without the FAA RMS interface the RPG shall (4) be capable of being operated unattended. The RPG functional area capabilities are detailed in the following sections. All capabilities will not be provided at every site. Tables and/or equipment stands shall (5) be provided to support all display, data entry, and control equipment. All display, data entry, access to RDA and RPG control, and RDA, RPG, and PUP status monitoring and error detection will be handled through the MSCF control position and the FAA RMS interface.

3.7.3.1 Product Generation

Base data shall (1) be used to detect and measure meteorological phenomena based on supplied algorithms. The algorithms are defined in the NEXRAD Algorithm Report, R400-AR401. Algorithms shall (2) be implemented in an easily changeable manner, based on a system design to be specified. The RPG shall (3) produce the following types of products (Defined in Appendix B.) as described in Appendix E:

a. Base Products

b. Derived Products

c. Alphanumeric Products

d. Derived Data Array Products

In addition to product data, each product shall (4) include the following descriptive information: the standard annotations set, identification of range obscured data, and appropriate other meteorological information. All times displayed or included in products shall (5) be expressed as Coordinated Universal Time (UTC). All distances to be numerically displayed or included in products shall (6) be expressed in nautical miles, all altitudes in feet, and all speeds in knots. Presentation of base products and derived products to operational personnel assumes the use of a color graphic display. Presentation of alphanumeric products does not require this capability.

3.7.3.1.1 Base Products

Base products shall (1) provide reflectivity estimates for each elevation angle to a range of 460 km (Note the RDA is not required to provide data above 70,000 ft MSL. See Section 3.7.2.2.1.1 for base data coverage requirements). Base products shall (2) provide mean radial velocity and spectrum width estimates for each elevation angle to a range of 230 km. The highest resolution provided in a base product shall (3) be equal to the resolution available from the base data.

These products shall (4) be formatted to facilitate display as a vertical projection onto the earth's surface, e.g., 100 km at 20 degrees will be displayed at approximately 94 km. For a given coverage area (see Table E-1a), each elevation scan shall (5) be displayed at the same geographic scale relative to the earth's surface.

3.7.3.1.2 Derived Products

Derived products shall (1) provide users with access to large volumes and varieties of data in easily displayable formats. These large volumes of data shall (2) be concentrated into easily interpretable products to identify specific meteorological phenomena.

3.7.3.1.3 Alphanumeric Products

Alphanumeric products shall (1) provide weather information in a form suitable for display. This information shall (2) include alert messages, supplemental and summary data, and free text messages.

3.7.3.1.4 Derived Data Array Products

Derived data array products shall (1) provide information in a form suitable for transmission to and processing in a system external to the WSR-88D System. These products are not in a displayable format and can include intermediate outputs from the meteorological algorithms.

3.7.3.2 Product Storage

The RPG shall (1) provide the capability for on-line storage of all products. The RPG shall (2) accept input from the MSCF for defining and changing the product mix and retention time (up to a maximum of six hours) for products to be retained in the on-line RPG storage. Products stored within the RPG on-line storage shall (3) not be capable of being altered from a PUP, nor by input from any principal user or other user interface.

The RPG on-line storage of products shall (4) be capable of storing base data for up to 1 hour and other products for 6 hours as defined by the full load product mix in Table E-1a. When load shedding of products stored on-line is required, the shedding shall (5) be performed by deleting the oldest product(s) with the least amount of retention time and replacing it with the newest product produced.

3.7.3.3 Product Distribution

Each RPG shall (1) make products available for distribution to the users as defined in the following sections. Upon receipt of the appropriate message from a user, the RPG shall (2) transmit a list of products available for distribution to that user. The number of sites which an RPG must be capable of distributing products shall (3) be limited only by the limits shown in Section 3.2.1.5.

Adaptation data inputs from the MSCF or FAA RMS interface shall (4) control the number and types of products distributed through any Legacy Class User port. Characteristics of external interfaces are defined in section 3.7.1.8, Interface Requirements.

3.7.3.3.1 Distribution to Legacy Class 1 Users

For each Legacy Class 1 User, the RPG shall (1) provide those products requested by that user, including both products to be sent on a routine basis and products requested on a onetime basis. Products generated because alert criteria were met shall (2) be transmitted to the requester prior to all other products defined for transmission to that requester. Different Legacy Class 1 Users may request different product sets for routine receipt from an RPG. The distribution of products shall (3) satisfy the users' frequency and priority requirements within the constraints of available communications bandwidth.

If the culmination of requested products from a line exceeds the narrowband communication line capacity during a volume scan time, the RPG shall (4) distribute products based on transmission priority. The transmission priority value shall (5) provide control of the product transmission sequence to the PUP so that a onetime product selection may be interleaved with or transmitted prior to products defined for routine transmission to the PUP. If no transmission priority value is included with the onetime product selection, then the product shall (6) be transmitted prior to the products defined for routine transmission to the PUP.

All products stored on-line within the RPG shall (7) be available to any Legacy Class 1 User. Any product which has not been generated prior to the receipt of a request (e.g., cross section) shall (8) be generated and distributed to the requester. The RPG shall (9) support on-line requests for changes and additions to the set of products routinely sent to a Legacy Class 1 User.

It shall (10) also support on-line changes to their frequency or priority. In the event a product request can not be met, the RPG shall (11) transmit a response message describing the reason why.

3.7.3.3.1.1 Distribution to a Collocated Legacy Class 1 User

For selected WSR-88D Systems, the RPG shall (1) include a Legacy Class 1 User capable of exchanging data at no less than 56 Kbps, full duplex. Product distribution services shall (2) conform to the requirements specified for Legacy Class 1 Users above.

3.7.3.3.2 Distribution to Legacy Class 2 Users

Each RPG shall (1) be capable of providing products to any Legacy Class 2 User in response to a onetime request (i.e., dialup). The specific products available for distribution to any Legacy Class 2 User shall (2) be controlled by adaptation data through the MSCF or FAA RMS interface.

3.7.3.3.3 Distribution to Legacy Class 4 Users

Each RPG shall (1) be capable of routinely providing a selected set of products to all Legacy Class 4 Users controlled by adaptation data input from the MSCF or the FAA RMS interface. It shall (2) be possible to select the method of product distribution for each Class 4 port controlled by adaptation data input from the MSCF or the FAA RMS interface.

3.7.3.3.4 Distribution of Base Data to Users

The RPG shall (1) distribute the base data stream (unaltered from the RDA) through the Base Data Distribution Interfaces.

3.7.3.4 RDA and RPG Control

Control capabilities will provide for operation of the WSR-88D System. These include, but are not limited to:

a. RPG Startup
b. RPG Restart
c. RDA Restart and Warm Startup
d. User Interface Connection Control
e. Controlled Shutdown
f. RDA Mode Control
g. RPG Reconfiguration
h. Archiving Level II and Level III Control
i. Product Generation Control
j. Product Storage Control
k. RPG Adaptation Control
l. RDA Backup Power Control
m. Communication Interface Configuration
n. RPG and RDA Redundant Channel Control
o. Volume Coverage Pattern Control
p. Clutter Suppression Control

3.7.3.4.1 RPG Startup

An RPG startup capability shall (1) be provided to initiate the operation of the RPG without any concern for the current state of the remainder of the WSR-88D System. RPG startup shall (2) be used to initiate RPG operation or after a RPG system failure of longer than one hour. It shall (3) also be used after system failures which make it impossible to recover any data present at the time of the failure.

RPG startup shall (4) also be used when the RPG restart function (see Section 3.7.3.4.2) fails to operate properly. RPG startup response time is specified in Section 3.2.1.3. During RPG startup, it shall (5) resume its previous mode, either test mode or operational mode. The RPG startup capabilities (via the operating system and/or applications software) shall (6) include:

a. Verification of the configuration.

b. Initialization of RPG equipment, firmware, and software.

c. Initialization of all clocks and internal timers.

d. Establishment of the interface with the RDA (if operating).

e. Establishment of the interfaces with all applicable users.

f. Notification to the users that the system is again available.

g. Establishment of the FAA RMS (if configured).

3.7.3.4.2 RPG Restart

An RPG restart capability shall (1) be provided to restore the previous state of the RPG after a failure from which recovery is possible without maintenance action. RPG restart shall (2) also be capable of being performed automatically or manually. A RPG restart shall (3) be performed when the RPG experiences non-catastrophic failures, (Defined in Appendix B. (See Catastrophic Failures)) power interruptions of less than one minute, and other such failures.

All unit adaptation and control information shall (4) be stored in such a manner that required response times can be met for a restart up to at least one hour after power interruption. The RPG restart response time is specified in Section 3.2.1.3. The RPG restart capabilities shall (5) include:

a. Automatic reboot of the system software (if necessary).

b. Restoration to the operating state (e.g., scan mode, product menus, adaptation data, etc.) existing when service was interrupted.

c. Re-initialization of all clocks and internal timers.

d. Reestablishment of the interface with the RDA (if operating).

e. Reestablishment of interfaces with all applicable users.

f. Verification of the configuration.

g. Notification to the users that the system is again available.

h. Notification to users of potentially degraded data.

g. Establishment of the FAA RMS interface (if configured).

If the approved design includes a distributed RPG architecture that facilitates restart of individual subcomponents (for example a communication server, product server, control workstation, etc.), then a restart capability for each RPG subcomponent shall (6) be provided to restore the subcomponent to an operational state after a controlled shutdown or a non-catastrophic failure of that subcomponent. A restart of an RPG subcomponent shall (7) include the following:

a. Re-initialization of all subcomponent clocks and internal timers.

b. Verification of the subcomponent configuration.

c. Reestablishment of the available user interfaces with the RPG.

d. Notification to the users that the subcomponent is again available.

e. Automatic redistribution of processing load, if the subcomponent is a processor.

3.7.3.4.3 RDA Restart and Warm Startup Control

An RDA restart and warm startup capability shall (1) be provided from the RPG through the MSCF and FAA RMS interface. It shall (2) include those restart and warm startup functions defined in Section 3.7.2.8.2. It shall (3) also include reestablishment of the interface of the RDA with its RPG (if operating).

3.7.3.4.4 Interface Connection Control

The capability shall (1) be provided to connect, terminate, or prevent connection of any RPG interface.

3.7.3.4.5 Controlled Shutdown

The capability shall (1) be provided to shut down in a controlled manner the following parts of the system:

a. The RDA as stated in Section 3.7.2.8.3.

b. The communications links with communications interfaces.

c. The RPG, or its subcomponents.

The controlled shutdown of a communications interface shall (2) not affect other RPG interfaces. The controlled shutdown of the RPG shall (3) include the controlled shutdown of all internal and external communications interfaces, notification of the shutdown to all connected users, and the return of the RPG to a condition from which an RPG startup is required to resume operation. If the approved design includes a distributed RPG architecture that facilitates restart of individual subcomponents (for example a communication server, product server, control workstation, etc.), then a controlled shutdown capability for each RPG subcomponent shall (4) be provided to place the subcomponent into a state from which the subcomponent can be restarted without accomplishing an RPG Startup procedure.

A controlled shutdown of an RPG subcomponent shall (5) include notification to all connected users. A controlled shutdown of one subcomponent (e.g., a communication server, product server, control workstation) shall (6) not affect the operational state of any other subcomponent.

3.7.3.4.6 Mode Control

3.7.3.4.6.1 RDA Mode Control

The capability shall (1) be provided for the RPG to change modes of the RDA. This shall (2) include all modes defined in Section 3.7.1.6.4.7.1.

3.7.3.4.6.2 RPG Mode Control

The RPG shall (1) be capable of operating in two modes, test and operational. In the test mode, products shall (2) be sent only to the collocated PUP (if one is provided as part of the RPG) for test and monitoring purposes. In the test mode, status messages shall (3) be sent only to the Collocated PUP, MSCF, and the FAA RMS interface.

However, status indicating the RPG is in test mode shall (4) be sent to all users before the users are disconnected. When the RPG enters test mode, the RPG shall (5) command the RDA into maintenance mode. Changing from the test mode to the operational mode shall (6) be possible without repeating the full RPG startup procedure.

When entering the operational mode, the following capabilities shall (7) also be provided:

a. Establishment of interfaces with all applicable users.

b. Verification of the operational mode configuration.

c. Notification to dedicated users that the system is available.

d. Command the RDA out of maintenance mode.

3.7.3.4.7 RPG Reconfiguration

The capability shall (1) be provided to manually reconfigure RPG equipment. This capability is provided by the MSCF and the FAA RMS interface. If the RPG is configured with more than one processor, the capability shall (2) be provided to control the shifting of loads between the processors. At redundant sites, the RPG shall (3) provide the capability to have resources (e.g., the storage capacity, processing capacity) manually reallocated between redundant RPGs.

3.7.3.4.8 Archive Level II and Archive Level III Control

The capability is provided as described in Section 3.7.1.6.4.9 to control and monitor data archive through the MSCF and the FAA RMS interface.

3.7.3.4.9 Product Generation Control

3.7.3.4.9.1 Routine Product Generation

The RPG shall (1) routinely generate a predefined set of products. In addition, the RPG shall (2) generate those products that have been selected by Class 1 Users for routine receipt. In addition, the RPG shall (3) generate products at the Class 1 User or MSCF specified frequency, on a per product basis.

3.7.3.4.9.2 Alert Product Generation

The RPG shall (1) be capable of generating one product for each of the alert categories (See Appendix J) for which alert conditions are met in any of the Class 1 Users' selected alert areas. When a product is generated due to the detection of an alert condition, if the product is an elevation based product, the product shall (2) be generated for the elevation angle corresponding to the maximum value exceeding the alert condition. If the product is a window product, it shall (3) be centered at the coordinates of the meteorological phenomenon causing the alert condition.

The product shall (4) be automatically sent to the Class 1 User(s) whose alert areas are affected and who have requested the automatic product distribution. The product selected for generation for each alert category shall (5) be an adaptable parameter at the RPG.

3.7.3.4.9.3 One-time Product Generation

The RPG shall (1) generate products in response to onetime product requests from Class 1 Users.

3.7.3.4.10 Product Storage Control

The capability shall (1) be provided to select or change the set of product types to be stored in the on-line storage. In addition, the capability shall (2) be provided to specify, on a per product basis, the frequency at which the product is stored and the storage time period.

3.7.3.4.11 RPG Adaptation Control

The RPG shall (1) store and use the most recent RPG adaptation parameter values, as appropriate to operations. The RPG shall (2) provide the capability to use the baseline adaptation data.

3.7.3.4.12 RDA Backup Power Control

The capability shall (1) be provided by the MSCF to perform a systematic, controlled switch over and recovery of operations between commercial and backup power for all WSR-88D equipment located at the radar site.

3.7.3.4.13 Communication Interface Configuration

It shall (1) be possible to configure any narrowband port to emulate any of the three Legacy classes, up to 46 ports (fully expanded), by adaptation data alone.

3.7.3.4.14 RDA and RPG Redundant Channel Control

The capability to control the state of the FAA and NWS redundant channels is specified in Section 3.7.1.6.4.15.

3.7.3.4.15 Volume Coverage Pattern (VCP) Control

The capability to select the operational VCP from the set of defined local and remote (adaptation data) VCP suites shall (1) be provided (Note: "Local" scan strategies are stored in the RDA. "Remote" scan strategies are stored in the RPG). The capability shall (2) be provided to modify VCP parameters by elevation scan where appropriate. The parameters shall (3) include, but are not limited to Doppler PRF selection, SNR, sector definition, and velocity measurement increment.

3.7.3.4.16 Clutter Suppression Control

The capability to control the application of clutter filtering to include clutter suppression region definition, notch width selection, and bypass map editing, shall (1) be provided. A minimum of 4 files for defining clutter suppression regions shall (2) be stored in adaptation data. Each file shall (3) allow for a minimum of 15 clutter suppression regions.

3.7.3.5 RDA, RPG, and PUP Status Monitoring and Error Detection

3.7.3.5.1 Status Monitoring

The capability shall (1) be provided to monitor the status of the RDA, the RPG, and each communications interface. This status monitoring capability shall (2) include operational modes, conditions, and parameters, as well as error conditions. Alarm messages received shall (3) be considered status messages for the purposes of further dissemination.

Status shall (4) be provided to the MSCF and the FAA RMS interface: (a) when requested; (b) periodically, as specified; and (c) when there is a change in the status of the RDA, the RPG, or any of the WSR-88D communications interfaces. A status message shall (5) be provided to any communications interface: (a) when requested, (b) upon connection, and (c) when there is a change in the status of the RDA or RPG.

3.7.3.5.2 Storage of Status Messages

The capability shall (1) be provided to detect and store on-line all status and error messages. When stored on-line, a descriptive English language message shall (2) be provided for each status or error message. Status and error messages shall (3) be stored on-line for at least 24 hours. A hardcopy device for the recording of all status and error messages shall (4) be provided.

3.7.3.6 Archive Level III

The capability shall (1) be provided within the RPG to generate the archive record of all products, and status messages on a permanent and easily transportable medium. This is defined as Archive Level III. The capability shall (2) be provided to ingest previously archived RPG status and error messages and send them for display to the MSCF. The capability shall (3) be provided for continuous status message archiving.

The first information written to each archive recording medium shall (4) include the site id. The individual physical archive medium shall (5) be capable of storing at least 168 hours worth of the full load archiving product mix as defined in Table E-1. The Archive Level III medium shall (6) be write-protectable.

Archive Level III shall (7) support the ability to rapidly read specific previously recorded data. Archive data shall (8) meet an availability rate of 96% (record 96% of the required products when the RPG is producing products).

3.7.3.7 Data Ingest

3.7.3.7.1 Rain Gage Ingest and Processing

Hydrometeorological processing requires rain gage data for quality control of rainfall estimates. Based on criteria as defined by the Precipitation Detection Function in Appendix D, Section 2, a WSR-88D shall (1) ingest rain gage data.

3.7.3.8 Alert Processing

The RPG shall (1) generate alert outputs based upon automatically identified meteorological phenomena occurring or projected to occur in alert areas defined by each Class 1 User. Each alert area shall (2) be definable within the range of coverage (See Appendix J) on a grid divided into squares of no larger than 16 X 16 km.

3.7.3.8.1 Alert Categories

The RPG shall (1) be capable of generating alerts for all categories of phenomena identified in Appendix J.

The categories of Group "a." are ones that have different data for each grid square.
The coarsest resolution product available may be used to generate these data.
The categories of Group "b." are based on volume data and use the algorithm outputs.

The categories of Group "c." are a subset of "b." but shall (2) alert based on levels or phenomena projected to occur in an alert area according to the forecast motion of the storm cell centroid(s).
For each alert area, each Class 1 User may choose up to 10 categories to alert on.
The capability for additional categories shall (3) be provided in the amounts listed in Appendix J.

3.7.3.8.2 Alert Criteria

There shall (1) be one set of thresholding criteria for each alert category as outlined in Appendix J. The values used in the thresholding criteria shall (2) be part of the adaptation data. All criteria shall (3) be set up as greater than or equal to the value selected. When an alert condition has been detected, an alert message shall (4) be transmitted to the appropriate user.

3.7.3.8.3 Alert Message

The alert message shall (1) contain at a minimum the alert area, location, date and time, and a brief description of the alert criteria. For those alerts that are storm cell related (i.e., Groups b and c, Appendix J, except for VAD and rainfall accumulation) the storm cell ID shall (2) also be provided. Upon receipt of the appropriate message from a Class 1 User, the RPG shall (3) transmit the alert threshold values to that user.

PRINCIPAL USER PROCESSING (PUP) SEGMENT

3.7.4 Principal User Processing Functional Area

The Principal User Processing (PUP) functional area displays the products and information received from any RPG functional area. The PUP functional area includes display and data entry equipment which provides the capabilities as specified in Section 3.7.4.1. It also includes the following functional capabilities as specified in Sections 3.7.4.2 through 3.7.4.9, respectively:

a. Product Request

b. Product Display

c. Local Product Storage

d. Product Annotation and Distribution

e. PUP Control

f. Status Monitoring

g. PUP Overload

h. Archiving

3.7.4.1 PUP Display and Data Entry

Each PUP shall (1) include two color graphic displays, an alphanumeric display, data entry equipment, and hard copy capability. Worktables and/or equipment stands shall (2) be provided to support this equipment. The PUP primary operator's chair shall (3) also be provided. At selected locations it shall (4) be possible to locate the display and data entry equipment at a maximum of 300 cable feet from the PUP processing equipment, while maintaining full functionality.

3.7.4.1.1 Color Graphic Displays

Each color graphic display provided as part of the PUP configuration shall (1) be a raster scan, 60 Hz, non-interlaced unit with a diagonal dimension of at least 19 inches, and a resolution of at least 640 x 512 (horizontal x vertical) picture elements (pixels). It shall (2) be possible to simultaneously display eight different luminance values of any of the primary colors (i.e. red, green, blue). Each luminance value, as measured on the display screen, shall (3) be at least 10% (of the highest luminance value of the primary color being displayed) different from any other luminance value.

It shall (4) also be possible to select and simultaneously display at least 128 different colors. These colors shall (5) be selected from the set that results from combining the primary color luminance values defined in the preceding paragraph. Each color graphic display shall (6) be capable of displaying either a single 512 x 512 pixel product, or up to four 256 x 256 pixel products.

When multiple products are simultaneously displayed, it shall (7) be possible to update, annotate, or replace a single product or change its background map without affecting the display of any other products which are simultaneously being displayed. The product display and product annotation capabilities are called out in Sections 3.7.4.3 and 3.7.4.5.

3.7.4.1.2 Alphanumeric Display

The alphanumeric display provided as part of the PUP configuration shall (1) be physically distinct from the PUP color graphic displays. The alphanumeric display shall (2) support the presentation of at least 24 lines of data, each of which contains at least 80 characters. The alphanumeric display shall (3) include separate areas for the display of products and requested information and for the input and previewing of operator-entered data.

3.7.4.1.3 Data Entry Devices

Each PUP shall (1) provide the capability to support data entry through an alphanumeric input device, a programmable function selection capability, and a cursor control device. The following types of entries shall (2) be provided:

a. Annotation, including the ability to add, move, and delete data, special symbols, and line segments.

b. Maps and map modifications.

c. Commands, as required to support PUP functional capabilities.

No combination of errors in data entry shall (3) require a PUP restart. Invalid entries shall (4) result in an appropriate message being provided at the operational position.

3.7.4.1.3.1 Alphanumeric Input Device

The capability shall (1) be provided to support a keyboard generating standard ASCII code. Inputs shall (2) be displayed on either of the color graphic displays or the alphanumeric display, based on operator selection. The input capability shall (3) include all of the ASCII 128 character and control command set (ANSI x3.4) and 64 special characters and symbols. Special symbols shall (4) be displayable on either of the color graphic displays.

3.7.4.1.3.2 Programmable Function Selection

The capability shall (1) be provided to support programmable function selection through a single manual action for at least 30 functions. When a particular single action function selection is activated, a predetermined sequence of events shall (2) take place without further operator intervention. This capability shall (3) be provided for functions that are time consuming or frequently performed. The capability to assign a particular sequence of events to a specific function selection activator or to change the programming of an existing function selection activator shall (4) be provided.

3.7.4.1.3.3 Cursor Control

The capability to control a color graphic display cursor symbol without using a keyboard shall (1) be provided. This capability shall (2) enable the operator to position a cursor at any pixel on a color graphic display. The operator shall (3) have the capability of defining one of the two color graphic display cursors as being a master cursor with the other color graphic display cursor being a slave cursor. When a display is used in the 1/4 screen mode, there is no requirement for the capability to designate one of its four cursors as the master cursor.

When multiple products are being displayed, a multiple slave cursor capability shall (4) be provided which displays a cursor symbol on each product display on the same geographic basis as shown for the master cursor. A cursor home capability shall (5) be provided when a cursor is designated as a master cursor. The coordinates of the master cursor shall (6) always be displayed and consist of range/azimuth/height or latitude/longitude/height as selected by the operator (the value for height is not required for composite products). Linking of the slave cursor shall (7) apply both to multiple products (e.g., 256 x 256) being displayed on a single display unit and to individual products (e.g., 512 x 512) being displayed on each of two display units.

3.7.4.1.4 Hard Copy

A capability shall (1) be provided for generating either a color or a monochrome hard copy output of a displayed product. The hard copy output shall (2) have the same scale of resolution as the graphic version of the product. The color hard copy capability shall (3) provide for generation of at least 16 colors.

The monochrome hard copy capability shall (4) provide for generation of at least six intensities. Hard copy output shall (5) be controlled by the PUP operator. The capability to initiate and terminate the hard copy output process for products shall (6) be provided. The generation of a hard copy shall (7) not require "freezing" the graphic display device for more than 3 seconds.

3.7.4.2 Product Request

3.7.4.2.1 Class 1 Interface to an RPG

3.7.4.2.1.1 Routine Product Requests

Each PUP shall (1) be capable of requesting any set of products for routine receipt from an associated RPG. The PUP shall (2) be capable of specifying the frequency at which a product is to be sent (up to the frequency at which the product is generated) and its priority. The PUP shall (3) also be capable of requesting a change at any time to the set of products routinely sent from the associated RPG, or to their frequency or priority.

The requests for these products and selection of their frequency and priority shall (4) be based on adaptation data and on-line PUP operator inputs using the display and data entry equipment called out in Section 3.7.4.1. Each PUP shall (5) have the capability to readily display to the PUP operator the menu of products available from the associated RPG and also the set of products currently being routinely provided by the associated RPG, together with their frequency and priority.

3.7.4.2.1.2 One-time Product Requests

Each PUP shall (1) also be capable of requesting products on a one-time basis from any associated RPG. For any one-time product selection the PUP shall (2) provide a capability to include a RPG to PUP transmission priority value.

3.7.4.2.1.3 Alert Products

Each PUP shall (1) be capable of specifying if the designated product (See Section 3.7.3.4.9.2) will be sent when its alert criteria have been met.

3.7.4.2.2 Class 2 Interface to an RPG

A PUP shall (1) be capable of requesting selected products on a one-time basis from any RPG. For any one-time product selection the PUP may include a RPG to PUP transmission priority value. The PUP shall (2) be able to specify whether or not background map data is to be included as part of the product to be sent.

3.7.4.3 Product Display

Each PUP shall (1) be capable of displaying WSR-88D products using (a) the data routinely sent from the RPG in conjunction with locally stored data, such as background maps and other overlays, and (b) the data received from any RPG as the result of a one-time request. Any annotations made to a product shall (2) be normally preserved when the product is displayed. It shall (3) be possible to display the product without the annotations in order to de-clutter the displayed product.

Background maps shall (4) be stored locally at the PUP and displayed with the appropriate product when it is selected. Products shall (5) be displayed at the PUP in response to an operator request for a specific product. One-time product requests and alert-paired products shall (6) automatically display on either graphics screen if a product is not currently displayed on the screen.

The product presentation shall (7) use the information in the local PUP data base, if available. If it is not available, the specific product shall (8) be automatically requested from the associated RPG. The time required for call-up and display of products is called out in Section 3.2.1.3 and its subsections. The product display function shall (9) include the following capabilities:

a. Product Display Selection

b. Overlay Capability

c. Re-centering

d. Magnification and Resolution Change

e. Time Lapse Display

f. Display Queued Product

g. Alert Notification

3.7.4.3.1 Product Display Selection

Each PUP shall (1) contain a product display selection capability using the display and data entry equipment called out in Section 3.7.4.1. The product display selection shall (2) identify the product type to be displayed, the display or portion of a display on which it is to be displayed, and the RPG which generated the product. This capability shall (3) cover the selection of any base, derived, or alphanumeric product.

In the case of products that depict multiple data levels, the capability shall (4) be provided to filter selected data levels or combine multiple data levels when displaying the product based on PUP

operator input. If filtering is selected, those data levels below the data level identified by the operator shall (5) not be displayed. If combining is selected by the PUP operator, two or more data levels shall (6) be depicted using the same color (if a pixel map) or by the same contour line (if a contour map).

3.7.4.3.2 Overlay Capability

Each PUP shall (1) be able to display selected products and background maps as overlays. Any combination of displayed overlays and radar data shall (2) be geographically registered within an accuracy of one kilometer or the resolution of the coarsest product displayed. The following overlay combinations shall (3) be provided, with each overlay within the combination capable of being independently selected and deselected. The background (i.e., non-data area) color is included in the number of colors required per overlay.

Table 3-19 OVERLAY COMBINATIONS

Combination	Characteristics
1	1 overlay of 16 colors
2	1 overlay of 8 colors and 1 overlay of 2 colors
3	2 overlays of 4 colors each
4	1 overlay of 4 colors and 2 overlays of 2 colors each
5	4 overlays of 2 colors each

3.7.4.3.2.1 Product Overlay Selection

Each PUP shall (1) contain a product overlay selection capability using the display and data entry equipment called out in Section 3.7.4.1. Products which can be used as overlays are identified in Appendix E. Any product overlay available in local PUP storage shall (2) be capable of being selected or deselected. When a product overlay is selected, it shall (3) take precedence and be observable on a pixel-by-pixel basis over product data and background map data that would otherwise have been displayed. When a product overlay is deselected, any product data or background map data not displayed because the product overlay data took precedence shall (4) be displayed.

3.7.4.3.2.2 Background Map Selection

Each PUP shall (1) contain a background map selection capability using the display and data entry equipment called out in Section 3.7.4.1. The background map selection shall (2) identify lines and alphanumerics and other symbols to be displayed together with the product presented on a color graphic display. Any background map adapted for use with an individual PUP shall (3) be capable of being selected or deselected by the operator.

The PUP operator shall (4) have the capability to determine whether the background map or product data has display precedence. When the background map data has display precedence, it shall (5) be observable on a pixel-by-pixel basis over the product data. When the product data has display precedence it shall (6) be observable on a pixel-by-pixel basis over the background map data.

When background map data is deselected, any other background map data not displayed because the deselected map data took precedence shall (7) be displayed. For each product type, background maps shall (8) be selectable for concurrent display. These background maps shall (9) be displayed whenever the product type is displayed, unless the operator requests otherwise.

The specific background maps to be used with a given product shall (10) be adaptable. Background map data for the radar area shall (11) be stored into high and low resolution maps:

a. Low Resolution - covering the full Cartesian space.

b. High Resolution - consisting of 16 maps, each containing data for one-sixteenth of the full Cartesian space. High resolution will contain all low-resolution detail and additional detail when available.

3.7.4.3.3 Recentering

Each PUP shall (1) contain a recentering capability using the display and data entry equipment called out in Section 3.7.4.1. This shall (2) include the capability to off-center a product display to any specified geographic point (indicated by the cursor position) within the geographic area covered by the product. It shall (3) also include the capability to recenter the display to a preselected point (e.g., the location of the applicable radar or of the PUP itself).

Where multiple products with the same geographic coverage are being simultaneously displayed, the capability shall (4) be provided to re-center a single product display or all such product displays simultaneously. When recentering takes place, the entire product display area (256 x 256 or 512 x 512 pixels) shall (5) be filled with product data to the extent that the data for the corresponding geographical area is in the local PUP data base.

When a product display is recentered, all overlays (map data) and annotation symbols being displayed shall (6) be recentered accordingly. If a second off-center or preset center action is requested prior to completion of the first off-center or preset center request, then the system shall (7) stop processing of the first request and process the second request.

3.7.4.3.4 Magnification-and-Resolution Change

Each PUP shall (1) contain a magnification and resolution change capability for base and derived products using the display and data entry equipment called out in Section 3.7.4.1. During the processing time required to accomplish the action the display image may be static for up to the total period required to complete the action, but not longer than the response time requirement in section 3.2.1.3.

3.7.4.3.4.1 Magnification Change

Magnification change is defined for all base and derived products and provides the capability to expand or reduce the geographic coverage of a currently displayed product without, in the case of pixel data (e.g., base products), changing the geographic resolution of the displayed data. The magnification change capability shall (1) provide for a x2, x4, and a x8 magnification. Magnification change shall (2) be reversible. (Note: magnification function is not be required when a display is used in a 1/4 screen mode). If a second magnification action is requested from the same PUP during the period required to complete the first magnification action, then the system shall (3) stop processing of the first request and process the second request.

3.7.4.3.4.2 Resolution Change

Base products and derived product resolution are defined in Table E-1, Appendix E. Resolution change shall (1) include the capability to change both the geographic coverage of a displayed product and the geographic resolution of the data for those products having multiple resolutions. Resolution change may be accomplished through the selection of the different resolution of the displayed product from the associated RPG. When a resolution change request is made, the current display center coordinates shall (2) be used for the center of the requested image.

Following initiation of a resolution change request, a positive response shall (3) be provided to the operator that the request has been received and is being processed. If a second resolution change action is requested prior to the completion of the first resolution change action, then the system shall (4) stop processing of the first request and process the second request.

3.7.4.3.4.3 Magnification/Resolution Change of Product Overlays

When a magnification or resolution change is made to a product display, all overlays shall (1) be repositioned accordingly without changing the display resolution of lines(i.e., map lines not becoming thicker) or changing the size of alphanumerics and other symbols.

3.7.4.3.5 Time Lapse Display

Each PUP shall (1) contain a time lapse display capability for each type of base and derived product maintained in the local PUP data base (see Section 3.7.4.4). The last image in the sequence shall (2) remain on the display and be updated as part of the normal operational product updating sequence. Each PUP operational position shall (3) have the capability to preselect up to three products for future time lapse display.

The time lapse display capability shall (4) support the sequential presentation of up to 72 images of the selected product or the number available in the local data base, whichever is less. The real-time interval between display images shall (5) be an operator selectable integer multiple of the product update period. The response time limits for display-time interval between display images is specified in Section 3.2.1.3. The operator shall (6) have the following minimum control of the images:

a. Single sequence of images with the last image remaining on the display.

b. Repeat of a. above with a single user action.

c. Stop of sequence, with advance or reverse of sequence, one image at a time.

3.7.4.3.6 Display Queued Product

Each PUP shall (1) have the capability to display a queued product in response to a PUP operator action. Whenever a PUP receives a product which was requested by the PUP operator or which is normally displayed upon receipt, and all potential display units are currently used to display other products, then an indication shall (2) be provided to the PUP operator that a product is available for display. The PUP operator shall (3) have the capability to request the display of a queued product.

In which case the first product entered into the queue shall (4) replace the currently displayed product on the display unit indicated by the operator. Any other products in the queue shall (5) remain available for display in response to a later operator action. The PUP operator shall (6) also have the capability to merely acknowledge the presence of one or all queued products.

If the presence of products is acknowledged without display, the queued products shall (7) be removed from the queue. The queued product indication to the operator shall (8) be updated accordingly.

3.7.4.3.7 Alert Notification

A PUP with a Class 1 interface will present both audible and visual notification that certain meteorological phenomena are occurring within, or are projected to enter, the alert areas.

3.7.4.3.7.1 Alert Areas

There shall (1) be up to two operator defined alert areas for each PUP. The alert areas shall (2) be definable from the alert grid (Section 3.7.3.8). An alert area may be made up of any group of alert area grid squares. An alert area may be noncontiguous and the two defined alert areas may overlap. The PUP shall (3) be capable of displaying that PUP's alert areas as an overlay. Each alert area shall (4) be uniquely identified on the display.

3.7.4.3.7.2 Alert Threshold Criteria

The PUP shall (1) be capable of selecting threshold criteria for up to 10 of the alert categories defined in Appendix J for each of the two alert areas. Each threshold criterion selected shall (2) be from the set of threshold values defined at the RPG.

3.7.4.3.7.3 Alert Procedure

When an alert condition has been met within an alert area, the alphanumeric alert message and an audible and a visual notification shall (1) be provided to the PUP. No alert shall (2) be reissued for the same alert category within a given alert area without the intervention of a volume scan devoid of such alerts. The operator shall (3) be able to turn off the alert notification with an acknowledgment procedure. The volume of the audible alert mechanism shall (4) be manually adjustable from inaudible to at least 78.0 dB(A) at 1 meter.

3.7.4.4 Local Product Storage

Each PUP shall (1) include the capability to maintain a local data base containing the products and other data that are used regularly within the PUP. All products received from the associated RPG shall (2) be retained locally for six hours. The local data base shall (3) have the capability to include but not be limited to:

a. Background Map Data

b. Base Products

c. Derived Products

d. Alphanumeric Products (including alert messages)

e. Data formatted for Time Lapse Display

f. System Status Information

3.7.4.5 Product Annotation and Distribution

3.7.4.5.1 PUP Product Annotation

The PUP shall (1) include the capability for local annotation of selected products and their local storage. The annotation capability shall (2) include the ability to add, move and delete alphanumeric data, special symbol data, and line segments. The annotations shall (3) be nondestructive of the data and shall (4) remain a part of the product unless they are removed by manual action.

3.7.4.5.2 PUP Product Distribution

Each PUP shall (1) include a capability to control the distribution of locally annotated and other products to external users and to other users.

3.7.4.6 PUP Control

PUP control provides the capability necessary for the PUP to accomplish its operational functions. PUP control requirements are detailed in the following sections.

3.7.4.6.1 PUP Cold Startup

A PUP cold startup capability shall (1) be provided to initiate the operation of the PUP without any concern for the current state of the remainder of the WSR-88D. PUP cold startup shall (2) be used to initiate operation when the PUP is first put into operation. It shall (3) also be used after failures which make it impossible to recover data present at the time of the failure.

PUP cold startup shall (4) also be used when the PUP restart function (see Section 3.7.4.6.2) fails to operate properly. The response time limits for the PUP cold startups specified in Section 3.2.1.3. The PUP cold startup capabilities shall (5) include:

a. Initialization of PUP equipment, firmware, and software,

b. Initialization of all clocks and internal timers,

c. Establishment of the interface with the associated RPG (if operating),

d. Establishment of all dedicated communications links,

e. Verification of the assumed configuration,

f. Notification to all dedicated users (if connected) that the PUP is operational, and

g. Establishment of products desired and their frequency and priority.

3.7.4.6.2 PUP Restart

A PUP restart capability shall (1) be provided to restore the previous state of the PUP after a failure from which recovery is possible without maintenance action. PUP restart shall (2) be capable of being initiated manually or automatically. PUP restart shall (3) be performed when the PUP experiences transient failures, momentary power failures, and other such short-term failures.

All unit adaptation and control information shall (4) be stored in such a manner that required response times can be met for a restart up to at least one hour after power interruption, and that the PUP can be returned to the state existing immediately prior to the outage. The restart capabilities shall (5) include:

a. Automatic reboot of the system software (if necessary),

b. Restoration to the operating state (e.g., display mode, adaptation data, functions selected, etc.) that was in existence when service was interrupted,

c. Re-initialization of all clocks and timers,

d. Reestablishment of the interface with the associated RPG (if operating),

e. Reestablishment of all dedicated communications links,

f. Verification of the assumed configuration, and

g. Notification to all dedicated users (if connected) that the system is again available.

3.7.4.6.3 PUP Shutdown

Each PUP shall (1) have the capability to shut down in a controlled manner. The controlled shutdown shall (2) return the PUP to a state from which a PUP startup is required to resume operation. The controlled shutdown shall (3) terminate the receipt of products from any RPGs. It shall (4) include the notification to the principal user external system and other users of the expected shutdown in a manner that permits, to the extent feasible, these users to request and receive needed information from the PUP prior to termination of data distribution by the PUP.

3.7.4.6.4 Start/Stop Communications

Each PUP shall (1) have the capability to start or stop communication with any of its communications link interfaces. The stopping of communication with the associated RPG shall (2) not affect communication with users. The start or stop of communication with one user shall (3) not affect communication with any other user or with an RPG.

3.7.4.6.5 Change Adaptation Data

Each PUP shall (1) have the capability to locally change adaptation parameter values. Examples of parameters which are adaptable are described in Appendix H. Each PUP shall (2) also have the capability to locally adapt existing background maps by adding or deleting symbols and line segments. When a background map has been locally adapted, both the currently adapted version and the version which existed prior to any local adaptation shall (3) be retained in the local PUP data base.

3.7.4.6.6 PUP Communication Line Configuration

It shall (1) be possible to configure any narrowband port to emulate Legacy classes 1, 2, 4, up to 10 (fully expanded) ports, by adaptation data alone.

3.7.4.6.7 Other User Distribution

It shall (1) be possible to select at the PUP the method of product distribution for each Class 4 port interfaced to the PUP. The possible methods shall (2) be as required by Specification 3.7.3.3.3.

3.7.4.7 Status Monitoring

Each PUP shall (1) provide the capability for the PUP operator to monitor the status of all major components of the PUP, as well as the status of the associated RPG and RDA, the RPG communications link, and any external PUP interfaces. This status monitoring capability shall (2) include operational modes, conditions, and parameters, as well as error conditions. When the status of any of these items changes, a descriptive English language message shall (3) be displayed and also written to a status file.

In addition, the capability shall (4) be provided to detect and record all hardware and software errors. When an error occurs, a descriptive English language message shall (5) be displayed and written to a permanent error log. The capability shall (6) also be provided to maintain a permanent record of the time and content of alert messages received by the PUP.

These status monitoring and error detection functions shall (7) run concurrently with normal system operation. The capability shall (8) be provided to allow the PUP operator to determine (a) the current status of the PUP equipment, the PUP communications interfaces, and the associated RPG and RDA, and (b) the status of the WSR-88D System over the past six-hour period. The capability shall (9) also be provided to allow the PUP operator to request the display of a test pattern on any graphic display.

3.7.4.8 PUP Overload

Overload Warning Threshold adaptation parameters shall (1) define the utilization level that, when reached or exceeded, will result in an overload warning being issued. Overload types shall (2) include as a minimum: processor, memory, communication interfaces, input data buffers, mass storage, and archival storage utilizations. A Product Overload Shedding/Recovery Priority adaptation parameter shall (3) define the order for deleting products when an overload situation occurs on an interface between functional areas, or an interface between a functional area and an external user's system.

The recovery from an overload condition shall (4) be performed automatically as soon as conditions allow. Products shall (5) be recovered in the reverse of the shedding order.

3.7.4.9 Archiving

Each PUP shall (1) have the capability to maintain an archive record of received background maps, selected products, and product overlays on a permanent and easily transportable medium. This is defined as Archive Level IV. Each PUP shall (2) have the capability to specify the frequency at which this data is archived. The PUP shall (3) have the capability to ingest, from the archive medium, products, background maps, and product overlays previously archived by any PUP for processing or display.

The capability shall (4) be provided to display archived PUP status messages. The capability shall (5) also be provided to archive the entire local product database based on a PUP operator action. The current recording state (i.e., whether archiving is active or inactive and, if active, what products are being recorded) shall (6) be readily displayable to the PUP operator. The capability shall (7) be provided to select continuous status message archiving.

3.7.4.10 OJT Training Support

The capability shall (1) be provided to support OJT within a PUP. A PUP shall (2) be able to perform OJT independently of whether the RPG or any other PUP in the WSR-88D System is operational. During OJT, the PUP operator shall (3) have access to the entire range of functions performed by the operational software using either live or recorded data.

During OJT, the operator shall (4) be able to select portions of the operational data base for training purposes, and also be able to build and maintain a data base to be used exclusively for training. The PUP shall (5) permit PUP OJT while simultaneously monitoring the associated RPG interface for alert messages. In this case, products (with the exception of alert messages) need not be processed by the PUP, however they shall (6) be retained in the RPG data base. When an alert message is received by a PUP performing OJT, it shall (7) be presented to the PUP operator in accordance with Section 3.7.4.3.7.

FACILITIES SEGMENT

3.7.5 Facilities Functional Area

The Facilities functional area includes construction or modification of buildings and towers, provision and installation of Real Property Installed Equipment (RPIE) such as power generation and air conditioning equipment which are needed in support of the RDA, RPG, PUP, and Support functional areas.

At each radar site and MLOS site , the required WSR-88D equipment, structures, and WSR-88D support equipment include, utilities and utility extensions, footings and foundations, ancillary equipment shelter(s) and associated footings and foundations, towers, environmental control, backup power, fuel storage and associated piping, grounding, and wideband communications link to user site including any wideband repeater installations.

Towers constructed at selected sites shall (1) be of structural steel. For MLOS, repeater, and passive reflector towers, an option for either a self-supporting tower or a guyed tower shall (2) be provided. Provisions for a commercial T-1 (1.54 Mb/s) service to replace Microwave may be required at certain sites. Provisions to house the RPG equipment when collocated at the radar site shall (3) also be provided , including the fully expanded RPG, the redundant configuration of Sections 3.2.1.5.1 and 3.2.1.5.2, and the combination of both.

An automatic fire detection capability for the WSR-88D indoor environment equipment located at the radar site (excluding radome interior) shall (4) be provided. Equipment supplied satisfies the requirements with respect to space, electrical, environment, and architecture as specified in Sections 3.7.5.1 through Section 3.7.5.4, respectively.

3.7.5.1 Space

Equipment to be located in an operator work area at a principal user site comprising all equipment required to perform any operator function, including all PUP functional area equipment, and a display terminal for the MSCF, shall (1) not require a horizontal area greater than 12 square meters.

3.7.5.2 Electrical

The equipment installed in the WSR-88D facilities shall (1) satisfy electrical requirements in the following subsections.

3.7.5.2.1 Power Characteristics

The power characteristics for facilities will satisfy the following:

Steady State Voltage	120/208 VAC + -10% (3 Phase, 4 wire)
Steady State Frequency	60 Hz + -5%

Each WSR-88D System shall (1) be designed to be compliant with IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits, with respect to lightning, transient suppression, and motor starting disturbances caused by the air conditioning system when both the air conditioning system and other radar equipment are operating in parallel and receiving power from a standby engine/generator. To accommodate overseas installations, the capability to convert alternate primary power sources to the standard primary power defined above shall (2) be provided. Optional provisions shall (3) be made to accommodate the following primary voltage and frequency configurations:

Table 3-20 PRIMARY VOLTAGE AND FREQUENCY CONFIGURATIONS

	single phase volts AC	three phase volts AC	frequency in Hertz	
a	120	208	60	(typical U.S.)
b	127	220	50	
c	220	380	50	
d	230	400	50	
e	240	415	50	
f	277	480	50	
g	100/200	-	50	
h	100/200	-	60	
i	110/220	-	60	

A single frequency converter shall (4) be provided to support a collocated RDA/RPG. A separate converter shall (5) be provided to support the PUP. When connected to the 50 Hz power through the frequency converter. All other aspects of the WSR-88D system shall (6) remain unchanged. Each WSR-88D System shall (7) withstand a power outage without any damage. It shall (8) be capable of automatic restarting and rapid recovery after power is restored.

3.7.5.2.2 Lighting

Radome and MLOS obstruction lighting shall (1) be provided as per specification AC 70/74601F. Otherwise, WSR-88D facilities shall (2) not require any special lighting effects other than incandescent lighting with dimmer control.

3.7.5.2.3 Cables

Cables used in an outdoor environment shall (1) be designed for direct earth burial and shall (2) be armored to be gopher resistant. The cable shielding, grounding, and routing shall (3) be in accordance with paragraph 5.1.1.2.5 of MIL-STD188-124A, using the guidelines of MIL-HDBK-419. The limits on electromagnetic emissions and susceptibility shall (4) be as stated in Section 3.2.6.11 of this document.

3.7.5.2.4 Electromagnetic Interference Shielding

The WSR-88D system shall (1) include sufficient electromagnetic interference shielding and filtering to meet the requirements stated in Section 3.2.6.12. The requirements and practices to be followed regarding shielding effectiveness, screening, seams/joints/apertures, gaskets, and conductive surface coating shall (2) be as given in paragraph 5.3.2 of MIL-STD-188-124A, using the guidelines of MIL-HDBK-419. The guidelines for attenuation requirements, selection of suppression components, and mechanical considerations as described by the Electronic Industries Association (Filtering Electronic Equipment, Bulletin No. 9) shall (3) be used.

3.7.5.2.5 Internal and External Cableways

Cableways shall (1) be in accordance with National Electrical Code (NEC) requirements. Electromagnetic interference requirements for cableways are specified in Section 3.2.6.12.

3.7.5.2.6 Grounding

The radar equipment shall (1) operate with a facility grounding system whose resistance complies with the National Electrical Code. The grounding connections and grounding methods shall (2) be as required in paragraph 5.1.1.3 of MIL-STD-188-124A, using the guidelines of MIL-HDBK-419. The resistance of the radar equipment to earth shall (3) be 10 ohms or less.

3.7.5.3 Environmental

The equipment installed in facilities satisfies environmental requirements in the following sections.

3.7.5.3.1 Personnel

Working environment and safety requirements for operating and maintenance personnel are stated in Section 3.3.6.

3.7.5.3.2 Equipment

Equipment should be compatible with the environment in which it will operate and not cause any deleterious effects on the natural environment. To provide visual compatibility with the environment, provisions shall (1) be made for the selection (on a case-by-case basis) of optional alternate colors of: the radome, the tower, and any other major outdoor facility item such as a separate shelter, backup power generator, etc. The choice of alternate colors to be provided shall (2) be in accordance with color numbers 30219, 34127, and 34258 of FED-STD-595A. For FAA safety reasons, provisions shall (3) be made for optional alternate colors of the tower structure (radome not included) in accordance with paragraphs 8, 9, and 10.b of AC 70/7460IF.

3.7.5.3.3 Electromagnetic Environment

The 2.72.9 GHz band, nationally, is a Government-exclusive frequency band intended for the primary use of the Aeronautical Radio-navigation Service(air traffic control radars) and the Meteorological Aids Service(weather radars). The WSR-88D System operates in the Communication Electronics equipment environments within CONUS as well as at DOD overseas bases. This will require preplanning and EMC analysis to minimize the impact of interfering signals. To ensure that the WSR-88D System will not be susceptible to electromagnetic interference within the allocated frequency band, the following steps are taken:

a. The antennas shall (1) be capable of being located at the sites designated by the Government.
b. The design shall (2) take into account the presence of a composite interference signal profile. A composite interference signal profile (composite of contributing PRFs, scan rates, pulse widths, frequencies, etc.) can be based on equipment in the high equipment density areas within CONUS.
c. The design shall (3) provide the flexibility to incorporate the recommendations of EMC analysis including one or more of the following items:

    (1) Inserting filters in the receiver equipment,
    (2) Providing adjustable transmitter and receiver frequencies in the allocated band
    (3) Augmenting the signal processing software capability,
    (4) Incorporating special rejection circuits for interference, and
    (5) Providing adjustable antenna coverage volume.

3.7.5.4 Architecture

Architectural requirements for installed equipment are detailed in the following subsections.

3.7.5.4.1 Clearances

Consoles and cabinets shall (1) be of a modular design with no unit exceeding 0.8 m x 1.2 m in plan; the vertical dimension shall (2) not exceed 2 m.

3.7.5.4.2 Access

Access to all enclosures for cabling and ventilation shall (1) be designed to allow installation on both standard and raised floor facilities. A cable access capability shall (2) be provided through the rear of the cabinet near the base, and also through the bottom surface of the cabinet. Ventilation openings shall (3) be limited to the front, rear, and top surfaces of the cabinet.

3.7.5.4.3 Human Factors

Human factors requirements for consoles and other equipment are in Section 3.3.7.

3.7.5.4.4 Telecommunications

3.7.5.4.4.1 RDA Intercom and RDA/RPG Voice Communications

The RDA shelter shall (1) include intercom capability. At a minimum, the intercom capability shall (2) provide for voice communication between the radome interior and the RDA shelter interior. The intercom system shall (3) operate independent of primary power.

All equipment, cabling, and connections shall (4) be provided. Options for UHF/VHF radios, (minimum 3002 voice grade for domestic usage) 4-wire dedicated leased line, or (minimum 3002 voice grade for domestic usage) 2-wire dialup service shall (5) be provided in the RDA shelter to facilitate communications for the primary maintaining agency and operating personnel.

3.7.5.4.4.2 RDA Data Communications

The RDA facilities, as a minimum, shall (1) support connection and equipment space, as appropriate, for either private hard-wire, private T-1, commercial T-1, private fiber optic, or private MLOS connection to allow base data transfer to the RPG and one base data user.

The characteristic circuit requirements for the RDA are as follows:

a. Commercial facilities for the base data access and control link to the RPG shall (2) support at a minimum AT&T compatible framed T-1 service at 1.544 Mbps. The same signal format is required for the private hard-wire, private T-1, private fiber optic, or private MLOS facilities.

b. Base Data User access shall (3) support at a minimum AT&T compatible framed commercial or private T-1 carrier at 1.544 Mbps.

3.7.5.4.4.2.1 Microwave-Line-of-Sight System

A microwave line-of-sight (MLOS) system shall (1) be one option to provide base data and control communications between the RDA and the RPG. The option for the microwave antennas at the radar site to be mounted either on the radar tower or on a separate tower which is not less than 200 ft from the radar tower shall (2) be provided. The MLOS system shall (3) employ a Fault Alarm System (FAS) which shall (4) monitor all MLOS major and minor alarms.

When active repeaters are used, the state and condition of the power source and MLOS repeater alarms shall (5) also be monitored. The FAS will have both audible and visual alarms. The FAS alarms shall (6) be reported at the Master System Control Function location(s). At selected sites, obstruction lighting shall (7) be provided on the MLOS towers in accordance with FAA specifications AC 70/74601F.

3.7.5.4.4.2.2 Microwave Repeaters

Microwave radio repeater sites shall (1) operate from commercial primary power. A 24 hour capacity backup battery system shall (2) be provided. Backup generator power shall (3) also be provided. This shall (4) have a seven day running capacity and shall (5) be automatically initiated after a loss of commercial power of 1 hour or greater.

After commercial power has been restored for at least 1 hour, the site shall (6) be automatically switched back to commercial power. Each change in power source shall (7) result in appropriate reporting at the FAS.

3.7.5.4.4.2.3 MLOS Facilities

MLOS antennas, reflectors, and towers shall (1) comply with EIA Standards 195C and 222E. Wind loading design for all towers shall (1a) be EIA Zone B at a minimum. In cases where a separate MLOS tower is employed at the radar, repeater, or RPG site, the option for a radio shelter shall (2) be provided to house the MLOS equipment. The radio shelter shall (3) support operation of the MLOS equipment over the range of the outdoor environmental conditions defined under Section 3.2.6.

3.7.5.4.4.3 RPG Data Communications

A communications demarcation frame with the capacity to terminate 100 pairs of telephone cable shall (1) be provided at each RPG. An appropriate multi-conductor cable with sufficient capacity to connect the maximum number of product user ports as defined in Table 3-4b shall (2) be provided from the RPG modems to the communications demarcation frame. Both ends of this cable shall (3) be appropriately marked to allow future expansion of ports.

Provisions for intrusive line testing shall (4) be included. Intrusion shall (5) allow on-line monitoring as well as the ability to break the line(s) for look-back and look-forward testing. The point of intrusive testing shall (6) be at communications/equipment racks or cabinets and shall (7) provide for easy connection of test equipment via a patch panel or other similar equipment.

Appropriate commercial/private telecommunications circuits will be provided and cross-connected, as required. There are a number of possible RPG configurations. The number and types of communication circuits required for a specific RPG site depends on the mix of product user ports served by that site, the proximity of users to the specific site, and the proximity of the RPG to the RDA. Table 3-4b specifies the minimum deployed and maximum number (full load) for each legacy data user type and the base data distribution ports. The proximity of the RDA and right of way governs choice of base data access telecommunication facilities.

The facilities, as a minimum, shall (8) support connection and equipment space, as appropriate, for either private hard-wire, private T-1, commercial T-1, private fiber optic, or private MLOS connection. The characteristic circuit requirements for the RPG support are as follows:

a. Commercial facilities for the base data access and control link shall(9) be the same as that defined for the RDA in section 3.7.5.4.4.2.

b. Base Data Users access shall(10) be the same as that defined for the Base Data Distribution Interface in Section 3.7.1.8.2.6.

c. Legacy Class 1 (56 Kbps) shall(11) support commercial 4-wire dedicated connection of minimum specification for DDS or private dedicated hardwired connection up to 300 ft according to EIA Standard RS-422/449.

d. Legacy Class 1 (14.4 Kbps minimum) shall(12) support a commercial 4-wire dedicated (or private dedicated hard-wired) connection of minimum specification 3002 voice grade.

e. Legacy Class 2 (14.4 Kbps minimum) shall(13) support a switched commercial 2-wire dial line of minimum specification 3002 voice grade.

f. Legacy Class 4 (14.4 Kbps minimum) shall(14) support either a 2-wire switched commercial dial line or a commercial 4-wire dedicated connection of minimum specification 3002 voice grade.

SUPPORT SEGMENT

3.7.6 Support Function Area

The Support functional area includes an off-line diagnostics capability, adaptation data maintenance, map generation, computer performance monitoring, test data generation capability, test software, and CM.

3.7.6.1 Off-Line Diagnostics

An off-line diagnostic capability shall (1) be provided at each maintenance and logistics support facility and within each WSR-88D System. This capability shall (2) permit isolation of faults to the LRU or group of three LRUs. Fault isolation shall (3) be manually initiated, with all manual actions requested via prompts. In addition to isolating equipment failures, the off-line diagnostic capability shall (4) verify the correct operation of the equipment after the failure has been corrected.

3.7.6.2 Support Software

The following support software capabilities are provided.

3.7.6.2.1 Adaptation Data Maintenance

Adaptation data is that data which is installation-dependent, or parameters that the system is required to use that may vary according to operational needs such as the latitude, longitude, and elevation of a site and the geographic information used to generate maps applicable to that site. Adaptation data maintenance software includes the following capabilities.

a. The capability to generate adaptation data for the entire system shall (1) be provided. It shall (2) be possible to generate any subset of the adaptation data. The adaptation software shall (3) provide the capability to store the generated data on a mass storage device.

b. The capability to accept input from an operator's console or an input file (which specifies which adaptation data to generate and how to generate it) shall (4) be provided.

c. The capability to add, modify, or delete data from the adaptation data base shall (5) be provided.

d. It shall (6) be possible to identify a particular set of adaptation data and copy it from a mass storage device.

e. The capability to make local changes to the adaptation data base for a particular facility shall (7) be provided.

f. It shall (8) be possible to merge a local adaptation data base with a more general adaptation data base and produce a single composite data base.

g. All changes and additions made to the adaptation data base shall (9) be recorded.

3.7.6.2.2 Generation

High resolution maps, including but not limited to geo-political, navigation, topography, watershed, rivers and river basins, shall (1) be provided to support positioning and analysis of WSR-88D product data. The capability shall (2) be provided to produce and maintain these maps for the RPG and PUP functional areas.

3.7.6.2.2.1 Background Map Contents

Background maps shall (1) include:

a. Political Boundaries outlining states and counties, and annotating counties. States and counties will include the same detail in both LOW and HIGH resolution. Counties will be annotated (named) only in HIGH resolution.

b. Geographic Boundaries
   (1) State Boundaries - including international treaty lines, national boundary lines (both land and water) and state lines (both land and water). The detail will be the same for both LOW and HIGH resolution.
   (2) County lines - including county lines (both land and water), corporate limits and small independent cities. The detail will be the same for both LOW and HIGH resolution.

c. Range Rings
   Low resolution - polar rings and radii spacing shall (2) be determined as a function of the product with which they may be associated. A status line shall (3) indicate the spacing of the polar rings and radii.

   High resolution - Radii spaced every 10 degrees of azimuth, and polar circles drawn every 10 nm from the RDA position. There shall (4) be tick marks every 1 nm along each radius, with emphasis on every fifth tick mark.

d. Airports
   All commercial and military airports as defined by the USGS Digital Line Graph data. The detail will be the same for both LOW and HIGH resolution.

e. Navigation Aids
   The detail will be the same for both LOW and HIGH resolution.
   (1) VHF Omni-Directional Range (VOR)
   (2) VHF Omni-Directional Range/Tactical Air Navigation (VORTAC)
   (3) VHF Omni-Directional Range/Directional Measuring Equipment (VORDME)
   (4) Non-Directional Beacon (NDB)
   (5) Instrument Landing System (ILS)

f. Radar Data Acquisition Sites
   Acronym and icon for all other active RDA sites within 250 nm range.
   The detail will be the same for both LOW and HIGH resolution.

g. City and Town Names
   Low resolution - Five large cities spaced at least 50 nm from one another, and within 125 nm range from the site.
   High resolution - three cities/towns for each county (borough, parish, census area, etc.) in each of the fifty states, and within 250 nm range of the site.

h. Special Use Airspace
   Vectorial detail will be the same for both LOW and HIGH resolution.
   Textual information will appear only on HIGH resolution.
   (1) Prohibited Areas
   (2) Restricted Areas

(3) Military Operation Areas
A PUP icon indicating the location of each PUP located on a Military installation.

(4) Warning Areas (International Waters)

I. Rivers
Rivers and streams (perennial and intermittent), centerline of water bodies, canals (navigable and other), U.S. coastlines including the Great Lakes, and permanent water bodies (lakes, reservoirs and islands).
The level of detail included in LOW and HIGH resolution is a function of data sources and software/hardware design and will be determined by the government.

j. River Basin Boundaries (Watersheds)
The level of detail included in LOW and HIGH resolution is a function of data sources and software/hardware design and will be determined by the Government.

k. Airways Including Military Refueling Zones and Training Routes
The detail will be the same for both LOW and HIGH resolution.

l. Grid Overlays
Vectorial detail will be the same for both LOW and HIGH resolution.
Vectorial detail will be the same for both LOW and HIGH resolution.
Textual information will appear only on HIGH resolution.

m. Highways
Interstate highways, major limited access highways (U.S., state and other) minor U.S. limited access highways, U.S. non-limited access highways, and state secondary highways.
The level of detail included in LOW and HIGH resolution is a function of data sources and software/hardware design and will be determined by the government.

n. County Names
A six character abbreviation for each county (borough, parish, census area, etc.) within 250 nm of the site shall (5) be included in the high-resolution map.
This applies only to sites in the 50 states.
County names will be displayed only in HIGH resolution.

o. Latitude/Longitude Tick Marks (Overseas)
For sites outside the 50 states, the background map shall (6) contain a small tick mark (plus sign) every 5 degrees of latitude and longitude on low-resolution and every degree on high-resolution.

3.7.6.2.3 Computer Performance Monitoring

A capability shall (1) be provided to record information concerning the utilization of the various system resources and to format this information into a form suitable for output such as peak and average memory or CPU utilization.

3.7.6.2.4 Test Data Generation

Test data generation software shall (1) be provided for use in developing, testing, and maintaining the WSR-88D operational software and in training WSR-88D operators, users, and maintenance personnel. The data generated shall (2) be stored in a transportable, machine readable form. The test data generation software shall (3) provide the capability to generate simulated radar data, including noise returns and echoes, and to process [Shall (4)] inputs which specify the characteristics of the test data to be generated.

3.7.6.2.5 Test Software

Test software shall (1) be provided to verify the performance of the operational software.

The test software:

1. shall (2) be operable in an interactive mode with prompting for all required inputs.
2. shall (3) be operable in an automatic mode requiring minimum operator action.
3. shall (4) generate formatted output products that show the responses associated with each input and the cumulative results for each test.
4. shall (5) include data samples that are both within and outside the range specified for the function under test.
5. shall (6) be subject to the same quality control procedures as the operational software.

3.7.6.2.6 Configuration Management

Software tools and appropriate hardware platforms shall (1) be available to support hardware and software configuration management (CM).

4 QUALITY ASSURANCE

This Quality Assurance section establishes the Test and Evaluation (T&E) requirements for the WSR-88D System.

4.1 Scope of Test and Evaluation

Quality Assurance T&E includes Computer Program Test and Evaluation (CPT&E), Development Test and Evaluation (DT&E), System Test, Operational Test and Evaluation (OT&E), and Beta Test and Evaluation. CPT&E is that testing conducted during development of the software at the module, Computer Program Component (CPC), and Computer Program Configuration Item (CPCI) levels. This testing is progressive and ensures that the smallest elements of the software are functional as they are integrated together into working components performing specific functions and ultimately integrated into functioning CPCIs.

DT&E is that T&E required during the development of planned product improvements of the WSR-88D System to satisfy the user agencies that the baseline requirements have been met. DT&E is formal testing that covers all functional areas within the system, all configuration items of hardware and software (including firmware), all internal and external interfaces, and all automatic test equipment hardware and software. DT&E shall consist of hardware qualification testing, hardware integration testing, and software development testing and evaluation.

A System Test is the first level of formal test where qualified and integrated software subsystems are tested as a complete operational configuration. The software and/or hardware is put under control of the Configuration Management Section. The System Test should thoroughly test the WSR-88D functionality, verify the system is stable over time, and measure system performance. OT&E is that T&E which evaluates the operational effectiveness and suitability of the WSR-88D system in its operational environment.

Beta Testing is that T&E which evaluates the WSR-88D System for use in its operational environment by field personnel. This differs from Operational Testing in that operational tests are conducted by the Radar Operations Center (ROC) test organization in a controlled operational environment, while Beta testing is conducted at field sites and includes a period of testing through use, when field sites use the new product to perform their forecast and warning missions. Major upgrades to the WSR-88D System shall be tested in accordance with approved test plans. Testing for planned product improvements such as the Open Systems development will be defined in a master test plan.

4.1.1 **General Test Requirements**

The following general test requirements are common to all parts of the NEXRAD T&E. The ROC shall satisfy these requirements in the preparation of the detailed test documentation defined herein and in the conduct of the required tests.

1. The ROC is required to update test documentation to reflect changes in test requirements that result from changes to the baseline requirements.
2. The ROC shall provide all test documentation defined herein, all test inputs, all test software, all test instrumentation (properly calibrated), and all test personnel resources needed for testing, unless specifically stated otherwise in this document.
3. Successful completion of software and hardware tests will be used to mark particular milestones and to gauge progress.
4. Pretest inspections shall be required prior to each test. The test inspections shall ensure that the test configuration is in accordance with approved test procedures, that the equipment and software are at the correct revision level, and that prior deficiencies or discrepancies have been corrected. The test inspections shall also ensure that all test documentation and test equipment are available.
5. The configuration for each test shall be identified by the ROC in the test plans. Selection of the test configuration shall be supported by reliability/availability data and proof that all equipment, software, and interfaces will be exercised.
6. Completion of tests defined herein shall not in any way void the warranty and latent defect clauses nor waived requirements for delivery of a compliant system.
7. The ROC may, at its discretion, require retest of previously completed tests where it is judged that correction of a deficiency may affect the results of prior testing. However, for Commercial-Off-The-Shelf equipment (unmodified for the WSR-88D system), retest shall not be required for alternate (both earlier and later) revisions or part number changes that do not affect form, fit, or function to the same vendor commercial equipment when such changes were not implemented to correct a deficiency identified in prior WSR-88D testing. In such a case, verification shall be made that the other version of the equipment meets all applicable WSR-88D requirements.

4.1.2 **Documentation Requirements**

4.1.3 **Test Plans**

The ROC shall submit a test plan for each of the program phases. The test plans shall describe in specific terms how the requirements of the specifications shall be satisfied. The test plans shall serve as the basis for preparation of the test procedures.

4.1.4 **Test Procedures**

The ROC shall submit detailed test procedures based on the specified test requirements. Separate test procedures shall be submitted for each major test to be performed as defined in the approved test plans.

4.1.5 **Test Data Sheets**

The ROC shall provide data sheets consistent with the test. The test data sheets will be used by the personnel conducting and witnessing the tests to record the results of each step defined in the test procedure.

4.1.6 **Test Results**

The ROC shall provide test logs and test reports to document the results of tests.

4.1.7 **Test Logs**

The ROC shall maintain a test log (test record) during conduct of all WSR-88D tests. The test log shall, as a minimum, contain:

1. Results of pretest inspections,
2. Exceptions to approved test procedures and test configurations,
3. Start and completion times of tests,
4. Test anomalies, including unexpected test results or equipment failures,
5. Corrections taken to fix test anomalies,
6. Results of retesting performed to verify corrective actions, and
7. Test procedure paragraph reference and the date and time of entry.

4.1.8 **Test Reports**

The ROC shall provide copies of the completed test data sheets and test logs, along with a summary of test results, shall be provided.

4.1.9 **Other Test Documentation**

The ROC shall provide other documents, listings, and supporting data required to document the results of the WSR-88D tests.

4.2 Development Phase T&E

The Development Phase DT&E shall include the following test categories:

1. Configuration Item Reliability Predictions
2. Configuration Item Performance Tests
3. Computer Program Configuration Item Tests
4 DT&E Functional Tests

The tests shall be based on plans and procedures developed by the ROC.

4.2.1 **Configuration Item Reliability Predictions**

The ROC shall provide reliability predictions of the Configuration Items (CIs). The CI reliability predictions shall use documented failure rate data. Failure rate data for parts and circuits which are not documented shall be validated by statistical analysis of other data sources. For CI reliability prediction:

1. Predictions for commercial off the shelf equipment shall be based upon the manufacturer's detailed historical failure data or test data. If such data is not available, the predictions shall be based on the performance and experience with similar equipment.

2. For purposes of predicted reliability analysis, 40°C shall be used as the mean ambient air temperature external to CIs not requiring air conditioning.

3. For CIs requiring air conditioning, 25°C shall be used as the mean ambient air temperature external to the CIs.

4. Fixed ground equipment factors, as defined in MIL HDBK 217, shall be used in any analytical model that may be produced.

4.2.2 **Configuration Item Performance Tests**

CI performance tests shall be conducted based on test procedures prepared in accordance with the CI development specifications. The results of the CI performance tests shall be recorded in Software Development Files (SDFs).

4.2.3 Computer Program Configuration Item Tests

The testing of operational and support Computer Program Configuration Items (CPCIs) shall be in accordance with the Software Test Description (STD). As a minimum, these tests shall ensure that all boundary and out of range data input conditions are tested. Included shall be tests of each CPCI, tests of the interfaces between CPCIs, and a load test. The CPCI tests shall verify performance, and shall include verification of all switch actions, displays, and manual inputs associated with each CPCI. The test of interfaces between CPCIs shall be based on a scenario which demonstrates compatibility of CPCIs. The load test shall verify, in normal and full load conditions, the response time requirements specified in Section 3.2.1.1. The results of the CPC tests shall be recorded in Software Development Files (SDFs). Tests shall be provided for the following functional areas:

1. The RDA CPCI tests shall verify all applicable requirements specified in Section 3.7.1 and the more detailed functional requirements of the Computer Program Development Specifications. The operability of the RDA functional area in all configurations shall be demonstrated.

2. The RPG CPCI tests shall verify all applicable requirements in Section 3.7.2 and the more detailed functional requirements of the Computer Program Development Specification. The operability of the RPG functional area in all configurations shall be demonstrated.

3. The PUP CPCI tests shall verify all applicable requirements in Section 3.7.3 and the more detailed functional requirements of the Computer Program Development Specifications. The operability of the PUP functional area in all configurations shall be demonstrated.

4.2.4 DT&E Functional Tests

The ROC shall perform functional string reliability tests, functional area performance tests, maximum configuration tests, environmental tests, and human engineering tests as defined in the following sections.

4.2.5 Performance Tests

Testing of each functional area shall be performed to verify that functional area performance satisfies the requirements of this document.

4.2.6 **RDA Performance Tests**

The RDA performance shall consist of a series of tests using the operating parameters established for the site, and using live and recorded weather data. The ROC shall perform tests to verify the performance of the radar and its associated signal processor in the presence of ground clutter and various weather phenomena.

4.2.7 **RPG Performance Tests**

The RPG performance tests shall demonstrate that, under full load conditions, all requirements of this document are met.

4.2.8 **PUP Performance Tests**

The PUP performance tests shall demonstrate that, under full load conditions, all requirements of this document are met.

4.2.9 **Environmental Tests**

Survivability and performance requirements of the operating and nonoperating environmental conditions specified in Section 3.2.6 shall be demonstrated by the ROC. The test facilities for environmental testing shall be adequate to accommodate all of the equipment in each functional area except the radar antenna and pedestal. Environmental testing shall be performed in accordance with MIL STD 810 and MIL STD 462. For commercial off the shelf equipment, environmental testing shall be based upon the manufacturer's detailed environmental testing data.

4.2.10 **Human Engineering Tests**

Tests and demonstrations for equipment not exempted by this document shall be conducted on appropriate combinations of equipment items to verify that the requirements of Section 3.3.7 have been met.

4.3 System Tests

The System Test shall thoroughly test the CPCI functionality, verify the system is stable over time, and measure system performance.

4.3.1 **Functional Area Interface Tests**

Functional area interface tests shall be performed which demonstrate that the designs of the functional areas of the WSR-88D Unit are compatible and that they interface properly. The functional area interface tests shall provide for communications testing to demonstrate that the communications requirements of this document have been satisfied. Digital data channels between sites performing RDA, RPG, and PUP functions shall be demonstrated to meet specified limits. Communications interfaces external to the WSR-88D Unit shall also be tested.

4.3.2 **Communications Functional Area Tests**

Communications functional area performance tests shall be conducted to demonstrate that under full load conditions, all requirements of this document are met.

4.3.3 **System Performance Tests**

System level performance tests shall be conducted under full load conditions to demonstrate that the system level performance requirements of Section 3.2.1 have been met. The demonstration of system level performance by a combination of test, simulation and analysis is permitted.

4.3.4 **Maintainability Test and Evaluation**

The maintainability requirements of Section 3.2.4 shall be verified by a maintainability prediction and by a maintainability demonstration.

4.3.4.1 Maintainability Prediction

An MTTR and MDT prediction shall be made.

4.3.4.2 Maintainability Testing

A maintainability demonstration shall be performed on the system, to verify that the maintainability requirements specified in Section 3.2.4 have been met. Maintainability testing shall not start until the predicted MTTRs and MDTs are shown to be equal to or less than the required values. All maintenance fault isolation aids which are provided shall be verified prior to this test.

Maintainability testing shall be done in accordance with Test Method 9 of MIL STD 471A using a consumer risk of twenty percent. The test procedures shall include the list of faults that might be introduced into the equipment, the rationale for the selection of numbers and types of faults for the test, and the procedures to be used. The maintainability demonstration shall be performed using techniques found in the maintenance manuals. The number and type of faults in the list shall take into consideration the mean time between failures, the estimated mean time to repair, and the kinds of components within each piece of equipment so that the list will be representative of the variety of failures that can occur in the system and the maintenance procedures required for repair of failures in accordance with Appendix A of MIL STD 471A. The fact that the system has redundant equipment shall not be a consideration either in selecting or in correcting the faults. The test shall be performed under conditions closely simulating the actual operational conditions. On line and off line maintenance diagnostic software and operational system maintenance procedures and concepts shall be used in the tests. Maintainability demonstrations shall also be performed on special and nonstandard test equipment used to isolate component failures on printed circuit boards, memories, power supplies, and other replaceable items.

4.3.5 **Maximum Unexpanded Full Configuration Test**

It shall be demonstrated that the WSR-88D RPG and PUP functional areas can meet the narrowband communication line configuration unexpanded limit requirements specified in paragraphs 3.2.1.8, 3.7.2.5.13 and 3.7.3.6.6. This shall be accomplished by functionally exercising up to 8 lines in each line class, concurrently.

4.3.6 **Maximum Full Expansion Configuration Test**

It shall be demonstrated that the WSR-88D RPG and PUP functional areas can meet the narrowband communication line configuration expanded limit requirements specified in paragraphs 3.2.1.8, 3.7.2.5.13 and 3.7.3.6.6. This shall be accomplished by functionally exercising up to 8 lines in each line class, concurrently.

4.3.7 **System Functionality Tests**

Functionality tests at the System Test level shall include the following:

1. Boundary value or limits test
2. Syntax tests
3. State transition tests
4. Valid and invalid data input (error handling)
5. User guide procedures

4.3.8 **Stability Tests**

Stability tests shall be used to evaluate how well the system remains operating over time, how well it operates when various faults are introduced, and how well the system handles stressful operating loads or configurations.

4.4 Operational Test and Evaluation (OT&E)

Operational Test and Evaluation (OT&E) shall evaluate the operational effectiveness and suitability of the WSR-88D in a simulated operational environment. The focus of OT&E is on the complete system, including installation instructions, system documentation, and training materials. The test is planned by Radar Operations Center (ROC) meteorologists and electronics technicians trained in testing and executed at the ROC by field users (operational and maintenance) representing all three agencies. Operational scenarios applicable to the three agencies (developed by the ROC) will be executed by appropriate agency representatives using the ROC WSR-88D test bed. These scenarios will be designed to verify that field users can perform their forecast and warning missions using the WSR-88D system. Other objectives of OT&E are to verify (in a simulated operational environment):

4. Software installation instructions.
5. Stability of the software.
6. Functionality of the PUP and MSCF.
7. Narrowband and Wideband communications stability.
8. Documentation is correct.
9. Training materials are both thorough and correct.

4.5 Beta Test and Evaluation (BT&E)

Beta Test and Evaluation shall be planned by Radar Operations Center (ROC) meteorologists and electronics technicians and conducted by field personnel at operational field sites. Beta Test and an associated Beta Use period are the last steps in determining whether proposed systems (hardware, software, procedures, and documentation) meet criteria for implementation at agency sites. Beta Test is conducted jointly by ROC personnel and site personnel. The Beta Use period begins after ROC personnel leave the site and lasts from 14-30 days. BT&E will verify that:

1. The system meets operational requirements of the agencies.
2. The system is compatible with existing agency communications and computer-based equipment and does not have an adverse impact on its capabilities, performance, or operations.
3. The system includes adequate documentation (e.g., installation instructions, user documentation, reference manuals, and technical manuals).
4. The system can survive handling, installation, and the operational environment.
5. The system operates under certain configurations that cannot be easily simulated using the ROC WSR88-D test bed.

Table 4-1 REQUIREMENT/VERIFICATION CROSS-REFERENCE MATRIX

Section 3 Requirement	Method	Class	Section 4 Verification
3.2.1.1(1)	2-Demo	2-DT&E	4.2.3, 4.2.4.1
3.2.1.1(2)	2-Demo	2-DT&E	4.2.3, 4.2.4.1
3.2.1.1(3)	4-Test	2-DT&E 3-SYSTEM	4.2.3, 4.2.4.1, 4.3.3
3.2.1.1(4)	2-Demo	2-DT&E 3-SYSTEM	4.2.3, 4.2.4.1,4.3.3
3.2.1.1(5)	2-Demo	2-DT&E 3-SYSTEM	4.2.3, 4.2.4.1, 4.3.3
3.2.1.1(6)	4-Test	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(7)	4-Test	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(8)	4-Test	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(10)	4-Test	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(11)	4-Test	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(12)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(13)	2-Demo	3-SYSTEM	4.2.3,4.3.3
3.2.1.1(14)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(15)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(16)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4.1,4.3.3
3.2.1.1(17)	2-Demo	3-SYSTEM	4.2.3,4.3.3
3.2.1.1(18)	4-Test	3-SYSTEM	4.2.3,4.3.3
3.2.1.1(19)	4-Test	3-SYSTEM	4.2.3,4.3.3
3.2.1.1(21)	2-Demo 4-Test	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.2.1.1(22)	2-Demo	3-SYSTEM	4.3.3
3.2.1.1(23)	4-Test	2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.2.1.1(24)	4-Test	2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
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3.2.1.2(2)	2-Demo	2-DT&E 3-SYSTEM	4.2.4, 4.3.3
3.2.1.2(3)	2-Demo	2-DT&E 3-SYSTEM	4.2.4, 4.3.3
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3.2.1.3(1)	4-Test	2-DT&E 3-SYSTEM	4.2.4, 4.3.3
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3.2.1.3.1(1)	2-Demo	2-DT&E	4.2.4, 4.3.3
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3.2.1.3.1(3)	2-Demo	2-DT&E	4.2.4
3.2.1.3.2(1)	2-Demo	2-DT&E	4.2.4
3.2.1.3.3(1)	2-Demo	2-DT&E	4.2.4
3.2.1.3.4(1)	2-Demo	2-DT&E	4.2.4
3.2.1.3.4(2)	2-Demo	2-DT&E	4.2.4
3.2.1.3.5(1)	2-Demo	2-DT&E	4.2.4

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3.2.1.3.7(1)	2-Demo	2-DT&E	4.2.4
3.2.1.3.7(2)	2-Demo	2-DT&E	4.2.4
3.2.1.3.8(1)	2-Demo	1-CPT&E 2-DT&E	4.2.4
3.2.1.3.8(2)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.4
3.2.1.3.9(1)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
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3.2.1.3.9(3)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	
3.2.1.3.10(1)	4-Test	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.2.1.3.11(1)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.2.1.3.12(1)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.2.1.3.13(1)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.2.1.3.14(1)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
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3.2.1.3.16(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.2.1.3.17(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.2.1.5(2)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.2.1.5.1(4)	2-Demo	3-SYSTEM	4.3.3
3.2.1.5.1(5)	2-Demo	3-SYSTEM	4.3.3
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3.2.1.5.1(7)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
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3.2.1.7(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.2.1.7.1(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.2.1.7.2(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.2.2(1)	3-Exam	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.2.3.1 (1)			
3.2.4.1(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.4.1(2)	1-Analysis	3-SYSTEM	4.3.3
3.2.4.1(3)	1-Analysis	3-SYSTEM	
3.2.5.1.1(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.2(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.2(2)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.2(3)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.2(4)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.3(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.3(2)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.3(3)	1-Analysis	3-SYSTEM	4.3.3
3.2.5.1.3(4)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.1(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.1(2)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.1(3)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.2(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.2(2)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.3 (1)			
3.2.6.4(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.5(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.6(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.7(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.8(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.8(2)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.9(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.10(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.11(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.12(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.6.12 (2)			
3.2.6.12.5(1)	1-Analysis	3-SYSTEM	4.3.3
3.2.7(1)	3-Exam	3-SYSTEM	4.3.3
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3.3.1.2(1)	1-Analysis	3-SYSTEM	4.3.3
3.3.1.2(2)	1-Analysis	3-SYSTEM	4.3.3
3.3.1.2(3)	1-Analysis	3-SYSTEM	4.3.3
3.3.1.2(4)	1-Analysis	3-SYSTEM	4.3.3
3.3.1.2(5)	1-Analysis	3-SYSTEM	4.3.3
3.3.1.3(1)	1-Analysis	2-DT&E	4.2.4
3.3.1.3(2)	1-Analysis	2-DT&E	4.2.4
3.3.1.4(1)	3-Exam	2-DT&E	4.2.4
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3.3.6(4)	1-Analysis	2-DT&E	4.2.4
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3.3.7.1.2(3)	3-Exam	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.3.7.2(2)	3-Exam	3-SYSTEM	4.3.3
3.3.7.2(3)	3-Exam	3-SYSTEM	4.3.3
3.3.7.2(4)	3-Exam	3-SYSTEM	4.3.3
3.3.7.2(5)	3-Exam	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.3.8.1(1)	3-Exam	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.3.8.1(2)	3-Exam	1-CPT&E	4.2.3,4.2.4

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3.3.8.3.2(1)	3-Exam	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.3.8.3.2(2)	3-Exam	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.3.8.4(1)	3-Exam	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.3.10(1)	3-Exam	1-CPT&E 2-DT&E	4.2.3,4.2.4
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3.4.2.1(1)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
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3.7.1.1.1(3)	4-Test	1-CPT&E	4.2.3
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3.7.1.2(1)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.2(2)	2-Demo	1-CPT&E	4.2.3
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3.7.1.2(5)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.3(1)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.7.1.3.1(1)	2-Demo	2-DT&E	4.2.4
3.7.1.3.1(2)	2-Demo	2-DT&E	4.2.4
3.7.1.3.2(1)	2-Demo	2-DT&E	4.2.4
3.7.1.3.2(2)	2-Demo	2-DT&E	4.2.4
3.7.1.3.2(3)	2-Demo	2-DT&E	4.2.4
3.7.1.3.2(4)	2-Demo	2-DT&E	4.2.4
3.7.1.3.2(5)	2-Demo	2-DT&E	4.2.4
3.7.1.4(1)	2-Demo	2-DT&E	4.2.4
3.7.1.4(2)	2-Demo	2-DT&E	4.2.4
3.7.1.5(1)	2-Demo	2-DT&E	4.2.4
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3.7.1.6.1(1)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
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3.7.1.6.1(6)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.1(7)	2-Demo	2-DT&E	4.2.3,4.2.4,4.3.3
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3.7.1.6.1.2(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.1.2(3)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
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3.7.1.6.2(3)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.2(4)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
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3.7.1.6.3.1(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.3.1(2)	2-Demo	2-DT&E	4.2.4,4.3.3

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3.7.1.6.3.1(4)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.3.1(5)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.3.1(6)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.3.1(7)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.3.2(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.7.1.6.3.2(7)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
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3.7.1.6.4.1(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
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3.7.1.6.4.3(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.7.1.6.4.7.1(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.7.1(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.7.1(3)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.7.2(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.8(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.8(2)	2-Demo	1-CPT&E	4.2.3,4.2.4

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		3-SYSTEM	
3.7.1.6.4.9(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.9(2)	2-Demo	1-CPT&E	4.2.3
3.7.1.6.4.9(3)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.9(4)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.9(5)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.9(6)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.10(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.10(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.10(3)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.11(1)	4-Test	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.12(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.12(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4
3.7.1.6.4.13(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.14(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.15(1)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.15(2)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.15(3)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.15(4)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.16(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.16(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.16(3)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.1.6.4.17(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.17(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.17(3)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.17(4)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.17(5)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.17(6)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.18(1)	4-Test	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3

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3.7.1.6.4.18(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.18(3)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.18(4)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.18(5)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.19(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.20(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.20(2)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.21(1)	2-Demo	1-CPT&E 3-SYSTEM	4.2.3,4.3.3
3.7.1.6.4.22(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.6.4.22(2)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.7(1)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.7(2)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.1(1)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.1(1)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.1(2)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.1(3)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.1(4)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.1(5)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.1(6)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.1(7)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.1.2(1)	2-Demo 4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.1(1)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.1(2)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.1(3)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.2(1)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.2(2)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.2(3)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.2(4)	2-Demo 4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.3(1)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.3(2)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.3(3)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.3(4)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.4(1)	1-Analysis 2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.4(2)	1-Analysis 4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.4(3)	1-Analysis 2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.5(1)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.5(2)	4-Test	2-DT&E	
3.7.1.8.2.6(1)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.6(2)	2-Demo	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.6(3)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.8.2.6(4)	4-Test	2-DT&E	4.2.4,4.3.1
3.7.1.9(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.9(2)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.9(3)	2-Demo	2-DT&E	4.2.4,4.3.3

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		3-SYSTEM	
3.7.1.9(4)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.1.9(5)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.2.1.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.5(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.5(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.5(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.5(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.5(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.1.5(6)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.1.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.1.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.1.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.1.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.1.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.2.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.1.3(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.2.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.2.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.2.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.3.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.4(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.2.4(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(1)	2-Demo	3-SYSTEM	4.3.3

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3.7.2.3.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(6)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(7)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(8)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(9)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.2(10)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.4.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.1(5)	2-Demo	3-SYSTEM	
3.7.2.3.5.1(6)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.1(7)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.3.5.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.3(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.3 (6)			
3.7.2.4.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.5.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.5.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.5.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.5.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.5.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.5.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.4.5.2 (4)			
3.7.2.5(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.5(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.5(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.6(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.6(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.6(3)	2-Demo	3-SYSTEM	4.3.3

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3.7.2.6(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.6(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.6(6)	2-Demo	3-SYSTEM	4.3.3
3.7.2.6(7)	2-Demo	3-SYSTEM	4.3.3
3.7.2.6(8)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.1(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.2(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.7.2(6)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.1(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.2(1)			
3.7.2.8.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.2(5)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.2(7)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.8.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.9(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.9(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.9(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.10(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.10(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.10(3)			
3.7.2.11(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(3)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(4)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11 (5)			
3.7.2.11(6)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(7)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(8)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(9)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(10)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(11)	2-Demo	3-SYSTEM	4.3.3
3.7.2.11(12)			
3.7.2.12(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.12(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.13(1)	2-Demo	3-SYSTEM	4.3.3
3.7.2.13(2)	2-Demo	3-SYSTEM	4.3.3
3.7.2.13(3)	2-Demo	3-SYSTEM	4.3.3
3.7.3(1)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.7.3(2)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4

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3.7.3.1.1(2)	4-Test	1-CPT&E	4.2.3
3.7.3.1.1(3)	4-Test	1-CPT&E	4.2.3
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3.7.3.2(5)	4-Test	2-DT&E	4.2.4
3.7.3.3(1)	4-Test	2-DT&E	4.2.4
3.7.3.3(2)	4-Test	2-DT&E	4.2.4
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3.7.3.3.1.1(2)	4-Test	2-DT&E	4.2.4
3.7.3.3.2(1)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
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3.7.3.4.1(4)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.3.4.1(5)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.3.4.1(6)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.7.3.4.3(2)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.7.3.4.6.2(2)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.3.4.6.2(3)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
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3.7.3.4.7(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4
3.7.3.4.7(2)	2-Demo	2-DT&E 3-SYSTEM	
3.7.3.4.7(3)	2-Demo	2-DT&E 3-SYSTEM	
3.7.3.4.9.1(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.3.4.9.1(2)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
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3.7.3.4.9.2(4)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
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3.7.3.4.11(1)	4-Test	1-CPT&E	4.2.3
3.7.3.4.11(2)	2-Demo	1-CPT&E	4.2.3
3.7.3.4.12(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4
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3.7.3.4.15(1)	2-Demo	1-CPT&E	4.2.3
3.7.3.4.15(2)	2-Demo	1-CPT&E	4.2.3
3.7.3.4.15(3)	2-Demo	1-CPT&E	4.2.3
3.7.3.4.16(1)	2-Demo	1-CPT&E	4.2.3
3.7.3.4.16(2)	2-Demo	1-CPT&E	4.2.3
3.7.3.4.16(3)	2-Demo	1-CPT&E	4.2.3
3.7.3.5.1(1)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4
3.7.3.5.1(2)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4
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3.7.3.5.1(4)	2-Demo	2-DT&E 3-SYSTEM	4.2.3,4.2.4
3.7.3.5.1(5)	2-Demo	2-DT&E	4.2.3,4.2.4

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3.7.3.5.2(2)	2-Demo	1-CPT&E	4.2.3
3.7.3.5.2(3)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.7.3.5.2(4)	2-Demo	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.7.3.6(1)	2-Demo	1-CPT&E	4.2.3
3.7.3.6(2)	2-Demo	1-CPT&E	4.2.3
3.7.3.6(3)	2-Demo	1-CPT&E	4.2.3
3.7.3.6(4)	3-Exam	1-CPT&E	4.2.3
3.7.3.6(5)	1-Analysis	2-DT&E	4.2.4
3.7.3.6(6)	1-Analysis	2-DT&E	4.2.4
3.7.3.6(7)	2-Demo	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.3.6(8)	1-Analysis	2-DT&E 3-SYSTEM	4.2.4,4.3.3
3.7.3.7.1(1)	1-Analysis	2-DT&E	4.2.3
3.7.3.8(1)	1-Analysis	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.3.8(2)	1-Analysis	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.3.8.1(1)	4-Test	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.7.3.8.1(2)	4-Test	1-CPT&E	4.2.3
3.7.3.8.1(3)	4-Test	1-CPT&E	4.2.3
3.7.3.8.2(1)	1-Analysis	1-CPT&E	4.2.3
3.7.3.8.2(2)	1-Analysis	1-CPT&E	4.2.3
3.7.3.8.2(3)	1-Analysis	1-CPT&E	4.2.3
3.7.3.8.2(4)	2-Demo	1-CPT&E 2-DT&E 3-SYSTEM	4.2.3,4.2.4,4.3.3
3.7.3.8.3(1)	1-Analysis	1-CPT&E	4.2.3
3.7.3.8.3(2)	1-Analysis	1-CPT&E	4.2.3
3.7.3.8.3(3)	1-Analysis	1-CPT&E 2-DT&E	4.2.3,4.2.4
3.7.4.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.1(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.1(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.1(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.1(4)	2-Demo	3-SYSTEM	4.3.3

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3.7.4.1.3.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.3(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.3(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.3.3(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.4(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.4(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.4(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.4(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.4(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.1.4(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.1(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.1.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.2.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(8)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3(9)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.1(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.1(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(8)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(9)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.2.2(10)	2-Demo	3-SYSTEM	4.3.3

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3.7.4.3.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.3(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.3(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.3(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.4.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.5(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.5(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.5(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.5(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.5(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.5(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.6(8)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.2(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.3(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.3.7.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.4(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.4(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.5.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.5.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.5.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.5.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.5.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.1(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.1(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.1(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.1(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.1(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.2(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.2(2)	2-Demo	3-SYSTE	4.3.3
3.7.4.6.2(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.2(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.2(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.3(1)	2-Demo	3-SYSTEM	4.3.3

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3.7.4.6.3(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.3(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.3(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.4(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.4(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.4(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.5(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.5(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.5(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.6(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.7(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.6.7(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(8)	2-Demo	3-SYSTEM	4.3.3
3.7.4.7(9)	2-Demo	3-SYSTEM	4.3.3
3.7.4.8(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.8(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.8(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.8(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.8 (5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.9(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.9(2)	2-Demo	3-SYSTEM	4.33
3.7.4.9(3)	2-Demo	3-SYSTEM	4.3.
3.7.4.9(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.9(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.9(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.9(7)	2-Demo	3-SYSTEM	4.3.3
3.7.4.10(1)	2-Demo	3-SYSTEM	4.3.3
3.7.4.10(2)	2-Demo	3-SYSTEM	4.3.3
3.7.4.10(3)	2-Demo	3-SYSTEM	4.3.3
3.7.4.10(4)	2-Demo	3-SYSTEM	4.3.3
3.7.4.10(5)	2-Demo	3-SYSTEM	4.3.3
3.7.4.10(6)	2-Demo	3-SYSTEM	4.3.3
3.7.4.10(7)	2-Demo	3-SYSTEM	4.3.3
3.7.5(1)	3-Exam	5-BETA	
3.7.5(2)	3-Exam	5-BETA	
3.7.5(3)	3-Exam	5-BETA	
3.7.5(4)	3-Exam	5-BETA	
3.7.5.1(1)	3-Exam	5-BETA	
3.7.5.2(1)	3-Exam	5-BETA	
3.7.5.2.1(1)	3-Exam	5-BETA	
3.7.5.2.1(2)	3-Exam	5-BETA	
3.7.5.2.1(3)	3-Exam	5-BETA	
3.7.5.2.1(4)	3-Exam	5-BETA	
3.7.5.2.1(5)	3-Exam	4-OT&E	
3.7.5.2.1(6)	1-Analysis	5-BETA	
3.7.5.2.1(7)	1-Analysis	5-BETA	
3.7.5.2.1(8)	2-Demo	5-BETA	
3.7.5.2.2(1)	1-Analysis	5-BETA	
3.7.5.2.2(2)	1-Analysis	5-BETA	
3.7.5.2.3(1)	1-Analysis	5-BETA	
3.7.5.2.3(2)	1-Analysis	4-OT&E	
3.7.5.2.3(3)	1-Analysis	5-BETA	
3.7.5.2.3(4)	1-Analysis	5-BETA	

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3.7.5.2.4(1)	1-Analysis	2-DT&E 5-BETA	
3.7.5.2.4(2)	1-Analysis	2-DT&E 5-BETA	
3.7.5.2.4(3)	1-Analysis	2-DT&E 5-BETA	
3.7.5.2.5(1)	3-Exam	NA	
3.7.5.2.6(1)	1-Analysis	NA	
3.7.5.2.6(2)	3-Exam	NA	
3.7.5.2.6(3)	3-Exam	NA	
3.7.5.3.2(1)	1-Analysis	3-SYSTEM 5-BETA	
3.7.5.3.2(2)	3-Exam	NA	
3.7.5.3.2(3)	3-Exam	NA	
3.7.5.3.3(1)	1-Analysis	5-BETA	
3.7.5.3.3(2)	1-Analysis	5-BETA	
3.7.5.3.3(3)	1-Analysis	5-BETA	
3.7.5.4.1(1)	3-Exam	5-BETA	
3.7.5.4.1(2)	3-Exam	5-BETA	
3.7.5.4.2(1)	3-Exam	NA	
3.7.5.4.2(2)	3-Exam	NA	
3.7.5.4.2(3)	3-Exam	NA	
3.7.5.4.4.1(1)	3-Exam	5-BETA	
3.7.5.4.4.1(2)	3-Exam	5-BETA	
3.7.5.4.4.1(3)	3-Exam	5-BETA	
3.7.5.4.4.1(4)	3-Exam	5-BETA	
3.7.5.4.4.1(5)	3-Exam	5-BETA	
3.7.5.4.4.2(1)	3-Exam	5-BETA	
3.7.5.4.4.2(2)	3-Exam	4-OT&E	
3.7.5.4.4.2(3)	3-Exam	5-BETA	
3.7.5.4.4.2.1(1)	3-Exam	5-BETA	
3.7.5.4.4.2.1(2)	3-Exam	5-BETA	
3.7.5.4.4.2.1(3)	3-Exam	5-BETA	
3.7.5.4.4.2.1(4)	3-Exam	5-BETA	
3.7.5.4.4.2.1(5)	3-Exam	5-BETA	
3.7.5.4.4.2.1(6)	3-Exam	5-BETA	
3.7.5.4.4.2.1(7)	3-Exam	5-BETA	
3.7.5.4.4.2.2(1)	3-Exam	5-BETA	
3.7.5.4.4.2.2(2)	3-Exam	5-BETA	
3.7.5.4.4.2.2(3)	3-Exam	5-BETA	
3.7.5.4.4.2.2(4)	3-Exam	5-BETA	
3.7.5.4.4.2.2(5)	3-Exam	3-SYSTEM 5-BETA	
3.7.5.4.4.2.2(6)	3-Exam	3-SYSTEM 5-BETA	
3.7.5.4.4.2.2(7)	3-Exam	3-SYSTEM 5-BETA	
3.7.5.4.4.2.3(1)	3-Exam	5-BETA	
3.7.5.4.4.2.3(1a)	3-Exam	5-BETA	
3.7.5.4.4.2.3(2)	3-Exam	5-BETA	
3.7.5.4.4.2.3(3)	3-Exam	5-BETA	
3.7.5.4.4.3(1)	3-Exam	5-BETA	
3.7.5.4.4.3(2)	3-Exam	5-BETA	
3.7.5.4.4.3(3)	3-Exam	2-DT&E 5-BETA	
3.7.5.4.4.3(4)	3-Exam	5-BETA	
3.7.5.4.4.3(5)	3-Exam	5-BETA	
3.7.5.4.4.3(6)	3-Exam	5-BETA	
3.7.5.4.4.3(7)	3-Exam	2-DT&E 5-BETA	
3.7.5.4.4.3(8)	3-Exam	5-BETA	

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3.7.5.4.4.3(9)	3-Exam	5-BETA	
3.7.5.4.4.3(10)	2-Demo	5-BETA	
3.7.5.4.4.3(11)	2-Demo 3-Exam	2-DT&E 3-SYSTEM	
3.7.5.4.4.3(12)	2-Demo 3-Exam	2-DT&E 3-SYSTEM	
3.7.5.4.4.3(13)	2-Demo 3-Exam	2-DT&E 3-SYSTEM	
3.7.5.4.4.3(14)	2-Demo 3-Exam	2-DT&E 3-SYSTEM	
3.7.6.1(1)	2-Demo	2-DT&E 4-OT&E	
3.7.6.1(2)	2-Demo	2-DT&E	
3.7.6.1(3)	2-Demo	2-DT&E	
3.7.6.1(4)	2-Demo	2-DT&E	
3.7.6.2.1(1)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(2)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(3)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(4)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(5)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(6)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(7)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(8)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.1(9)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.2(1)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.2(2)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.2.1(1)	3-Exam	2-DT&E 3-SYSTEM	
3.7.6.2.2.1(2)	3-Exam	2-DT&E 3-SYSTEM	
3.7.6.2.2.1(3)	3-Exam	2-DT&E 3-SYSTEM	
3.7.6.2.2.1(4)	3-Exam	2-DT&E 3-SYSTEM	
3.7.6.2.2.1(5)	3-Exam	2-DT&E 3-SYSTEM	
3.7.6.2.2.1(6)	3-Exam	2-DT&E 3-SYSTEM	
3.7.6.2.3(1)	3-Exam	2-DT&E 3-SYSTEM	
3.7.6.2.4(1)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.4(2)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.4(3)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.4(4)	2-Demo	2-DT&E 3-SYSTEM	
3.7.6.2.5(1)	2-Demo 3-Exam	1-CPT&E	
3.7.6.2.5(2)	2-Demo	1-CPT&E	

Section 3 Requirement	Method	Class	Section 4 Verification
	3-Exam		
3.7.6.2.5(3)	2-Demo 3-Exam	1-CPT&E	
3.7.6.2.5(4)	2-Demo 3-Exam	1-CPT&E	
3.7.6.2.5(5)	2-Demo 3-Exam	1-CPT&E	
3.7.6.2.5(6)	2-Demo 3-Exam	1-CPT&E	
3.7.6.2.6(1)	3-Exam	1-CPT&E 2-DT&E	

APPENDIX A - DELETED

APPENDIX B – DEFINITIONS

1. Definition Of Terms

1.1 Adaptation Data

Generally, adaptation data are defined as modifiable parameters. These parameters may consist of system configuration, algorithm parameters, telephone numbers (auto dial), or other like data. Such data may be generated and/or modified at either a centralized location or locally within an RDA, RPG or PUP.

1.2 Alarm

An alarm is an attention getting notification of a system, equipment or software failure or an out of tolerance operating conditions that is provided to the operator.

1.3 Alert

An alert is the attention getting mechanism associated with receipt of an alert message at a Class 1 user indicating the initial detection of a significant meteorological parameter or phenomenon.

1.4 Alphanumeric Products

Those products generated within the RPG functional area that present, in an alphanumeric format, some representation of information in base products, derived products, or other alphanumeric products whether manually or automatically generated (e.g., a free text message).

1.5 Availability (Achieved) A(a)

The probability that equipment, when used under stated conditions in an ideal support environment, will operate satisfactorily at any given time. Availability requirements for the WSR-88D hardware are in Section 3.2.5. The calculation of A(a) excludes supply downtime and waiting or administrative downtime. It is expressed as:

$$A(a) = \frac{MTBMA}{MTBMA + MAMD}$$

where:

MTBMA = Mean Time Between Maintenance Actions (failures or preventive maintenance.

MAMD = Mean Active Maintenance Downtime resulting from both corrective and preventive maintenance actions.

1.6 Availability (Inherent) A(i)

The probability that equipment, when used under stated conditions without consideration for any scheduled or preventive maintenance and in an ideal support environment, will operate satisfactorily at any given time. Availability requirements for the WSR-88D hardware are in Section 3.2.5. The calculation of A(i) excludes preventive maintenance downtime, supply downtime, and waiting or administrative downtime. For a system consisting of components or configuration items (CI), it is expressed as:

$$A(i) = f(\text{all } A(j))$$

where: The exact functional relationship is design dependent and is defined by the developer's reliability model and,

A(j) is the availability of the "j^{th}" CI and is given by

$$A(j) = \frac{MTBF(j)}{MTBF(j) + MTTR(j)}$$

where:

MTBF(j) = Mean Time Between Failure of the jth CI [upper test (2_o) per MIL-STD-781 C]

MTTR(j) = Mean Time To Repair the j^{th} CI (see MTTR(CI))

1.7 Base Data

Those digital fields of reflectivity, mean radial velocity and spectrum width data in spherical (i.e., rho, theta, phi) coordinates provided at the finest resolution available from the RDA to the RPG and to the base data users. These data resolutions are specified in Sections 3.7.2.2.2.1 and 3.7.2.2.2.2.

1.8 Base Products

Those products generated within the RPG functional area that present some representation of each base data field. This representation may not necessarily be either in full resolution or depict the full area of coverage. Base Products can be used by a user to generate a graphic display or perform further processing.

1.9 Catastrophic Failure

Any hardware or software condition that results in the inability to perform the minimally required RDA and/or RPG functions shown in Section 3.2.5 for at least one Class 1 PUP.

1.10 Channel, Dual

The minimum equipment configuration needed to provide 100% redundancy (excluding the antenna assembly) in the capability to perform the single channel functions.

1.11 Channel, Single

The minimum equipment configuration needed to perform RDA key functions 1, 2 and 3 as defined in Table 3-5.

1.12 Cold Startup

Cold startup is a series of procedures intended to bring the radar from an idle state, (i.e., no software loaded, no hardware initialized) to the warm startup state (i.e., standby); an Operator must manually intervene and start the process by issuing the command that causes the radar to load, initialize, and start the RDA application software and initialize the radar hardware. The radar enters a Startup sequence which includes (but not limited to) establishing the communications link with the RPG, commanding the pedestal to the park position, establishing the controlling channel, initializing the maintenance display interface, and performing initial radar calibrations. Upon completion of cold startup procedures, the radar will be in the Standby state if previously commanded to perform a normal shut-down using the Terminate command.

1.13 Collocated

The data signaling rate and interconnecting cable characteristics, using the EIA-RS-422A transmission standard, determine the distance that WSR-88D equipment can be considered collocated. The RDA is collocated with a RPG when the two are separated by not greater than 80 meters of cable. The RPG is collocated with its PUP when the communication rate is 56 Kbps.

1.14 Commercial -Off-The-Shelf (COTS)

A commercial product made for commercial use. It is bought exactly as found in the civilian market, and allowed to flow with the changes and updates the vendor provides to his commercial customers.

1.15 Configuration Item (CI)

A CI is any individual item of equipment or combination of equipment items needed to perform some portion of the operational WSR-88D functional areas (i.e., RDA, RPG, or PUP). Furthermore, an independent CI is defined to have the following characteristics:

a. To fail without adversely affecting the performance capability of another CI.
b. To be able to have power turned on/off without an adverse effect on the performance capability of another CI.
c. The capability to have all external data, power, and/or control lines removed or restored without an adverse effect on the performance capability of another CI.

1.16 Derived Data Array Products

Those products generated automatically within the RPG functional area that present, in a non-displayable format, some combination of intermediate meteorological algorithm output, Base Products and derived products. These products are intended only for transmission to systems external to the WSR-88D System for further processing.

1.17 Derived Products

Those products generated within the RPG functional area that represent either some combination of Base Products or a base product that has been enhanced or otherwise changed by the use of automated processing techniques. Derived products can be used for graphic display of weather radar information or for further processing by a user.

1.18 Dwell Time

The time interval of target illumination over which samples are taken to make the required base data estimates.

1.19 Expansion Capability

The capability to easily add CIs or LRUs to any WSR-88D System for the purpose of increasing its data acquisition, processing, and/or product distribution capability. However, this addition will not require:

a. New CIs or new LRUs within a CI that are not part of the logistics system. A new CI that is form, fit and functionally compatible with an existing CI is permitted provided it complies with items 3-5 of this definition.
b. Modification of an existing LRU or CI (the addition of cables between pre-existing connectors on existing CIs is not considered a modification. Also, the addition of LRUs to a CI will not be considered a modification if such LRU additions are made by means of pre-existing wired connectors within a CI, e.g., the addition of a memory board to a CPU where one or more "slots" for such boards have been reserved).
c. The writing of new software (operational or maintenance).
d. The modification of any existing operational or maintenance software (changes made to the constants or parameter values are not considered modifications).
e. Addition or modification to any depot ATE capability.

1.20 FAA NIMS proxy agent/concentrator Interface (RMS)

The interface to the NAS Infrastructure Management System (NIMS). Proxy agent/concentrator will be used to allow National Airspace (NAS) subsystems, using proprietary and non-standard management functions, to communicate with the NIMS Manager as specified on DOT FAA Interface Control Document, NIMS/Managed Subsystem using the Simple Network Management Protocol Version 1 (SNMPv1), NAS-IC-51070000-1, dated 07/22/97.

1.21 Facility

The building(s) or enclosure(s) or that portion of the building(s) or enclosure(s) that houses some specific WSR-88D equipment.

1.22 Failure

Any hardware malfunction which degrades the performance of a CI below its specified value. Failures are considered either relevant or non-relevant as defined below:

a. Relevant failures include all malfunctions that are not specifically excluded as non-relevant. Each relevant failure occurrence is included in all calculations of reliability and availability.

b. A non-relevant failure is any failure which results from factors external to the components under test. Non-relevant failures are not included in the determination of MTBF or MTTR. Non-relevant failures are limited to those failures which are due to the following causes:

(1) Accidents
(2) Operator errors
(3) Failures caused by test instrumentation or monitoring equipment that is not part of the system.
(4) Maintenance induced failures, unless attributable to equipment design.
(5) Software failures.

1.23 Interface

The total software and hardware, excluding Data Communication Equipment, in the WSR-88D system necessary to communicate between two CIs within the WSR-88D System or between the WSR-88D System and another system.

1.24 Interface Connection

A capability within the system (e.g., back-plane slot) which, without any other changes to the system, but provided with the software and hardware, will serve as an Interface.

1.25 Line (Lowest) Replaceable Unit (LRU)

An essential support item which is removed and replaced at the field level to restore the end item to operational ready condition

1.26 Master System Control Function (MSCF)

The MSCF provides operator access to all RDA and RPG control, data entry, status monitoring, and error detection functions. The MSCF includes a human/machine interface in the form of a graphical user interface.

1.27 Maximum Time To Repair (MAXTTR)

The maximum corrective maintenance downtime within which 90% of all corrective maintenance actions can be accomplished (excluding supply and administrative downtime).

1.28 Mean Time Between Failures (MTBF)

The Mean Time Between Failure (MTBF) is defined as the statistical mean time between hardware failures requiring corrective maintenance action. With respect to the Inherent Availability requirements in this specification, MTBF is the "Upper Test MTBF (Theta o)" defined in MIL-STD-781.

1.29 Mean Time Between Visits (MTBV)

The mean time between visits to effect equipment repairs, excluding preventative maintenance and based on the concept that a visit is made only after redundant equipment failures have reduced the equipment at a radar site to its minimum operational configuration. This assumes equipment is at a location unattended by maintenance personnel.

1.30 Mean Time To Repair (MTTR)

The statistical mean of the distribution of repair times for individual failures. The summation of active repair times during a given period of time divided by the total number of malfunctions during the same time interval. This definition applies to components as well as the whole system.

1.31 Median Gain

That level over an angular region at which the probability is 50% that the observed or measured gain at any position of the antenna will be less than or equal to that level.

1.32 National Facility

Those principal users located at one of the following locations: SPC, AFGWC, TPC, or the NCEP.

1.33 Network Site

A Department of Commerce WSR-88D site in the conterminous United States that continuously collects, collates, and makes available radar data and products in support of the National Weather Radar Network.

1.34 NEXRAD Program

The summation of the procurement, testing and fielding of all hardware, software, facilities, communications, logistics, training, and staff, together with operations, training, and maintenance procedures. The program includes Network sites, Non-network sites, and Supplemental sites.

1.35 Non-Network Site

A non-CONUS Department of Defense site or a non-CONUS Department of Transportation site.

1.36 Operational Facility

Any local, regional, or national government facility which uses or supports the use of WSR-88D radar data in real-time in support of an operational mission.

1.37 Other User

Any user not identified as a principal user.

1.38 PC PUP

A SCO Unix-based meteorological software application. A Class 4 other-user dedicated interface commonly connected to a DOD PUP.

1.39 Port

An Interface, plus all required Data Communications Equipment (cables, modems, etc.) needed to communicate with another device, either within or outside of the WSR-88D System.

1.40 Preview Area

An area on the alphanumeric or graphic displays for the viewing of operator entered data before physical modification of the display occurs.

1.41 Principal User

The National Weather Service, Air Weather Service, Naval Meteorology and Oceanography Command, or Federal Aviation Administration.

1.42 Principal User Site

Site of the equipment necessary to perform the principal user function. May be collocated with another site (i.e., a radar site).

1.43 Product

A discrete collection of meteorological data and descriptive header information processed by the RPG and typically displayable as an graphical image or in tabular format.

1.44 Radar Operations Center

The Triagency organization tasked with providing hardware, software, operations, logistics, and training support to the WSR-88D program.

1.45 Radar Site

Site of a specific WSR-88D antenna and RDA equipment. May be collocated with another site (i.e., a principal user site).

1.46 RDA MSCF

The MSCF software executing at the RDA display/control position

1.47 Regional Facility

Those principal users located at one of the following locations: RFCs or ARTCCs (CWSUs).

1.48 Repair Time

The repair time for configuration items includes the total time required to detect and isolate the failure, to replace the CI or the failed component, check out the repair, and return the item to full operational status (includes the time to restore the system, load adaptation data, restore data base, etc., to its condition prior to the failure).

1.49 Response Time

The time interval between completion of all needed manual actions and completion of the results of those actions. For example, if a user calls up one product for display, the response time is the time interval between making the last needed keystroke to call up the product and completion of the display of the resulting product (not just the start of display of a product).

1.50 Restart

The purpose of a restart is to return the radar to a normal operational state. A restart can begin manually with the Operator at the maintenance position or MSCF issuing a Restart command, or automatically when a hardware or software condition causes the processor to reboot, when one of the RDA software tasks pauses, under certain error conditions (i.e., timeouts), and upon prime power recovery following a power failure. During the restart process, the operating system is reloaded and a cold startup is performed. At the completion of the restart process, the RDA will be returned to the state present at the time the restart was initiated (if initiated from the RPG), or to a default state (if initiated from the RDA).

1.51 RPG MSCF

The MSCF software executing at the RPG display/control position.

1.52 Scan Period

The time required for a radar to complete a full 360 degree rotation in azimuth.

1.53 Site

The geographic location of some specific WSR-88D equipment.

1.54 Standard Annotation Set

Each product includes a standard set of annotations to uniquely identify that product. The set of standard annotations to each product include: product name, RDA ID, date and time of volume scan, radar location (latitude/longitude), radar height (above MSL), and weather mode.

1.55 Startup

The process of initializing an RDA, RPG, or PUP without regard to its previous state.

1.56 Supplemental Site

A Department of Defense site in the CONUS.

1.57 Support Facility

A facility that provides some form of support primarily for the NEXRAD Program. This support may be in such areas as training, logistics, supply, or testing.

1.58 System Fault

A system fault is any malfunction which degrades WSR-88D performance below its specifications. Malfunctions arising from accidents, failures of test instrumentation or monitoring equipment are not considered a system fault for the purpose of defining availability requirements.

1.59 Throughput Time

The time interval measured from the completion of the base data necessary for the generation of a product until the product is displayed at an associated PUP for base, derived and alphanumeric products, or received at an associated PUP for derived data array products. This time interval includes transmission time but excludes RPG communications port queue time.

1.60 User

Any system user.

1.61 Volume Scan

The process of completing all elevation angle scans in a specific scanning sequence.

1.62 Volume Scan Time

The time interval between the start of one volume scan and the start of the next volume scan.

1.63 Warm Startup

Warm startup is a series of procedures that begins with the radar in Standby, Playback, or offline Operate states, and the Operator issuing an Operate command to bring the radar to the Operate state. During warm startup, the radar channel is checked to make sure it is the controlling channel and the pedestal is initialized; the end result of warm startup, the radar is in an Operate state.

1.64 WINPUP

A Windows-based meteorological software application. A Class 4 other-user dedicated interface commonly connected to a DOD PUP.

1.65 WSR-88D System

The combination of one RDA, one RPG, all associated Class 1 Users, and the necessary communications (external interfaces) to fully implement the operational capability. System configuration requirements are in Section 3.2.1.5.

APPENDIX C - DELETED

APPENDIX D - HYDROMETEOROLOGICAL PROCESSING FUNCTIONS

This appendix contains the Precipitation Detection Function and the Rain Gage Data Acquisition Function. The purpose of these functions is to collect data necessary for the precipitation processing described in the NEXRAD Algorithm Report (NAR), R400AAR201. The NAR contains the descriptions for the PRECIPITATION PREPROCESSING, PRECIPITATION RATE, PRECIPITATION ACCUMULATION, PRECIPITATION ADJUSTMENT, and the PRECIPITATION PRODUCTS algorithms which utilize these data.

1. Precipitation Detection Function

1.1 Functional Description

The Precipitation Detection Function processes each full volume reflectivity scan in order to perform three basic functions. It detects whether precipitation has occurred within a 230km radius of the WSR-88D radar and assigns a Precipitation Category appropriate to the situation. It maintains a Precipitation Status Message which indicates the operational mode and the Precipitation Category. Finally, when precipitation is first detected, it transmits the Precipitation Status Message to an off-site computer so that the offsite system can initiate precipitation gage polling.

Precipitation is detected by comparing rain rates (using the same Z-R relationship as the RATE algorithm) to threshold values contained in the Precipitation Threshold Table. Whenever the area covered by detected precipitation at any tilt exceeds the threshold value in the Precipitation Threshold Table, it is assumed that precipitation exists and a Precipitation Category is assigned to the situation. When significant precipitation is occurring, Precipitation Category 1 is assigned to the weather situation. When precipitation amounts and aerial extent are small, Precipitation Category 2 is assigned. Precipitation Category 1 remains in effect until 1 hour elapses with light precipitation , at which point Precipitation Category 2 is assigned, or a precipitation-free period of 1 hour occurs. Precipitation Category 2 remains in effect until a precipitation-free period of 1 hour occurs or precipitation Category 1 is detected. Precipitation Category 1 takes precedence over Precipitation Category 2. When no precipitation is detected, the Precipitation Category is 0.

The Precipitation Threshold Table includes a Nominal Clutter Area for each row in the table. This allows the performance of the function to be tuned to the clutter characteristics of individual NEXRAD sites, including the performance of any clutter filtering algorithm(s) applied to the Reflectivity Factor data before this function processes them.

1.2 Processing Environment

It is assumed that several pre-processing steps will be applied to the reflectivity data before the data are input to the Precipitation Detection Function (for example, clutter suppression). Care must be taken to ensure that these steps are accomplished without loss of data quality or quantitative accuracy.

Some of the important pre-processing steps expected before data are input to this function include:
Oxygen absorption correction [function of antenna elevation angle, range, height of antenna, and the assumed atmospheric state (probably the U.S. Standard Atmosphere)]
Assignment of zero values to all reflectivities below a specified/determined noise threshold
Signal processing in ground clutter areas as specified by a clutter map to suppress ground clutter, as well as anomalous propagation where possible, and other sources of interference, and
Automatic calibration and quality control functions as desirable and feasible.

Furthermore, this function assumes that the reflectivity data being input have been converted to equivalent reflectivity factor data, hereafter referred to as simply Reflectivity Factor data, using the standard assumptions in the classical radar equation. In addition, it is assumed that correction has been applied to adjust for any known biases and losses resulting from the signal processing, alterations in equipment calibration, dry radome attenuation (eventually, wet radome effects may also be addressed in the preprocessing), and any other known losses.

The Precipitation Status Message produced by this function is required by the PRE-PROCESSING, RATE, ACCUMULATION, ADJUSTMENT, and PRODUCTS algorithms in the Precipitation Processing Subsystem and the Rain Gage Data Acquisition Function.

1.3 Acquisition

Reflectivity Bins are intrinsic system parameters acquired directly from the radar.
Reflectivity Factor data are acquired from the NEXRAD base data and should include clutter filtering and other quality control procedures to the extent possible.
Elevation Angles are system adaptation parameters which may change with changing scanning strategies.

The Multiplicative ZR Coefficient and the Power ZR Coefficient are system adaptation parameters which are also used by the RATE algorithm.
The Precipitation Threshold Table including the Tilt Domains, the Nominal Clutter Areas, the Precipitation Categories, the Precipitation Rate Thresholds, and the Precipitation Area Thresholds are site adaptation parameters based on empirical studies to assure that significant precipitation events are not missed. They will be "fine tuned" for each site.
The Precipitation Status Message is an output of this function maintained continuously for access by other algorithms (notably the Rain Gage Data Acquisition Function) as needed.
The radar ID is a site adaptation parameter.
The Time Stamp is acquired from the WSR-88D system clock in UTC.
The Last Precipitation Detected Time is computed by the Precipitation Detection Function.

1.4 Computation

1.4.1 Notation

A_p = Area of precipitation detected at a particular Elevation Angle
Z = Reflectivity Factor value in dBZ at a particular range (r) and azimuth (az)
r = Range to nearest point of a particular Reflectivity Bin (km)
az = Azimuth of a particular Reflectivity Bin (degrees)
dr = Range resolution (bin size) of a particular Reflectivity Bin (km)
da = Azimuthal resolution (beam width) of a particular Reflectivity Bin (degrees)
T_p = Precipitation Rate Threshold in dBR for a particular row in the Precipitation Threshold Table
a = Multiplicative coefficient in the Z-R relationship
b = Power coefficient in the Z-R relationship
T_A = Precipitation Area Threshold in km^2 for a particular row in the Precipitation Threshold Table
T_N = Nominal Clutter Area in km^2 for a particular row in the Precipitation Threshold Table

1.4.2 Symbolic Formula

First Set $A_p = 0.0$.

For All Reflectivity Bins (i.e., all r and az)

If $Z(r,az) - 10 \log_b a > T_p$

Then $A_p = A_p + \frac{\Pi da}{360} [(dr)^2 + 2r\, dr]$

This computation proceeds by processing each individual Elevation Angle within the Tilt Domain. The Precipitation Rate Threshold (T_p) in the computation is defined separately for each entry in the Precipitation Threshold Table presuming the Elevation Angle falls within the specified Tilt Domain for a table entry.

If $A_p \geq T_N + T_A$, assign the Precipitation Category indicated by the Precipitation Threshold Table. Precipitation Category 1 has priority over Precipitation Category 2.

Once Precipitation Category 1 or Precipitation Category 2 is assigned, it remains in effect until the end of one precipitation-free hour. Once Precipitation Category 2 is assigned, it remains in effect until superseded by Precipitation Category 1 or until the end of one precipitation-free hour. The Precipitation Detection Function must be executed for each scan, regardless of the current Precipitation Category, in order to identify the existence of a precipitation-free hour, the initiation of precipitation, or a change in Precipitation Category.

1.5 Distribution

The Precipitation Status Message is transmitted whenever precipitation is first detected.

The Precipitation Status Message is used in the PREPROCESSING, RATE, ACCUMULATION, ADJUSTMENT, and PRODUCTS algorithms in the Precipitation Processing Subsystem and the Rain Gage Data Acquisition Function.

1.6 Definitions

Reflectivity Bins	Grid cells for Reflectivity Factor data being input to this function. Data are required from all elevation angles specified by the Elevation Angles.
Elevation Angles	Elevation angles from which Reflectivity Factor data are being input to the Precipitation Detection Function. The elevations used will vary from site to site.
Reflectivity Factor	Equivalent reflectivity factor data (in dBZ)
Multiplicative ZR Coefficient	Multiplicative coefficient in ZR conversion.
Power ZR Coefficient	Power coefficient in the ZR conversion equation
Precipitation Threshold	Table of threshold values for precipitation detection. The table is

Table — composed of five columns: Tilt Domain, Precipitation Rate Threshold, Nominal Clutter Area, Precipitation Area Threshold, and the Precipitation Category. The table can have at most 50 rows and the contents is determined by adaptation data. An example table follows:

Tilt Domain (degrees)	Precip. Rate Threshold (dBR)	Nominal Clutter Area (km2)	Precip. Area Threshold (km2)	Precip. Category
0-2	-3	20	20	2
0-4	1	15	10	1
2-4	-3	5	20	2

Consider a single volume scan at an elevation angle of 1°. If the area with Reflectivity Factor greater than or equal to an equivalent rain rate of 3 dBR exceeds 40 km2, then Precipitation Category 2 has been reached.

Consider an elevation angle of 3° within the same volume scan. If the area with Reflectivity Factor greater than or equal to an equivalent rain rate of 1 dBR exceeds 25 km2, then Precipitation Category 1 has been reached. Precipitation Category 2 would also be in effect, but since Precipitation Category 1 is more significant, it would take precedence.

Tilt Domain — Range of Elevation Angles in degrees for which a row in the Precipitation Threshold Table applies.

Precipitation Rate Threshold — Minimum rainfall rate (in dBR) for a Reflectivity Bin to count toward the precipitation area for a particular row in the Precipitation Threshold Table

Precipitation Area Threshold — Minimum areas (in km2) covered by Precipitation in the Precipitation Threshold Table

Radar ID — Identifier for the WSR-88D radar site.

Precipitation — The Precipitation Status Message is Status Message generated each time the Precipitation Detection Function is run and is composed of the following items: radar ID, Time Stamp, Last Precipitation Detected Time, Precipitation Category currently in effect, number of gages in gage data base, and time of last update to gage data base.

Time Stamp — Time of occurrence of Precipitation Status Message in UTC.

Last Precipitation Detected Time — Time Stamp when precipitation was last detected This will be updated every full volume reflectivity scan which detects precipitation

Nominal Clutter Area	Area (in km2) normally produced by clutter with a Reflectivity Factor equivalent to the Precipitation Rate Threshold for a particular row in the Precipitation Threshold Table.
Precipitation Category	A coded value equal to 0, 1, or 2 for each row in the Precipitation Threshold Table giving the Precipitation Category which has been reached when the area of detected precipitation exceeds the sum of the Precipitation Area Threshold plus the Nominal Clutter Area. 0 = No precipitation detected 1 = Significant precipitation detected 2 = Light precipitation detected

1.7 Limitations

If any scan mode in the WSR-88D system fails to meet the requirements of Table D-1, there can be no assurance that the Precipitation Detection Function will detect precipitation; i.e., the NEXRAD site may completely fail to recognize precipitation occurrence. Since the Precipitation Processing Subsystem assumes that no precipitation is occurring if none has been detected by this function, precipitation accumulation estimates will not be meaningful if this function fails to detect precipitation. In addition, if any scan mode does not meet the requirements of Table D1, there can be no assurance that the category of precipitation (0, 1 or 2) as assigned by this function is representative of current conditions. Since the data requirements for the Precipitation Processing Subsystem during precipitation periods are more stringent than those specified in Table D-1 and because they are category dependent (see tables within the Precipitation Processing Subsystem, NEXRAD Algorithm Report), failure of the Precipitation Detection Function to properly assign the Precipitation Category could result in meaningless precipitation estimates.

Table D-1 MINIMAL SCAN MODE REQUIREMENTS NECESSARY FOR DETECTING PRECIPITATION

Scan Characteristics	Requirements
Range	230 km or more
Range Resolution	2 km or less
Azimuthal Coverage	360 °
Azimuthal Resolution	2 ° or less
Tilts and Repetition	Lowest two tilts required by Precipitation Processing Subsystem (see PREPROCESSING algorithm) at least every 10 minutes. Four lowest tilts required by Precipitation Processing Subsystem at least every 30 minutes.

1.8 Future Developments

Due to the limitation cited above, the Precipitation Threshold Table will require fine tuning for best performance at each site using actual WSR-88D data.

Table D-3 SUMMARY OF VALID PEDTSEP CODES

Code	Description
PC PCI PCIRx PCIRxZ PCIRxZZ PCIZZ PCIZZZ PCIZZZZ PCZ PCZRx PCZRxZ PCZRxZZ PCZZZ PCZZZZ PCZZZZZ	All of these codes are logically equivalent meaning "instantaneous observed precipitation accumulator". All other codes beginning with PC are invalid.
PP PPZ PPZRx PPZRxZ PPZRxZ PPZRxZZ PPZZZ PPZZZZ PPZZZZZ	All of these codes are logically equivalent meaning "observed incremental precipitation". The increment duration is assumed 24 hours.
PPV PPVRx PPVRxZ PPVRxZZ PPVZZ PPVZZZ PPVZZZZ	All of these codes are logically equivalent meaning "observed incremental precipitation". The increment duration is specified by a preceding "DVx" code. If no "DVx" code has been specified, the data are presumed invalid.
PPa PPaRx PPaRxZ PPaRxZZ PPaZZ PPaZZZ PPaZZZZ	All of these codes are logically equivalent meaning "observed incremental precipitation." The increment duration is specified by "a" which must be one of the following:

"a" =	U	for one minute	C	for 15 minutes
	J	for 30 minutes	H	for one hour
	B	for two hours	T	for three hours
	Q	for six hours	A	for eight hours
	K	for twelve hours	L	for eighteen hours
	D	for twenty-four hours (daily)		

Notes:

"x" is used for "any character"

1. Other "a" codes for periods longer than 24 hours exist, but need not be posted to the NEXRAD database.
2. Provision should be made to expand the valid list of "a" codes above to include up to 20 values.

Table D-4 VALID DURATION CODE VARIABLE SPECIFIERS

Code	Description
DVNnn	Increment duration = nn minutes
DVHhh	Increment duration = hh hours
DVZ	Increment duration returns to default value (24 hours for incremented precipitation).

Note: Other DV codes for intervals in days, weeks, etc., exist, but are not valid for WSR-88D precipitation data. If any DV code other than those above appear, then no PPVxxxx data can be processed until after a valid DV code is specified.

Accumulation reports give a total accumulation above a baseline at the gage at an instant in time. The baseline is normally reset when the gage is serviced (recharged with antifreeze and oil) or, for some types of gages, it "wraps around" from 999.99 inches to zero inches. The ADJUSTMENT algorithm, which computes hourly accumulations, is able to recognize these resets of the baseline. Neither the Rain Gage Data Acquisition Function nor the ADJUSTMENT algorithm require that all reports for a single gage will be of one type or other.

The data base maintained by this function must always save the last 50 reports from each gage. This will permit storage of up to 4 hours of 5minute reports or a longer period from gages reporting less frequently. After 50 reports for a gage have been received, the oldest report for a gage is discarded each time a new report from that gage is received. The only exception to this strategy is the handling of revised reports (SHEF formats AR, BR or ER). A revised report replaces an existing report for the same time if one exists.

The gage data base contains three types of data: the gage identification, gage reports, and a distance matrix. The data base must hold 200 gages as a minimum. As described above, the gage reports section must retain the most recent 50 reports for each gage. The three types of data are described below.

Each gage identification consists of the Gage Identifier (38 characters), the Gage Latitude (decimal degrees), the Gage Longitude (decimal degrees, positive for west of 0o, negative for east), the Gage Azimuth (decimal degrees), and the Gage Range (km). The Gage Azimuth and Gage Range are computed from the Gage Latitude and Gage Longitude by this function. If the computed range exceeds 230 km, the gage is not added to the data base.

Each report consists of the Gage Data Type Flag, the Gage Data Time Stamp of the data, the Gage Data Increment in minutes (for incremental reports only), and the Gage Data Value in mm (accurate to 1 mm). The Gage Data Time Stamp refers to the ending time of an incremental precipitation report or the sampling time of an accumulation report. This function converts all times to UTC and all values to mm before posting. Negative values for the Gage Data Value must not be posted to the data base. If a missing information flag is set the report will not be posted to the data base.

The Gage Distance Matrix contains the computed distance in km from each gage to every other gage. It must be recomputed whenever the gage identification section is changed by adding, deleting, or modifying the location of a gage. Since the distance between gages A and B is the same as the distance between B and A, the Gage Distance Matrix contains N(N1)/2 distinct values where N is the number of gages.

The order of gages on the gage data base is not arbitrary. Since the ADJUSTMENT algorithm limits itself to 30 gages where rainfall actually occurs in an hour, this Rain Gage Data Acquisition Function must order the gages in such a way that they are scattered throughout the NEXRAD umbrella. This is accomplished by numbering the gages in such a way that the ADJUSTMENT algorithm can simply use the gage reports for the first 30 valid gages. The ordering is accomplished using the Gage Distance Matrix according to the following logic. Find the closest pair of gages and arbitrarily number one of them 1 and the other N (where N is the number of gages). Find the gage most distant from gage 1 and number it 2. Find the gage most distant from gage 2 (excluding gages 1 and N) and make it 3. Find the gage most distant from gage 3 (excluding gages 1, 2, and N) and make it 4. Repeat until all gages are ordered.

2.2 Processing Environment

This function is completely data-driven; it simply monitors the incoming line(s) and responds accordingly.

A message containing gage reports will be posted to the data base within 3 minutes of receipt of the message.

Processing of other than accumulation related changes to the data base will be deferred until no precipitation has been detected in the previous hour. At such a time, the changes will be processed, a new Gage Distance Matrix created, and the gages reordered within a 15minute processing time. During this time, the processing of data reports may be deferred, if necessary, for parsing and posting until the update is completed.

The gage data base must be maintained in such a way that data are not lost in the event of a system shutdown. Likewise, any SHEF format data or gage identification data which have been received but not yet posted to the gage data base must be protected.

2.3 Acquisition

The WSR-88D system will initiate collection of Gage Data Values by the Gage Data Support System(s) (GDSS) by means of an automatically generated phone call to the GDSS. Criteria for doing this are described by the Precipitation Detection Function. The GDSS will request the Precipitation Status Message from WSR-88D and terminate data acquisition based on this information.

The Gage Identifier, Gage Latitude, and Gage Longitude are contained in messages transmitted to the WSR-88D by the GDSS. These are retained by the gage data base.
The Gage Azimuth and Gage Range are computed by this function and retained in the gage data base.

The Gage Data Type Flag, Gage Data Time Stamp, Gage Data Increment, and Gage Data Value are received by WSR-88D from the GDSS. They will be stored in the gage data base maintained by this function.

The Gage Distance Matrix is computed by this function for use by the ADJUSTMENT algorithm and for ordering the gages within the gage data base. All data received from the GDSS will be in the SHEF format.

2.4 Data Summary

The entire gage data base including the Gage Identifier, Gage Latitude, Gage Longitude, Gage Range, Gage Azimuth, and Gage Distance Matrix; and all of the data reports which include Gage Data Type Flag, Gage Data Time Stamp, Gage Data Increment and Gage Data Value are continuously maintained by this function.

Precipitation Status Message, Gage Identifiers, Gage Latitudes, and Gage Longitudes may be transmitted by this function.

2.5 Definitions

Gage Identifier	A 3 to 8character identifier for a gage.
Gage Latitude	Latitude in decimal degrees (positive for north) of a gage.
Gage Longitude	Longitude in decimal degrees (positive for west of 0o, negative for east) of a gage.
Gage Range	Computed range from NEXRAD antenna in km for a gage (accurate to 0.1 km).
Gage Azimuth	Azimuth in decimal degrees from the WSR-88D to a gage (accurate to 0.1 degrees).
Gage Data Type Flag	Identifies reporting type-incremental or accumulation
Gage Data Time Stamp	Time of occurrence of gage value in Greenwich Mean Time accurate to 1 minute. For incremental reports = time of end of increment
Gage Data Increment	Increment length in minutes for incremental precipitation
Gage Data Value	Reported value in mm. This is an incremental value for incremental reports or a total accumulation for accumulation reports. Accuracy is to within 1 mm.
Gage Distance Matrix	Matrix containing distances from each gage to every other gage in Km (accurate to 0.1 Km).
Precipitation Status Message	See Precipitation Detection Function

APPENDIX E - WSR-88D PRODUCTS

This Appendix lists the WSR-88D products required. Table E1 provides a summary for each product of: the area of coverage; product resolution; frequency of product generation for full load sizing; throughput time requirement; response time requirement for onetime product requests; and the frequency of product archival for full load sizing. The final form of any product is subject to user agency approval.

1. Reflectivity

This product will provide the reflectivity data displayable as an image. (Defines the form of presentation on a graphic display; not necessarily the form of transmission.) Variations of the product will be organized to provide various areas of coverage and display resolutions. The product will be generated for any elevation scan based on user requirements. Each scan will be updated once per volume scan time. (Defined in Appendix B.) Each product will be available for both 8 and 16 reflectivity data levels. Each product will include a standard set of annotations, data level code, elevation angle, product resolution, and maximum data value (dB).

2. Mean Radial Velocity

This product will provide the mean radial velocity data displayable as an image. Variations of the product will be organized to provide various areas of coverage and display resolution. The product will be generated for any azimuth scan at a single elevation angle based on user requirements. Each scan will be updated once per volume scan time. Each product will include both 8 and 16 mean radial velocity data levels. Each product will include a standard set of annotations, data level code, elevation angle, maximum data values detected (knots, positive and negative), product resolution, and identification of range obscured data.

3. Spectrum Width

This product will provide the radial velocity spectrum width data displayable as an image. Variations of the product will be organized to provide various areas of coverage and display resolutions. The product will be generated for any azimuth scan at a single elevation angle based on user requirements. Each scan will be updated once per volume scan time. Each product will be available for 8 spectrum width data levels. Each product will include a standard set of annotations, data level code, elevation angle, maximum data value detected (knots), product resolution, and identification of range obscured data.

4. Combined Shear

This product will provide the combined (radial and azimuthal) shear of the mean radial velocity for a 230 km x 230 km area centered at the radar position. The shear information presented in this product will be the output of the Combined Shear Algorithm. It will be presented as a displayable image of shear values containing 16 data levels. The capability to establish the product resolution will be controllable by the user. This product will be produced for one elevation angle, as selected by the user, with the lowest elevation angle as the default. This product will be updated once per volume scan time.

This product will include a standard set of annotations, elevation angle, data level code, position and value of maximum shear value, and product resolution. Upon user request, all site adaptable parameters identified as inputs to the algorithms used to generate data for this product will be available at the alphanumeric display.

5. Combined Shear Contour

This product will provide contours of the combined shear and will be produced by contouring the output of the Combined Shear Algorithm used to produce the Combined Shear Product. The contouring interval(s) will be site adaptable.

This product will be displayable alone or as an overlay on reflectivity or velocity Base Products. This product will be updated once per volume scan time.
This product will contain a standard set of annotations, position and value of the maximum shear value, elevation angle, spatial resolution of contoured shear data and contouring interval(s). Upon user request, all site adaptable parameters identified as inputs to the algorithm used to generate data for this product will be available at the alphanumeric display.

6. Composite Reflectivity

This product will provide composite reflectivity data displayable as an image. For each geographical resolution element this product will provide the highest reflectivity value above the resolution element available from any elevation angle scan of a volume scan. This product will be available in two versions, one with the effects of anomalous propagation removed and one without. This product will be updated once per volume scan time. The product will be available for both 8 and 16 reflectivity data levels. The product will include a standard set of annotations, data level code, maximum data value (db) and it's position, and product resolution. In addition, storm information generated by the various meteorological algorithms, e.g., the Storm Cell Identification and Tracking or Tornado Vortex Signature Algorithms, will be included as graphic overlays. When selected, the algorithm generated information will be provided for all identified storm cells. When these additional overlays are selected, they will be provided routinely until deselected. The information in these optional overlays will be updated once per volume scan time.

7. Composite Reflectivity Contour

This product will provide composite reflectivity data as line contoured areas displayable as an image. For each geographical resolution element this product will provide the highest reflectivity value above the resolution element available from any elevation angle scan of a volume scan. This product is similar to the Composite Reflectivity Product except the imagery data will be converted to a contoured format. This product will be updated once per volume scan time. The number of contour intervals will be adaptable. The product will include a standard set of annotations, data level codes, contour interval, and maximum data value detected (db) and it's position. In addition, storm information generated by the various meteorological algorithms, e.g., the Storm Cell Identification and Tracking or Tornado Vortex Signature Algorithms, will be included graphic overlays. When selected, the algorithm generated information will be provided for all identified storm cells. When these additional overlays are selected, they will be provided routinely until deselected. The information in these optional overlays and annotations will be updated once per volume scan time.

8. Echo Tops

This product will provide the echo tops information displayed as an image. This product will be produced from the output of the Echo Tops Algorithm. The product will be updated once per volume scan time. The product will be available for 16 data levels referenced to mean sea level. The product will include a standard set of annotations, product resolution, data level codes, maximum data value detected (Height in feet, MSL) and its location.

9. Echo Tops Contour

This product will provide the echo tops information as line contoured areas displayable as an image. The contouring interval will be user selectable (in 1000 feet increments) with a minimum interval of 2000 feet and default to 5000 feet. The base contour value will be site adaptable and default to 30,000 feet MSL. All contour values will be annotated and displayed referenced to mean sea level.

The product will be updated once per volume scan time. The product will include a standard set of annotations, contour interval, contour base height, and maximum data value detected (Height in feet, MSL) and it's position.

10. Severe Weather Analysis Display

This product will provide, at the highest product resolution available, separate maps of reflectivity, mean radial velocity, spectrum width, and radial shear for 50 x 50 km areas.

This product will also be generated upon user request for a user-specified elevation angle and geographic center point.

The capability will exist to modify the mean radial velocity map by removing the storm motion of an operator selected storm from the velocity data. The modified map will be centered on the same geographic location as the original map. The method of removal will be as described in product 16, Storm Relative Mean Radial Velocity.

The product will contain 16 data levels for each data type displayed except spectrum width which will contain 8 data levels. The product will include a standard set of annotations, product resolution, data level codes, elevation angle, Height (AGE) of the phenomenon centerpoint, maximum data values detected.

11. Severe Weather Probability

This product will provide an alphanumeric set of severe weather probability values displayable in a graphic map format. These severe weather probability (S.P.) values will be produced using the Severe Weather Probability Algorithm. This product will be updated each time the VIL (Vertically Integrated Liquid) product is updated. The product will be produced in a form that can be used to generate an alphanumeric S.P. value for overlaying on any geographic product or which can be displayed independently with the S.P. value assigned to the VIL box corresponding to the center of an individual cell. Each product will include a standard set of annotations, data level code, and maximum data value detected (percent).

12. Velocity Azimuth Display Winds

This product will provide the Velocity Azimuth Display Algorithm derived wind speed and direction. Two versions of the product will be produced. For the first version, the wind speed and direction at up to 30 altitudes will be computed and displayed as wind barbs on a height scale.

The specific altitude levels at which VAD winds are computed and reported will be site adaptable in one thousand feet increments. The specific altitudes at which winds are requested will be used to derive the specific slant range and elevation angle for the VAD algorithm analysis. The use of lookup tables relating a specific slant range and elevation angle to a specific wind reporting altitude for computational efficiency is permitted. To facilitate this, off-line processing may be used to generate new lookup tables when new scanning sequences are invoked. The specific method of computing slant range and elevation angle are subject to user agency approval.

Wind speed and direction will be reported to the highest altitude level at which sufficient signal is available for processing by the VAD algorithm. The current and up to 10 previous height plots (user selectable) will be displayed simultaneously on a time versus height scale. Altitude levels will be shown referenced to mean sea level. This version of the product will include a standard set of annotations, and maximum wind speed and associated direction of most current plot. Upon user request, all site adaptable parameters identified as inputs to the algorithm used to generate data for this product will be available to the user.

A second version of the VAD winds product will be produced upon user request. This version will present the VAD wind analysis for a specific altitude. The data displayed will consist of the Doppler velocity data used to compute the VAD wind and the best fit function used to determine the horizontal wind speed and direction. The data will be presented to the user as a graphical plot of the actual Doppler velocity and its associated reflectivity and the best fit function on an orthogonal axis of speed versus azimuth. The vertical axis presented will be speed, scaled as necessary to allow all data to be displayed. The Nyquist velocity for the specific scan will be graphically annotated on the display if the range of the scaled vertical axis is sufficient. The horizontal axis will be azimuth, scaled from 0-360 degrees with true north as 0/360 degrees. This product will be available for any wind value included in the most recent time-height cross-section version of the VAD Winds Product. This version of the product will include a standard set of annotations, VAD slant range, elevation angle, wind speed and direction, altitude of winds, NIMS proxy agent/concentrator (RMS) error, and best fit function in the form

$A_1 + V \sin(I=I)$ (See Algorithm Report)

13. Combined Moment

This product will provide, at the highest product resolution available, separate maps of reflectivity, mean radial velocity, spectrum width, and radial shear for 50 x 50 km areas.

This product will provide the reflectivity, mean radial velocity and spectrum width data combined into a single product displayable as an image. The product will be generated on request for any user defined elevation scan and product center point coordinates. Each product will include a standard set of annotations, product resolution, data level codes, elevation angle, product center point coordinates, and maximum data values.

14. Cross Section

This product will provide a vertical cross section of reflectivity, mean radial velocity data or spectrum width displayable as an image for a user selected vector. This vector will be defined by the operator using two endpoints, up to 230 km apart, and at any orientation and location within 230 km of the radar. This product will be produced by mapping the nearest value in range along a radial, to a point in the plane of the vertical cross section defined by the intersection of the plane and the radial. The product will be produced by linearly interpolating vertically between the mapped values. The product will be available for both 8 and 16 data levels defining the intensity range and velocity range data levels, and 8 data levels only for spectrum width. The product will include a standard set of annotations, and maximum data value and location(s). The location of the line segment and the end points (az/ran) will also be indicated.

15. Weak Echo Region

This product will provide the weak echo region (WER) displayable as an image for a user selectable storm. The product will include a standard set of annotations, maximum data value (db), center point (azimuth/range), and heights (MSL) and elevation angles of each plane.

The WER product will be displayed as a set of up to eight stacked planes in perspective view. The centroid of the storm cell as determined by the SCIT algorithm will be the centerpoint of all planes. The planes will be corrected for the storm displacement during the volume scan using the storm motion as determined by the SCIT algorithm. Reflectivity in 16 data level from a single elevation angle will be displayed on a single plane, with the lowest elevation angle on the lowest plane, as viewed prospectively. Elevation angles will be shown in ascending order. Up to eight planes will be included in the product. The specific elevation angle assigned to each plane will be user selectable from those available in the current scan strategy at the time the product is requested, and default to

the lowest 8 elevation angles. The areal extent of a single plane will represent 50 x 50 km. No plane will obscure any other plane.

16. Storm Relative Mean Radial Velocity

This product will provide mean radial velocity for: (a) the Storm Relative Mean Radial Velocity Region, a 50 x 50 km geographic area centered anywhere within the radar's velocity coverage area with a storm motion removed, or (b) the Storm Relative Mean Radial Velocity Map, the entire area of radar coverage (to 230km) with the average storm motion removed. This product will be produced upon request for any elevation scan. The product will be generated as a displayable image by removing the radial (velocity component away from the radar antenna) component of storm motion from the mean radial velocity values.

For the Region product, the radial component of storm motion will be computed using the storm motion value computed for the identified storm cell by the Storm Cell Tracking Algorithm, or a value input by the user. For the Map product, the radial component of the storm motion will be computed using the vector average of all currently identified storm cells, or a value input by the user. The value of storm motion used to adjust the mean radial velocity values will be user selectable at the time of product request. Each product will contain 16 data levels for storm-adjusted mean radial velocity. Each product will include a standard set of annotations, data level codes, maximum values (positive and negative in knots) and their locations, product resolution, elevation angle, storm motion, coordinates of product center.

17. Vertically Integrated Liquid (VIL)

This product will provide vertically integrated liquid values displayed as an image. The output of the VIL Algorithm will be used to produce this product. The product will be updated once per volume scan time. The product will be available for 16 data levels. Each product will include a standard set of annotations, maximum data value (VIL value) and its location, and data code levels.

18. Storm Tracking Information

This product will provide information concerning the past, present and future positions of each identified storm cell. This product will be generated from the output of the Storm Cell Identification and Tracking algorithms. It will be produced in a tabular format of alphanumeric values, as a stand alone graphic product, and in a format for generating graphic overlays to other products. This product will be updated once per volume scan time. Each product will include a standard set of annotations and total number of identified storms for which tracking is available. Upon user request, all site adaptable parameters identified as inputs to the algorithm(s) used to generate data for this product will be available at the alphanumeric display.

19. Hail Index

This product will provide, for each storm identified by the Storm Cell Identification and Tracking algorithms, an indication of the probability the identified storm will produce hail, the probability the identified storm will produce severe (¾") hail, the maximum hail size produced by the storm, and the Hail Index. The hail indication values that are shown for each storm cell will be generated by the Hail Core Aloft Algorithm. This product will be produced in a format that can be used to generate an alphanumeric tabular type of display, an alphanumeric annotation to other products, or a graphic overlay. This product will be updated concurrently with the storm structure product. This product will include a standard set of annotations. Upon user request, all site adaptable parameters identified as inputs to the algorithm(s) used to generate data for this product will be available at the alphanumeric display.

20. Mesocyclone

This product will provide information about identified shear and mesocyclone features. This product will be generated from the output of the Mesocyclone Detection Algorithm. This product will be generated in a format that can be used to generate an alphanumeric tabular display for any identified feature or all simultaneously, a graphic display or a graphic overlay to other products. This product will be updated once per volume scan time. If on a particular volume scan there is no output from the Mesocyclone Detection Algorithm (i.e., no features of any type are identified), a version of the product will be produced that exhibits the negative condition. This product will include a standard set of annotations. Upon user request, all site adaptable parameters identified as inputs to the algorithm(s) used to generate data for this product will be available at the alphanumeric display.

21. Tornado Vortex Signature

This product will provide information regarding the existence and location of any identified Tornado Vortex Signature (TVS). This product will be produced from the output of the TVS Algorithm. This product will produce an alphanumeric tabular display of the algorithm output data for each identified TVS signature and generate a graphic overlay of the TVS signature information when such is identified. This product will be updated once per volume scan time. This product will include a standard set of annotations. Upon user request, all site adaptable parameters identified as inputs to the algorithm(s) used to generate data for this product will be available at the alphanumeric display.

22. Storm Structure

This product will provide, for each identified storm, a history of storm cell attributes. This product will be produced from and contain values that are output by the Storm Cell Identification and Tracking and Hail Core Aloft Algorithms. This product will be updated once per volume scan time. Storm Cell Attributes for the current volume scan will be represented in a displayable tabular alphanumeric format and will include a standard set of annotations. The history of storm cell attributes (Trend Data) will be represented in a non-displayable tabular format. Upon user request, all site adaptable parameters identified as inputs to the algorithm(s) used to generate data for this product will be available at the alphanumeric display.

23. Layer Composite Reflectivity

This product will display as an image the maximum or average composite reflectivity for a given layer. This product will be available in two versions, one with the effects of anomalous propagation removed and one without. All layer products will be on a geographically based Cartesian grid, centered on the radar. Up to three layers will be available for layer products at each site; the depth of each layer will be controlled via adaptation data. No layer will be less than 6,000 ft thick. Each layer product will be updated on a volume scan basis.

Eight data levels will be available for each product, including one for data below the minimum threshold and one for no data. The default values for the reflectivity will be the standard NWS DVIP levels, as defined in FMH #7. The data level thresholds will be controlled via adaptation data. It will be possible to select either a maximum value or the average reflectivity for the grid box, but not both simultaneously. The range of coverage for each product will be controlled via adaptation data; the default is a 460 km X 460 km square centered on the radar.

A three-dimension (3D) grid box will be defined as the vertical projection of the geographically based Cartesian grid square through the appropriate layer. All radar resolution volumes whose centers are contained in a given 3D grid box will be included in the computation for the 3D grid box. All 3D boxes whose centers fall in a radar resolution volume will include the radar resolution volume in the

computation for that 3D grid box. A center that falls on a boundary will be considered to fall on both/all sides of the boundary. The product resolution will be 4 km x 4 km.

Each product will contain a standard set of annotations, layer definition, data level code, maximum data value detected and its location.

24. Layer Composite Turbulence

These products will provide derived turbulence intensity values composited for three site-adaptable layers with the default values. Each product will be produced using the outputs of the Turbulence Algorithm. Eight data levels will be available for each product, including one for data below the minimum threshold and one for no data. Each of the three layers shall will be updated once per volume scan time.

A three-dimension (3D) grid box will be defined as the vertical projection of the geographically based Cartesian grid square through the appropriate layer. All radar resolution volumes whose centers are contained in a given 3D grid box will be included in the computation for the 3D grid box. All 3D boxes whose center falls in a radar resolution volume will include the radar resolution volume in the computation for that 3D grid box. It will be possible to select either a maximum value or the average value for the grid box, but not both simultaneously. The product resolution will be 4 km X 4 km. The product size will be a 300 km X 300 km square centered on the radar.
Each product will contain a standard set of annotations, data level code, layer definition, and maximum data value detected and its location.

25. User Alert Message

This product will provide a brief message containing descriptive information pertaining to all alerts identified in the current volume scan. The message will contain the location (azimuth/range), alert category, threshold exceeded, exceeding value, date and time, storm ID# (if appropriate), , and storm speed and direction of movement. The product will be updated once per volume scan. The product will include a standard set of annotations.

26. Radar Coded Message

The Radar Coded Message (RCM) will be produced in 2 stages: a pre-edit stage and a post-edit stage. The pre-edit stage will be automatically produced and transmitted to a single associated PUP, designated in adaptation data, and made available for editing. After editing, or editing opportunity as described below, the post-edit stage will be produced, in accordance with Appendix K and made available from the RPG. The capability will be provided to prohibit the distribution of the unedited post-edit stage RCM to Class 4 users. The RCM will be produced in 3 parts: Part A, Reflectivity; Part B, VAD Winds; and Part C, Remarks. The specific data content of each part is described below.

The pre-edit stage of Part A contains an intermediate graphic product and a tabular listing of alphanumerics. The intermediate graphic product shall contain reflectivity data for the 1/16 LFM grid over the radar area of coverage out to 460 km. The reflectivity intensity value for each grid box will be determined by assigning the maximum value of all Composite Reflectivity boxes whose centers are contained within the 1/16 LFM grid square.

The intermediate graphic product will be based on the 256 level, 1 km x 1 degree Composite Reflectivity and Hybrid Reflectivity Products but contain only 9 data categories: 6 for data within 230 km, 1 for missing or below threshold data within 230 km, and 2 for data beyond 230 km. Hybrid Scan Reflectivity data (output by the PRECIPITATION PROCESSING ALGORITHM) will be used for the region within 230 km of the radar and Composite Reflectivity data will be used for the region outside of 230 km. The selection of which reflectivity levels map into which of the 6 radar coded

message categories will be adaptable. For data beyond 230 km, a separate adaptable threshold will be provided for which:

a) all data above that threshold will be labeled as category 8, and
b) all data below that threshold will be labeled as category 9.

The intermediate graphic product will be presented to the user at the PUP for graphic editing by deleting data or changing data to another data level within areas outlined by using the cursor control device. Each area will have a variable-sized polygon of up to 20 sides. Other normal PUP functions such as magnify and cursor linking will be available during the edit procedure. A readout of the location of the cursor control device will be provided to indicate the 3-letter designation of the 1/16 LFM grid box. This readout will be displayed continuously while using this product and be updated at least once per second. The alphanumeric list will contain the height (MSL) and position of the maximum echo top. The height, and the position where provided, will be derived from the Echo Tops Product. The alphanumeric list will also include the location of the storm cells within 230 km of the radar having the highest cell-based VIL. The number of storm cells (centroids) reported will be adaptable from 1-20, with default value of 12. Locations of these centroids will be provided graphically by overlaying their respective storm identifiers on the intermediate graphic product. As available from the output of the Storm Cell Identification and Tracking Algorithms, the forecast centroid speed and direction will also be listed. The capability to manually edit these alphanumerics will be provided. When the user deletes an area during a graphic editing session, the centroids will be automatically deleted. After editing, the graphics and alphanumerics will be formatted into part A of the radar coded message.

Part B of the radar coded message will contain a single profile of the horizontal wind information derived from the output of the VAD algorithm. The capability to edit these alphanumerics will be provided.

Part C of this product will contain remarks in an alphanumeric format. This information will give the position of each detected mesocyclone or couplet (as derived from the Mesocyclone Detection Algorithm) and each detected TVS (as provided by the TVS Algorithm). In addition, for each centroid included in part A, part C will contain the Hail Index (as provided by the Hail Core Aloft Algorithm). The capability for entry of formatted remarks will be designed to minimize format errors and the manual entry and editing time. (The use of input assists such as on-screen menus, templates with defaults, and the use of the cursor control device for the LFM grid location input should be considered.) Unformatted remarks and the editor's initials will be input through the keyboard. The capability to edit, add to, or restore the pre-edit alphanumeric text of part C will be provided.

After the editing opportunity, parts A, B, and C will be combined into a single message ready for transmission. The message code will be as specified in Appendix K.
The pre-edit version of this product will be produced automatically up to 2 times per hour based on time of day specified in minutes after the hour. This product will also be produced upon one-time request from the designated PUP using data from the last completed volume scan. For a continually scanning radar, the product will be produced from the last completed volume scan prior to the scheduled time. Once alerted that the pre-edit version of the product is available, if the operator does not begin the editing procedure within an elapsed time, T (site adaptable, default of 120 seconds), the unedited version of the product will be produced automatically within 20 seconds. If the operator does respond, the edited post-edit version of the product will be produced within 20 seconds of the time the operator manually terminates the edit procedure. When the product is complete, it will be sent back to its RPG for distribution.

27. Free Text Message

This product will provide a capability for defining an alphanumeric message for onetime transmission to specific WSR-88D interface(s). The product will be generated by an operator through the MSCF or collocated PUP for transmission to the RPG's users or by the PUP operator for transmission to the PUP's users. Messages will be designated to be transmitted to one or several operator specified WSR-88D interfaces. Product will include a standard set of annotations.

28. Surface Rainfall Accumulation

These products will provide 1hour and 3hour rainfall accumulation maps displayed as an image. The 1hour map will be updated every volume scan time and the 3hour map will be updated at the top of each hour. These products will be available for 16 precipitation accumulation data levels. Each product will include a standard set of annotations, data level codes, hybrid scan date and ending time (or clock hour as appropriate) of the precipitation accumulation integration, maximum data value and its location, the applied bias based on gage reports , and the error variance of the bias estimate.

29. Storm Total Rainfall Accumulation

This product will provide a rainfall accumulation map displayed as an image. The product format and content will be the same as the Surface Rainfall Accumulation Product except the time period will be a variable and will equal the period of continuous rainfall in the radar area of coverage. These products will be available for 16 precipitation accumulation data levels. This product will be updated every volume scan time. This product will include a standard set of annotations, maximum data value detected and it's current position, data level codes hybrid scan beginning and end times and dates of the precipitation accumulation integration,, the applied bias based on gage reports , and the error variance of the bias estimate.

30. Hourly Digital Precipitation Array

This product will provide hourly running total digital radar-rainfall estimates in an array format (not display oriented) to support processing performed external to the WSR-88D System. This product will be updated once per volume scan time. The product will be available for 256 data levels for each array element. Each product will include a standard set of annotations, data level codes, hybrid scan date and ending time (or clock hour as appropriate) of the precipitation accumulation integration, maximum data value and its location, the applied bias based on gage reports, and the error variance of the bias estimate.

31. Supplemental Precipitation Data

This product will provide selected supplemental data generated or collected during the operation of the precipitation processing subsystem algorithms. This product will also provide the Gage-Radar Pairs used in the most recent determination of the Bias Adjustment Factor and the rain gage reports from the Gage Database (maintained in the RPG by the Gage Data Acquisition Function) for the time period 2 hours and 15 minutes prior to the time the Gage Database was last updated. This product will be produced in a tabular alphanumeric format.

This product will be updated once per volume scan time. This product will include a standard set of annotations and maximum data value and its location.

32. User Selectable Rainfall Accumulation

This product will provide a rainfall accumulation map displayed as an image, for a user selected accumulation period. The product format and content will be the same as the Surface Rainfall Accumulation and Storm Total Rainfall Accumulation products, except the accumulation period will be of variable duration (in whole clock hours), ranging from a beginning to an ending time specified by the user. The product will usually be generated by request, but may also be generated routinely

for limited, designated periods. One of these periods will be the Default Period, which will span a 24 hour period from 1200Z of the previous day to 1200Z of the present day. The default version of the product may be generated any time following the completion of the first volume scan to start after 1200Z each day, up to 6 hours later. The period of accumulation will be defined by the operator via two parameters: the Ending Hour (ranging from 0 to 23Z), and the Time Span (ranging from 1 to 24 whole clock hours prior to the Ending Hour). No more than 30 hours of rainfall data prior to the most recent clock-hour will be required to generate this product.

If a requested product cannot be generated due to an error condition, a message will be displayed explaining why, and the available hours of precipitation accumulation in the precipitation data base will be listed.

This product will include a standard set of annotations, maximum data value detected and it's current position, data level codes hybrid scan beginning and end times and dates of the precipitation accumulation integration,, the applied bias (based on gage reports) for each hour in the product, an indication whether each hour is included in the precipitation accumulation , and the error variance of the bias estimate.

33. Digital Hybrid Scan Reflectivity

This product will provide digital radar-reflectivity values for the composite Hybrid Scan, assembled from the lowest four elevation angles and yielding a representative reflectivity value at every sample bin location of a 1 degree by 1 kilometer polar grid, out to a range of 230 kilometers (124 nautical miles). This digital data is provided to support processing performed by external systems and is not display oriented. This product will be updated once every volume scan time. This product will be available for 256 data levels at each sample bin location. Each product will include a standard set of annotations, the hybrid scan data and time of the scan, and the maximum data value (db) and its location.

34. Clutter Filter Control

This product will provide for display of Clutter Filter Notch width and Bypass Maps as a radial image, for the user selected elevation segment and channel type. The product, while considered a volume product, is not generated every volume scan. The product will be generated upon detection of updated Clutter Filter Notch width Map and/or Bypass Map data received from the RDASC, or in response to user request(s) when product is not in the RPG Product Database. Two elevation segments are available for selection; they are low and high. Two channel types are available for selection; they are Surveillance and Doppler. (See Algorithm Report)

This product will include annotations for elevation segment number (1 or 2), channel (Surveillance or Doppler), Bypass Map generation date/time, Notch width Map generation date/time, and all other standard annotations.

Table E-1a. PRODUCT GENERATION & ARCHIVE PERFORMANCE LOAD

Product Name	Coverage	Resolution	Products	Archive
1. Reflectivity	0-230	1 x 1 °	lowest 4 + 6.2, 10.0, 14.0	lowest 1
	0-460	2 x 1 °	lowest 2	lowest 1
	0-460	4 x 1 °	None	
2. Mean Radial Velocity	0-60	0.25 x 1 °	lowest 1	lowest 1
	0-115	0.5 x 1 °	lowest 4 + 6.2, 10.0	lowest 1
	0-230	1 x 1 °	14 elevations	lowest 1
3. Spectrum Width	0-60	0.25 x 1 °	lowest 1	lowest 1
	0-115	0.5 x 1 °	None	
	0-230	1 x 1	lowest 3	lowest 1
4. Combined Shear	230 x 230	1 x 1	lowest 1	None
5. Combined Shear Contour	230 x230	1 x 1	None	
6. Composite Reflectivity	0-230	1 x 1	1 (16 lvl) 1 (8 lvl)	None None
	0-460	4 x 4	1 (16 lvl) 1 (8 lvl)	yes yes
AP removed	0-230	1 x 1	1 (8 lvl)	Yes
AP removed	0-460	4 x 4	1 (8 lvl)	Yes
7. Composite Reflectivity Contour	0-230	1 x 1	None	
	0-460	4 x 4	None	
8. Echo Tops	0-230	4 x 4	1	Yes
9. Echo Tops Contour	0-230	4 x 4	1	None
10. Severe Weather Analysis (4 Products):	50 x 50	see product description	None	
11. Severe Weather Probability	0-230	4 x 4	1 (with VIL)	yes
12. Velocity Azimuth Display VAD		1000 ft alt	None	
Wind Profile		1000 ft alt	1	None
13. Combined Moment	25 x 25		None	
14. Cross Section (230km X 70k')		1 x 0.5	3	None
15. Weak Echo Region	50 x 50	1 x 1	None	
16. Storm Rel Mean Radial Vel Region	50 x 50	0.5 x 1°	1	
Map	0-230	1 x 1°	lowest 4 + 6.2, 10.0, 14.0	lowest 1
17. Vertically Integrated Liquid	0-230	4 x 4	1	yes
18. Storm Tracking (SCIT)	0-460	N/A	1	yes
19. Hail Detection (Enhanced)	0-230	N/A	1	yes
20. Mesocyclone	0-230	N/A	1	yes
21. Tornado Vortex Signature	0-230	N/A	1	yes
22. Storm Structure	0-460	N/A	1	None
23. Layer Composite Reflec				
33M-60M	460 x 460	4 x 4	1	None
24M-33M	460 x 460	4 x 4	1	None
Sfc-24M	460 x 460	4 x 4	1	None
AP removed Sfc-24M	460 x 460	4 x 4	No longer available	None

Product Name	Coverage	Resolution	Products	Archive
24. Layer Composite Turb				
33M-60M	300 x 300	4 x 4	No longer available	
24M-33M	300 x 300	4 x 4	No longer available	
25. User Alert Message	N/A	N/A	1	Yes
26. Radar Coded Message	N/A	N/A	1	Yes
27. Free Text Message	N/A	N/A	1	None
28. Sfc Rainfall Accumulation 1hr	0-230	2 x 1°	1	yes
3 hr	0-230	2 x 1°	1	None
29. Storm Total Rainfall Accum	0-230	2 x 1°	1	Yes
30. Hourly Digital Precip Array	0-230	1/40 LFM	1	Yes
31. Supplemental Precipitation Data	N/A	N/A	1	Yes
32. User Selectable Precip Accum	0-230	2 x 1°	1	?
33. Digital Hybrid Reflectivity	0-230	1 x 1°	1	?
34. Clutter filter control	0-230		1	?
Note: Total product generation is depicted (both routine and one time requests).				

Table E-1b PRODUCT RESPONSE TIME & THROUGHPUT TIME

Product Name	Throughput (sec)	Response (sec)
Reflectivity	30	90
Mean Radial Velocity	30	90
Spectrum Width	30	90
Combined Shear	60	180
Combined Shear Contour	60	180
Composite Reflectivity	42	90
Composite Reflectivity Contour	42	90
Echo Tops	60	90
Echo Tops Contour	60	90
Severe Weather Analysis (4 products)	30	90
Severe Weather Probability	30	90
Velocity Azimuth Display	60	180
Combined Moment	60	90
Cross Section	N/A	90
Weak Echo Region	30	90
Storm Relative Mean Radial Vel Map/Region	30	90
Vertically Integrated Liquid	30	90
Storm Tracking Information (SCIT)	30	90
Hail Detection (Enhanced)	30	90
Mesocyclone	30	90
Tornado Vortex Signature	30	90
Storm Structure	30	90
Layer Composite Reflectivity Products	30	90
Layer Composite Turbulence Products	no longer available	no longer available
User Alert Message	30	N/A
Radar Coded Message	30	N/A
Free Text Message	30	N/A
Surface Rainfall Accumulation Products	30	90
Storm Total Rainfall Accumulation	30	90
Hourly Digital Precipitation Array	30	90
Supplemental Precipitation Data	TBD	TBD
User Selectable Precip Accumulation	TBD	TBD
Digital Hybrid Reflectivity	TBD	TBD
Clutter Filter Control	TBD	TBD

APPENDIX F – DELETED

APPENDIX G ACRONYMS/ABBREVIATIONS

Acronym	Description
AFI	Air Force Instruction
A/D	Analog/Digital
AFGWC	Air Force Global Weather Central
AFWA	Air Force Weather Agency
AFSS	Automated Flight Service Station
ANSI	American National Standards Institute
ASTM	American Standard Testing Methods
ATCSCC	Air Traffic Control System Command Center
ATE	Automatic Test Equipment
AWIPS	Advanced Weather Interactive Processing System
BITE	Built In Test Equipment
BWS	Base Weather Station
CCB	Configuration Control Board
CI	Configuration Item
CONUS	Continental United States
COTS	Commercial Off The Shelf
CPCI	Computer Program Configuration Item
CWSU	Center Weather Service Unit
DOC	Department of Commerce
DOD	Department of Defense
DOT	Department of Transportation
EIA	Electronic Industry Alliance
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FAA	Federal Aviation Administration
FAS	Fault Alarm System
GDSS	Gage Data Support System
GFP	Government Furnished Property
ICD	Interface Control Document
ITWS	Integrated Terminal Weather System
LCC	Life Cycle Cost
LRU	Line (Lowest) Replaceable Unit
MAX	Maximum
MIN	Minimum
MLOS	Microwave Line of Sight
MOC	Meteorological Operational Capability
MSCF	Master System Control Function
MSL	Mean Sea Level
MTBF	Mean Time Between Failures
MTBV	Mean Time Between Visits
MTTR	Mean Time to Repair
NAS	National Airspace System
NCEP	National Center for Environmental Prediction
NEDS	Naval Environmental Display Station
NEXRAD	Next Generation Weather Radar
NIDS	NEXRAD Information Dissemination Service
NIMS	NAS Infrastructure Management System
NOAA	National Oceanic and Atmospheric Administration

Acronym	Description
NMOC	Naval Meteorology and Oceanography Command
NOCD	Naval Oceanography Command Detachment
NWS	National Weather Service
NWSFO	NEXRAD Weather Service Forecast Office
NWSO	NEXRAD Weather Service Office
OJT	On Job Training
ROC	Operational Support Facility
PCPUP	Personal Computer Principal User Processor
PRF	Pulse Repetition Frequency
PRT	Pulse Repetition Time
PUES	Principal User External System
PUP	Principal User Processing
PUPIE	Principal User Processor Interactive Emulator
RDA	Radar Data Acquisition
RF	Radio Frequency
RFC	River Forecast Center
RFI	Radio Frequency Interference
RMS	Remote Monitoring System
RPG	Radar Product Generation
RPIE	Real Property Installed Equipment
SCC	System Command Center
SPC	Storm Prediction Center
SSM	System Status Monitor
STC	Sensitivity Time Control
T&E	Test and Evaluation
TPC	Tropical Prediction Center
TRACON	Terminal Radar Control Facility
UTC	Universal Coordinated Time
WARP	Weather and Radar Processor
WINPUP	Windows-based Principal User Processor
WCS	Writeable Control Store
WFO	Weather Forecast Office
WSFO	Weather Service Forecast Office

APPENDIX H - ADAPTATION PARAMETERS

The NEXRAD adaptation parameters that have been identified are listed in Table H-1. This is not a complete list, and no attempt has been made to maintain this list. The list identifies which parameters are applicable to the RDA, RPG, and PUP functional areas. Following Table H-1, the meaning and use of each adaptation parameter are discussed. The list is intended to be illustrative. The developer will supply a similar list detailing all parameters appropriate to the detailed system design chosen. Nominal values and acceptable ranges for each parameter will be defined by the ROC.

Table H-1 NEXRAD ADAPTATION PARAMETERS

ADAPTABLE PARAMETER	RDA	RPG	PUP
1. Radar Site Lat/Long Coordinate Position	x	x	x
2. Product Distribution:			
Product vs. PUP Functional Area		x	
Product vs. Principal User's External Systems		x	x
Product vs. Other User Interface		x	x
3. Product Selection to Map Background Pairing		x	x
4. Product to User Display Pairing		x	x
5. Product to Color Mix Pairing		x	x
6. Function Key Definition		x	x
7. Function Key Turn-on Setting (per Display)		x	x
8. Cursor Home Location (per Display)		x	x
9. Preview Area Location (per Display)		x	x
10. Cursor Coordinate Output Location (per Display)		x	x
11. Data Array(s) Output Location (per Array; per Display)		x	x
12. Symbol Size; Character Size; Line Width		x	x
13. Blink Rate		x	x
14. Inter-character and Inter-line Spacing of Alphanumeric Array Data		x	x
15. Leader Line to Character of Array Spacing		x	x
16. Data Type to Line Format Pairing		x	x
17. Task Overload Shedding Priority (per Functional Area)	x	x	x
18. Product Overload Shedding Priority (per Functional Area; Interface)	x	x	x
19. Display Preset Center Location (per-Display)		x	x
20. Overload Warning Threshold (per Overload Type)	x	x	x
21. Overload Warning Display (Minimum Time; Maximum Time; Maximum Time Following Overload Recovery)	x	x	x
22. Processor Storage Capacity (On-line)	x	x	x
23. Operational Mode (Initial Setting)	x		
24. Rain Gage Data Acquisition Computer Access Numbers		x	
25. RPG Access Numbers			x
26. Meteorological Phenomena for Alerts		x	x
27. Communication Timeout Periods		x	x
28. Alert Areas		x	x

1. Radar Site Latitude/Longitude Coordinate Position:

   A geographic position on the NEXRAD System geographic grid defining the radar site location to within a 1/4 km resolution.

2. Product Distribution: Product vs. PUP Functional Area (per RPG interface)

   Product Distribution: Product vs. Principal User External Systems (per RPG interface)

   Product Distribution: Product vs. Other User Interface (per RPG interface)

Tables defining the distribution of NEXRAD products. The Product vs. PUP Functional Area tables will be used by the RPG to control the distribution of products to associated and non-associated PUP functional areas. The Product vs. Principal User External Systems tables will be used by a NEXRAD Unit to control the distribution of NEXRAD products from the NEXRAD Unit to a Principal User External System. The Product vs. Other User Interface tables will be used by the NEXRAD Unit to control product distribution to Other Users.

3. Product Selection to Map Background Pairing

The Product Selection to Map Background Pairing adaptation parameter defines the background map(s) which are to be linked to a product selected for display. The actual display of the map data will be dependent upon the operator selection(s) of map types and the operator selection(s) of map content turn on/turn off.

4. Product to User Display Pairing

The Product to Principal User Display Pairing (per interface) adaptation parameter defines a default turn-on condition for each user display.

5. Product to Color Mix Pairing (per PUP)

The Product to Color Mix Pairing adaptation parameter defines a turn-on color selection for the presentation of each data item of each product.

6. Function Key Definition

The Function Key Definition adaptation parameter defines that set of functions performed automatically when a specific function key is selected (activated). Function key examples are product selection, product content turn on/turn off, map selections, map content turn on/turn off, cursor home, magnification selection, test pattern selection/deselection, off-center, preset center, resolution selection, accept queued output message, alarm acknowledge, and enter.

7. Function Key Turn on Setting (per Display)

The Function Key Turn on setting adaptation parameter defines the initial setting for each Function Key for use during system initialization.

8. Cursor Home Location (per Display)

The Cursor Home Location adaptation parameter defines the display location at which the cursor symbol is be displayed.

9. Preview Area Location (per Display)

The Preview Area Location adaptation parameter defines the display location at which the first alphanumeric character will appear on the display when an input message is entered.

10. Cursor Coordinate Output Location (per Display)

The Cursor Coordinate Output Location adaptation parameter defines the display location at which the first character of the cursor coordinate output message will appear on the display when a cursor position control function selection key is activated.

11. Data Array(s) Output Location (per Array; per Display)

The Data Array Output Location adaptation parameters define the size of each alphanumeric data array (number of characters per line, and number of lines) and the display location of the top left character position of each data array.

12. Symbol Size; Character Size; Line Width

The Symbol Size, Character Size, and Line Width adaptation parameters define the alphanumeric and special symbol character font and size in pixels for each character, and the pixels per line for line width.

13. Blink Rate

The Blink Rate adaptation parameter defines the number of times a data item is to be turned on/off in a time period, and the number of display refresh cycles to be used for both the on and the off condition.

14. Inter-character and interline spacing of alphanumeric array data

The Inter-character and interline spacing of array data adaptation parameter defines the number of pixels to be used as spacing between adjacent characters on a line, and the number of pixels to be used as spacing between adjacent lines of characters.

15. Leader Line to Character or Array Spacing

The Leader Line to Character or Array Spacing adaptation parameter defines the number of pixels between the end of a line and the center of a character or the center of a character in one of the four corners of a character array.

16. Data Type to Line Format Pairing

The Data Type to Line Format Pairing adaptation parameter defines the line format (solid, dotted, dashed) to be used for display of each type of line data.

17. Task Overload Shedding Priority (per Functional Area)

The Task Priority for Overload Shedding adaptation parameter defines the order for deleting (not performing) processing tasks when an overload situation occurs. Processing tasks are to be reactivated following elimination of the overload condition. Task reactivation is performed in a manner so as not to cause a cyclic condition between an overload and non-overload condition to occur.

18. Product Overload Shedding Priority (per Functional Area; Interface)

The Data Priority for Overload Shedding/Recovery adaptation parameter defines the order for deleting data when an overload situation occurs on an interface between functional areas, or an interface from a functional area to an external user's system interface or to an other user interface. The recovery from an overload condition is performed automatically. Data types are recovered in the reverse of the shedding order. Data types are recovered one data type at a time with the time delay between the recovery of each data type a part of the adaptation parameter.

19. Display Preset Center Location (per Display)

The Display Preset Center Location adaptation parameter defines the geographic coordinate position of the center of the display.

20. Overload Warning Threshold (per Overload Type)

The Overload Warning Threshold adaptation parameter defines the utilization level that, when reached or exceeded, will result in an overload warning being issued. Overload types include processor, memory, communication interfaces, input data buffers, mass storage, and archival storage utilizations.

21. Overload Warning Display (Minimum Time; Maximum Time Following Overload Recovery)

The Overload Warning Display adaptation parameters define the minimum time an overload message is presented on the display and the maximum time following recovery from an overload condition that an overload message is presented. The minimum time requirement for presentation of an overload takes precedence over the maximum time following recovery from overload requirement.

22. Processor Storage Capacity (Online)

The Processor Storage Capacity adaptation parameter defines the amount of on-line memory available for the operational system.

23. Operational Mode (Initial Setting)

The Operational Mode adaptation parameter defines the radar operational mode to be used following system initialization.

24. Rain Gage Data Acquisition Computer Access Numbers

The Rain Gage Data Acquisition Computer Access Numbers adaptation parameters define the telephone numbers for each rain gage computer.

25. RPG Access Numbers

The RPG Access Numbers adaptation parameters define the telephone numbers of each RPG for the automatic dial-in for NEXRAD products.

26. Meteorological Phenomena for Alerts

The Meteorological Phenomena for Alerts will specify thresholds for all alert categories. Each threshold criterion will contain a set of specific parameter values or phenomenon conditions. This set of adaptable thresholds will be maintained at each RPG.

27. Communication Time-out Periods

The Communication Time-out Periods adaptation parameters define the Time-out periods for the five "timers" identified in the ICD. Specifically, these are Status, Acknowledgment, Busy, Idle, and Interframe.

28. Alert Areas

The Alert Area adaptation parameter allows the PUP operator to define up to two Alert Areas. There is one set of Alert Areas per PUP or RPG Operational Position. Within the defined Alert Area(s) the PUP or RPGOP will be capable of specifying conditions which will cause an alert.

APPENDIX I - OPERATIONAL MODES AND SCANNING STRATEGIES

This Appendix describes Operational Modes and Scanning Strategies and provides a set of criteria for automatic selection/deselection of modes. Additional modes, strategies, and selection/deselection criteria will be defined by the ROC as updates to this Appendix.

1. OPERATIONAL MODES

Operational Modes are designated by capital letters, A, B, C, etc. The following modes are currently defined:

- o Mode A - Precipitation/Severe Weather
- o Mode B - Clear air observation
- o Mode M - Maintenance/Test

2. SCANNING STRATEGIES

Scanning Strategies are designated by Arabic numerals 1, 2,3, etc. The following strategies are currently defined:

a. Fourteen unique elevation angles from the base elevation angle to +20 degrees in elevation for a volume scan time of 5 minutes. The lowest 6 degrees of elevation will have no gaps between the one-way pattern 3 dB points of adjacent elevation scans. The pulse length is 1.57 μsec.

b. Nine unique elevation angles from the base elevation angle to +20 degrees in elevation for a volume scan time of 6 minutes. The lowest 4 degrees of elevation will have no gaps between the one-way pattern 3 dB points of adjacent elevation scans. The pulse length is 1.57 μsec.

c. Five unique elevation angles from the base elevation angle to +5 degrees in elevation for a volume scan time of 10 minutes. There will be no gaps between the one-way pattern 3 dB points of adjacent elevation scans. This scanning strategy will be capable of running using either of the two following different pulse lengths:

   1. Long pulse ≈ 4.71 μsec
   2. Short pulse ≈ 1.57 μsec

3. SELECTION/DESELECTION CRITERIA

An automatic method for deselection of Mode B, clear air observation will be developed. The criterion used for this will be the Precipitation Category (defined in the Precipitation Detection Function described in Appendix D). If the Precipitation Category is 1, a Precipitation/Severe Weather operational mode with a scanning strategy determined by adaptation data will be automatically selected. Automatic deselection of Mode B will not occur when the precipitation category is two (2).

APPENDIX J - METEOROLOGICAL PHENOMENA FOR ALERTS

	ALERT CATEGORIES	RANGE OF COVERAGE (km)	THRESHOLD CRITERIA
a.	Grid Group		
	Velocity (lowest elev)	0-115	Knots: 6 values
	Composite Reflectivity	0-345	dBZ_e: 6 values
	Echo Tops	0-230	K-feet: 4 values
	SWP	0-230	Probability (%): 5 values
	VIL	0-230	Kg/m^2: 6 values
b.	Volume Group[22] (non-grid, algorithm outputs)		
	VAD (lowest elev.)	NA	Knots: 6 values
	Maximum Hail Size	0-230	Inches: 6 values
	MESO	0-230	Uncorrelated Shear, 3-D Correlated Shear, Mesocyclone
	TVS	0-115	Detected
	Max Storm Refl	0-460	dBZ_e: 6 values
	Prob. of Hail	0-230	%: 6 values
	Prob. of Severe Hail	0-230	%: 6 values
	Storm Top	0-460	K-feet: 6 values
	Max 1-hr rainfall accumulation	0-230[23]	inches: 4 values
c.	Forecast Group[24] (Storm oriented)		
	Maximum Hail Size	0-230	Inches: 6 values
	MESO	0-230	Uncorrelated Shear, 3-D Correlated Shear, Mesocyclone
	TVS	0-115	Detected
	Max Storm Refl.	0-460	dBZ_e: 6 values
	Prob. of Hail	0-230	%: 6 values
	Prob. of Severe Hail	0-230	%: 6 values
	Storm Top	0-460	K-feet: 6 values

Expansion provisions will be made to accommodate additional alert categories as follows:

Group 1	1 additional
Group 2	9 additional
Group 3	10 additional

[22]See the NEXRAD Algorithm Report (December 1985) for definitions of outputs listed under Volume and Forecast Groups.

[23]Location of value not required.

[24]See the NEXRAD Algorithm Report (December 1985) for definitions of outputs listed under Volume and Forecast Groups.

APPENDIX K - RADAR CODED MESSAGE CODE

The Radar Coded Message, as described in Item 26, Appendix E, NEXRAD Products, is composed of three parts, preceded by a communications header. Part A, Reflectivity, and Part B, VAD Winds, will be encoded automatically. Part C, Remarks, will be encoded automatically or at the PUP as specified in that part. In the groups below, capital letters represent the fixed part of the group, and small letters represent variables. The message is encoded as follows:

Header .	The header is encoded as follows:
ccc	The communications node (PUP site identifier).
ROBEE or ROBUU	The product category for edited radar coded message. The product category for unedited radar coded message.
sidd(C/R)	Four letter RDA site identifier. (Example: cccROBEE sidd (C/R))

Part A: Reflectivity

Part A of the Radar Coded message (RCM) contains an intermediate graphic product and a tabular listing of alphanumerics. Data in the Radar Coded Message are located with respect to a polar stereographic grid. The local grid at each antenna site is designed to be a subject of the National Radar Grid so that data may be readily composited.

The National Radar Grid has a resolution of 1/4 LFM (Limited Fine Mesh Model) which is 47.625 km at 60 degrees north latitude. The vertical axis of the grid is parallel to the 105 degree west longitude meridian.

At each site, a local grid is chosen having 25 rows and 25 columns, with the antenna site located within the central box. The 25 rows and columns of the grid are assigned letters A through Y, so that the box containing the antenna site is always box MM. Box AA is at the upper left. As shown in Figure K-1, each box is further subdivided to form an overall 1/16 LFM grid.

The graphic product contains reflectivity data for the 1/16 LFM grid over the radar area of coverage out to 460 km. The reflectivity intensity value for each grid box is determined by assigning the maximum value of all Composite Reflectivity boxes whose centers are contained within the 1/16 LFM grid square.

The RCM is based on the 16 level, 4 km x 4 km Composite Reflectivity product but contains only 9 data level categories; 6 for data and 1 for missing or below threshold data within 230 km and 2 for data beyond 230 km. For data beyond 230 km, a separate threshold is provided for which: a) all data above that threshold are labeled as level 8, and b) all data below that threshold are labeled as level 9. The intermediate graphic product is displayed at the RPGOP or PUP for editing by changing or deleting data within outlined areas by using the cursor control device.

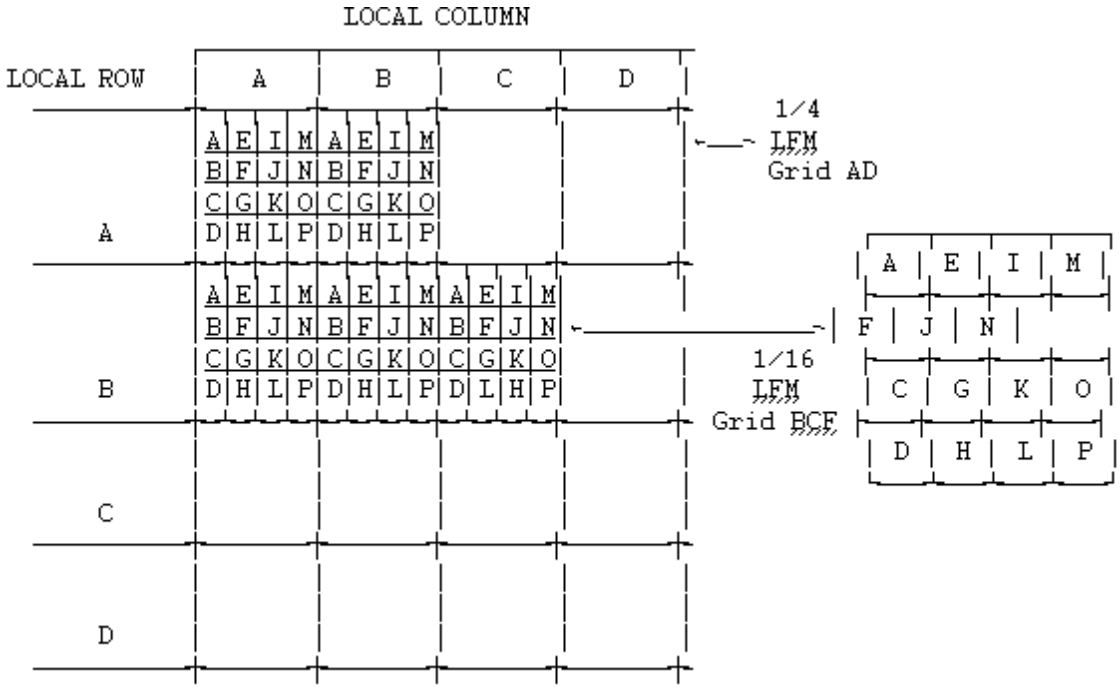

FIGURE K-1 1/16 LIMITED FINE MESH GRID

Figure K-1 1/16 LIMITED FINE MESH GRID

Within the tabular listing, data are provided for the maximum echo top. The height, and the position where provided, is derived from the Echo Tops product. The listing also shows the locations of the largest centroids within 230 km of the radar using the 1/16 LFM grid and provides the forecast centroid speed and direction, as available from the Storm Position Forecast algorithm.

Part A of the message is encoded as follows:

/NEXRAA	Part A indicator.
sidd	Four letter RDA site identifier
ddmmyytttt	The day (dd) of the month (mm), the year (yy), and the time (tttt), to the nearest minute, in Greenwich Mean Time (GMT).
edited or unedited	Status of message
RADNE	A group to encode no reportable reflectivity intensity values is provided, i.e., field NInnnn is zero. This will be corrected after graphic editing.
RADOM	A group to encode radar down for maintenance is provided.
/MDnnnn	A group of six characters to encode operational mode is provided. See Appendix I. Choices are PCPN and CLAR. (Example: /MDPCPN)
/SCnnnn	A group of six characters to encode scan strategy is provided. See Appendix I.

Choices are 1405 (14 scans in 5 minutes), 0906, 0510, etc. (Example: /SC1405)

/NInnnn: The total number (nnnn) of intensities (NI) reported in the following field (gggi) will be encoded. This group will be corrected after editing, if editing is performed. (Example: /NIO144)

gggi Reflectivity intensity is mapped onto the 1/16 LFM grid (ggg). Encode locations and intensities by a series of groups made up of three letters (1/16 LFM) followed by the maximum intensity of the designated grid box. The three letters (in order) are row, column, and sub-grid. The numbers following, represent intensities in succeeding sub-grid boxes in that row. That is, encode each 1/16 LFM grid box from west to east, starting with the northern-most row with data, followed by the next southern row, etc. In the interest of compacting the message, successive intensities of different or similar values may be listed after a single location as long as the intensities are continuous. When succeeding grid boxes contain the same intensity value, the number of succeeding boxes with the same value may be designated by a letter of the alphabet. That is, if 4 succeeding 1/16 LFM grid boxes (a total of five boxes) are at level 2, they could be coded as GGG2D. The "2D" may also be followed by different intensity values. Location/intensity groups are separated by a comma. (Example: ABF112D331,BCA1211)

/MThhh:ggg The location and height (MSL) of the maximum echo top (MT) within 230km radius of the radar are encoded using the three letter grid designator (ggg) and assigning the height coinciding with echo top product in hundreds of feet (hhh). (Example: /MT320:NLB)

/NCENnn: The total number (nn) of centroids (NCEN) reported in this portion of the message is encoded. This number corresponds to the corrected centroids below. (Example: /NCEN04:)

Cnnggg dddfff The centroid (C) number (nn), location (grid box) (ggg), direction from which it is moving (in one degree increments) (ddd), and its speed (fff) in knots, are encoded. Successive groups are separated by commas. If, during editing, data are deleted in a grid box that contains a centroid, this group will be corrected by deleting this centroid. (Example: C03QMB240012)

/ENDAA(C/R) A group to indicate the end of Part A.

The following is a summary example of the components of Part A.

/NEXRAA sidd 2812881330 Edited (C/R)

/MDnnnn /SCnnnn /NInnnn:

gggiii ... i,gggiii...i

/MThhh:ggg

/NCENnn: Cnnggg dddfff,Cnnggg dddfff

/ENDAA (C/R)

Part B: VAD Winds

Part B of the RCM contains a single profile of the horizontal wind information derived from the output of the VAD algorithm.

Part B of the message is encoded as follows:

/NEXRBB — Part B indicator.

sidd — Four letter RDA site identifier

ddmmyytttt — The day (dd) of the month (mm), the year (yy), and the time (tttt), to the nearest minute, in Greenwich Mean Time (GMT).

VADNA — The optional entry VADNA encoded for instances when no VAD wind data are available for the last 15 minutes, if appropriate.

hhhcdddfff — Coded heights (hhh) in hundreds of feet MSL; confidence (c) level, using RMS for the coded height; wind direction (ddd) and wind speed (fff), in knots, coincide with those derived from the VAD Winds product. The confidence level is encoded as a single letter in accordance with the following:

A = RMS of 1 m s^{-1}; B = RMS of 2 m s^{-1};
C = RMS of 3 m s^{-1}; D = RMS of 4 m s^{-1};
E = RMS of 5 m s^{-1}; F = RMS of 6 m s^{-1};
G = RMS of greater than or equal to 7 m s^{-1}.

Wind direction and speed, as output from the VAD algorithm, are reported at up to 19 heights, in feet MSL. Default heights are:

1,000	6,000	12,000	25,000
2,000	7,000	14,000	30,000
3,000	8,000	16,000	35,000
4,000	9,000	18,000	50,000
5,000	10,000	20,000	

(Example: 080C240060)

/ENDBB (C/R) — End of Part B indicator.

The following is a summary example of the components of Part B.

/NEXRBB sidd 2812881330 (C/R)

hhhcdddfff,hhhcdddfff,hhhcdddfff

/ENDBB (C/R)

Part C: Remarks

Part C of the Radar Coded Message contains remarks in an alphanumeric format. Automatically generated remarks provide information on the locations of tornadic vortex signatures, mesocyclones, centroids, storm tops, and hail indices.

The automated portion of Part C is encoded as follows:

/NEXRCC	Part C indicator.
sidd	Four letter RDA site identifier
ddmmyytttt	The day (dd) of the month (mm), the year (yy), and the time (tttt), to the nearest minute, in Greenwich Mean Time (GMT).
/NTVSnn:	The total number (nn) of tornadic vortex signatures (NTVS) detected by the TVS algorithm and reported in Part C is encoded. (Example: /NTVS03:).
TVSnnggg	The location (ggg) and number identifier (nn) of each tornadic vortex signature (TVS) is encoded using the three-letter grid box designator. (Example: TVS02NLB).
/NMESnn:	The total number (nn) of mesocyclones and areas of couplet (NMES) detected by the Mesocyclone Detection algorithm and reported in Part C is encoded. (Example: /NMES05:).
Mnnggg	The location (ggg) and number identifier (nn) of each mesocyclone or area of couplet (M) are encoded using the three-letter grid box designator. (Example: M03JLC).
/NCENnn:	The total number (nn) of centroids (NCEN) reported in Part C is encoded. (Example: /NCEN08:)
Cnnggg ShhhHi	The height (hhh) in hundreds of feet (MSL), of the storm top (S), as derived from the Storm Structure algorithm, for each centroid (C) identified in Part A to include location (ggg) is encoded. The centroid identifier number (nn) is the same as given in Part A. The hail (H) index (i), as provided by the Hail algorithm, is also given as one of the four following data levels: N - no hail; P - possible or probable hail; H - hail; U - unknown. (Example: C04QQD S440HP).

In addition to the automatically generated remarks, Part C provides for optional manual entries. A template is provided containing the fixed part of the groups listed below. The only groups to be sent are those to which data are added. It should be noted that the absence of a remark does not imply that the phenomenon does not exist.

/PCTRyyyy,aaa:gg — Precipitation type and intensity trend. Precipitation type (yyyy) may be coded for a representative area of the display. The type is variable and up to five characters in length. The intensity trend (aaa) is also variable in length and up to three characters in length. The location (gg) is reported using the two letter identifier for the 1/4 LFM grid.

For convective echo systems, the characteristic type of precipitation is defined as that type associated with the maximum observed intensity. For non-convective echo systems, the type of precipitation is defined as that type predominant in horizontal extent. If precipitation is reaching the surface, report that type.

Precipitation	Symbol
Rain	R
Rain Shower	RW
Freezing Rain	ZR
Freezing Rainshower	ZRW
Snow	S
Snow Shower	SW
Drizzle	L
Freezing Drizzle	ZL
Ice Pellet	IP
Ice Pellet Shower	IPW

Designated areas believed to be associated with thunderstorms may use the symbol T preceding the precipitation symbol.

Evaluate the intensity trend in terms of the net change in the characteristic intensity during a period of 1 hour for lines and areas and 15 minutes for cells.

Report the intensity trend as increasing (+) or decreasing (-), if, during the period, the net change in characteristic intensity (dBZe) changes from one intensity level to another.

If the net change in the characteristic intensity during the period does not change categories, report the intensity trend as NC (no change).

Report echo systems as NEW (new development) if they originated during the period specified above. Areas or lines that develop from a cell or cells during the hour preceding the report are reported as NEW.

For a mixed system, consisting of a liquid characteristic type of precipitation and a frozen secondary type, report the intensity trend of the liquid precipitation.

Intensity trend symbols are:

Symbol	Trend
+	Increasing
-	Decreasing
NC	No Change
NEW	New

(Example: PCTRRW,NEW:LO,LP)

/LEWP:gg — A line echo wave pattern (LEWP) is encoded using the two letter 1/4 LFM grid box location (gg). Example: /LEWP:KJ,LK,MK,NK,OK,PL).

/BASEhhh:gg — The base of an elevated layer (BASE) is encoded in hundreds of feet (hhh) (MSL) using the two letter identifier for the 1/4 LFM grid location (gg). (Example: /BASE090:LO,MO).

/MALFhhh:gg — The occurrence of precipitation which is mostly aloft (MALF) is encoded. The height (hhh) is reported in hundreds of feet (MSL). The location (gg) is coded using the two letter identifier for the 1/4 LFM grid. (Example: MALF050:KP,KQ)

/PALFhhh:gg — The occurrence of precipitation which is partially aloft (PALF) is encoded. The height (hhh) is reported in hundreds of feet (MSL) and the location (gg) is the 1/4 LFM grid identifier. (Example: /PALFO50:PM,PN).

/MLTLVLhhh — The height (hhh) of the melting level (MLTLVL) in hundreds of feet (MSL) is encoded. (Example: /MLTLVL075).

/EYEdddfffcc:ggg; LATeee.ex LONeee.ey — The location (ggg) of the eye of a hurricane or tropical storm (EYE), the direction (ddd) from which it is moving and the speed (fff), in knots, of are encoded. Confidence in the fix (cc) is reported as good (GF), fair (FF), or poor (PF). Further, the location of the eye is encoded in latitude (LAT) and longitude (LON). The location is expressed in whole degrees and tenths (eee.e) with provision for specifying north (N), south (S), east (E), or west (W) as appropriate. (Example: \EYE160010GF:00A;LAT28.4N,LON178.5W).

/CSpecificationdddfff:ggg; LATeee.ex LONeee.ey — The location (ggg) of the center of a hurricane or tropical storm (CSpecification), the direction (ddd) from which it is moving and the speed (fff) of movement, in knots, is encoded. Further, the location of the center is encoded in latitude (LAT) and longitude (LON). The location is expressed in whole degrees and tenths (eee.e) with provision for specifying north (N), south (S), east (E), or west (W) as appropriate. (Example: /CSpecification160005:00A,LAT28.4N,LON178.5W).

/REM: — This space is for any other remarks not covered in the above remarks.

/EDITED:int — If the radar coded message has been edited (EDITED) the editor will report such, adding his/her initials (int). (Example: /EDITED:DSS)

/ENDCC (C/R) — End of Part C indicator.

The following is a summary example of the components of Part C:

/NEXRCC sidd 2812881330 (C/R)
/NTVSnn: TVSnnggg,TVSnnggg,TVSnnggg
/NMESnn: Mnnggg,Mnnggg,Mnnggg
/NCENnn: Cnnggg ShhhHi,Cnnggg ShhhHi,Cnnggg ShhhHi

/PCTRyyyy,aaa:gg
/LEWP:gg,gg,gg,gg

/BASEhhh:gg,gg,gg

/MALFhhh:gg,gg
/PALFhhh:gg,gg
/MLTLVLhhh
/EYEdddfffcc:ggg;LATeee.ex,LONeee.ey
/CNTRdddfff:ggg;LATeee.ex,LONeee.ey
/REM:
/EDITED:int
/ENDCC (C/R)

End of Message
At the end of the message, the following group is sent:
/ENDALL (C/R) A group to indicate end of message shall be provided.

APPENDIX L - DELETE

APPENDIX M - DELETED

ANNEX A - EVOLUTIONARY WSR-88D REQUIREMENTS *VERSION 2.0 - DELETED*

The Annex A - Evolutionary WSR-88D Requirements section was moved to a separate document called "Evolutionary Requirements".