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INTERFACE CONTROL DOCUMENT FOR THE ARCHIVE II/USER

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Revision	**Description**	**Date**
-	Update for metadata (B-10) (Pages 3-3, 3-4)	26 May 1998
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A	Remove tape media references. Add network interface and LDM information.	April 2003
B	Incorporate changes to metadata for Open RDA and correct errata.	13 Apr 2005
C	Updated for Build 8.0	08 Feb 2006
D	Updated for Build 10.0 and change of address for Source.	25 March 2008

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1 SCOPE

1.1 Identification

This document defines the Next Generation Weather Radar (NEXRAD) Archive II Interface. This document identifies applicable standards and defines the protocol, syntax, and meaning of the binary data transmission frames. This ICD is not intended to serve as a tutorial document concerning the applicable standards. That is, the reader is assumed to be generally knowledgeable of the contents, terminology, etc., of the standards. This document maps the unique aspects of new Archive II communications into the appropriate standard. Distribution of this document is unrestricted.

1.2 System Overview

The WSR-88D acquires, generates, and distributes Doppler radar products for meteorological and hydrological applications. Specifically, the Radar Data Acquisition (RDA) functional area acquires radar data; controls antenna, transmitter, and receiver electronics; prepares radar data in a digital format; transmits radar data and status to the Radar Product Generator (RPG); and processes control information from the RPG. The RPG functional area receives radar data and status information from the RDA, formats and sends control commands to the RDA, generates radar products, and distributes radar products for graphical and alphanumeric display systems.

The Archive II functionality provides WSR-88D data to a local server running the Unidata Local Data Manager (LDM) software. The data can then be distributed to external users.

2 REFERENCE DOCUMENTS

The following documents are referenced herein. In the event of a conflict between the documents referenced herein and the contents of this document, the contents of this document shall be considered a superseding requirement.

2.1 Specifications:

2810000F	WSR-88D System Specification
2620002F	Interface Control Document for RDA/RPG
Source:	WSR-88D Radar Operations Center 1313 Halley Circle Norman, OK 73069 URL: http://www.roc.noaa.gov

2.2 Other Publications:

Unidata LDM Documentation	Local Data Manager (LDM) Documentation and Software
Source:	UCAR Office of Programs Unidata Program Center P.O. Box 3000 Boulder, CO 80307-3000 URLs: http://www.unidata.ucar.edu http://my.unidata.ucar.edu/content/software/ldm
Michael Burrows and D. J. Wheeler: 5/10/94. Digital SRC Research Report 124.	A block-sorting lossless data compression algorithm. (This is the basis for bzip2). ftp://ftp.digital.com/pub/DEC/SRC/research-reports/SRC-124.ps.gz
libbzip2 version 1.0.2.	bzip2 library by Julian Seward
bzip2 and libbzip2	The bzip2 and libbzip2 official home page.
Source:	The bzip2 utility used in this ICD is a component of the RedHat Enterprise Linux Operating System. The source can be found at: URL: http://www.bzip.org
MIL-STD-1777	Internet Protocol
MIL-STD-1778	Transmission Control Protocol
Source:	Documentation Automation and Production Service Building 4/D 700 Robins Avenue Philadelphia, PA 19111-5094
ISO 8802-2: 1989 ANSI/IEEE 802.2-1989	Part 2: Logical link Control
ISO/IEC 8802-3: 1993 ANSI/IEEE 802.3-1993	Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
Source:	American National Standards Institute 11 West 42nd Street 13th Floor New York, NY 10036 URL: http://www.ansi.org
IEEE P802.3u/D5, March 1995	IEEE Draft Standard for Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications: Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100 Mb/s Operation (version 5.0). Draft Supplement to 1993 version of ANSI/IEEE Std 802.3, 100BASE-T
Source:	IEEE Standards Office 445 Hoes Lane Piscataway, NJ 08855-1331

2.3 Request For Comments (RFCs)

Reference Number	Title
RFC 894	IP over Ethernet
RFC 826	Address Resolution Protocol
RFC 793	Transmission Control Protocol
RFC 791	Internet Protocol
Source:	Internet Architecture Board (IAB) Internet Engineering Task Force (IETF) URL: http://www.ietf.org/home.html

3 ARCHIVE II PHYSICAL LAYER

3.1 Applicable Standard

The physical layer will contain a LAN interface as specified in either the ANSI/IEEE 802.3 (10 Mbps) or 802.3u (100 Mbps) Standard with the following caveat: The 2 octet length field that is specified in paragraph 3.2.6 of the ANSI/IEEE 802.3 Standard will be used as a type field for the interface as specified in the DIX Ethernet standard, version 2.0. This variance is allowed by Note 7 to paragraph 3.2.6 of the ANSI/IEEE 802.3 Standard as long as the value of this field exceeds 0x05EE (hex), which is the maximum IEEE 802.3 frame size. All values that will be used in this interface for this field, as specified in the DIX Ethernet Version 2.0 standard are 0x0800 and larger.

3.2 Communications Medium, Transfer Rates, Mechanical Connection

A physical layer LAN port connection will be provided on an RPG LAN switch. Refer to the RPG hardware drawings for specific cable or hardware information.

3.2.1 10 MBps

The baseband medium for a 10 Mbps network will be twisted pair cable, as specified in the ANSI/IEEE 802.3 Standard, paragraphs 10.5 and 14.1.1.3 respectively. This baseband medium and its associated Medium Attachment Units (MAU) are referred to as type 10BASET in the ANSI/IEEE 802.3 Standard. The maximum segment length of 10BASET segments will be no longer than 100 meters.

3.2.2 100 MBps

The baseband medium for a 100 Mbps network will be Category 5 twisted pair cable, as specified in the draft ANSI/IEEE 802.3u Standard. This baseband medium and its associated Medium Attachment Units (MAU) are referred to as type 100BASET in the draft ANSI/IEEE 802.3u Standard. The maximum segment length of 100BASET segments will be no longer than 100 meters.

4 ARCHIVE II DATA LINK LAYER

4.1 Applicable Standard

The data link layer, which is composed of the Media Access Control (MAC) and Logical Link Control (LLC) sublayers for this interface, will be implemented as specified in the ANSI/IEEE 802.3 standard for the MAC sublayer and as specified in ANSI/IEEE 802.2 for the LLC sublayer.

4.2 Media Access Control Procedure

The media access control (MAC) sublayer mechanism for this interface will be Carrier Sense Multiple Access with Collision Detection (CSMA/CD) as specified in sections 3.0 and 4.0 of the ANSI/IEEE 802.3 Standard. The "improved" IEEE 802.3 MAC mechanism that listens for the carrier to return during the first part of inter-packet gap, as described in the ANSI/IEEE 802.8 Standard, will be implemented in the MAC sublayer for this interface. (The ANSI/IEEE 802.3 Standard specifies the physical layer as well as the MAC sublayer for this interface.)

4.3 Logical Link Control

The Logical Link Control (LLC) sublayer protocol for this interface will be implemented as specified in the ANSI/IEEE 802.2 standard.

5 ARCHIVE II NETWORK LAYER

5.1 Applicable Standard

The network layer for this interface will support the Internet Protocol (IP) as specified in RFC 791 and MIL-STD 1777 and as clarified in RFCs 950, 919, 922, and 1122. The Internet Control Message Protocol (ICMP) [RFC 792] and Address Resolution Protocol (ARP) [RFC 826] will also be implemented for this interface. Subnet and host addresses for this interface will be assigned as appropriate.

5.2 Internet Protocol (IP) Description

The Internet Protocol (IP) supports network layer data exchanges. The network layer provides the transparent transfer of data between transport entities. The IP addresses for the network nodes and data hosts are not publicly published.

6 ARCHIVE II TRANSPORT LAYER

6.1 Applicable Standard

The transport layer for this interface will support the Transmission Control Protocol (TCP) as specified in RFC 793 and MIL-STD 1778 and as clarified in RFC 1122.

6.2 Transport Header Description

Connection-oriented transport service is implemented using TCP. TCP is a connection-oriented, end-to-end reliable protocol designed to fit into a layered hierarchy of protocols which support multi-network applications. It provides for guaranteed delivery of data between pairs of processors in host computers attached to networks outside the WSR-88D system. The TCP port number used will be the well-known LDM TCP port 388.

7 ARCHIVE II APPLICATION LAYER

The OSI Model Session, Presentation, and Application layers are defined by an Applications Programming Interface (API), and the format of the messages which are transferred.

7.1 Application Programming Interface (API)

The interface between TCP and an application process consists of a set of calls much like the calls an operating system provides to an application process for manipulating files. There are calls to open, put, get, or close the LDM data store queues. The Archive II application uses the LDM API to manage the data and the TCP/IP transmission protocols.

7.1.1 LDM Overview

Unidata's Local Data Manager (LDM) software acquires data and shares them with other networked computers. A data product is treated as an opaque unit, thus nearly any data can be relayed. In particular, the LDM can handle data from different data streams. Data can either be ingested directly from a data source by a client ingestor, or the LDM server can talk to other LDM servers to either receive or send data. Ingestors scan the data stream, determine product boundaries, and extract products, passing those products on to the server product queue. The data, in turn, can be processed locally and/or passed on to other LDM servers.
The LDM server software used by Archive II is configured to store products and allow them to be forwarded to other LDM servers.

7.1.2 LDM Distribution

The Unidata Program Center distributes the LDM software via FTP and WWW at http://www.unidata.ucar.edu/packages/ldm/. Note: LDM data should not be shared outside the receiving organization without the approval of the data provider.

7.1.3 LDM Support

For further information contact:
UCAR Unidata Program Center
P.O. Box 3000
Boulder, Colorado, USA 80307
(303) 497-8643
Internet: *support@unidata.ucar.edu*

7.1.4 LDM Platforms

The LDM is designed to run on a UNIX/Linux workstation. The following items comprise the minimum platform requirements: UNIX/Linux workstation, adequate disk storage for data, TCP/IP Ethernet, standard C compiler (unless the LDM binary version is downloaded), and Perl. The workstation must also maintain a monotonic clock accurate to within one second.

7.2 Connection Procedure

Based upon entries in its ldmd.conf file, the user's LDM server initiates data exchange with another LDM server by establishing a network connection and requesting data. If the other LDM's ldmd.conf file contains an entry to accept the request, the connection is made and data transferred.

7.3 Data Exchange

This section describes the end-user data structures and values used to store and retrieve Archive II data with the LDM. It also covers the data structures unique to the Archive II data in the LDM context.

7.3.1 LDM Database Keys

Each LDM data record is assigned a key and feedtype when it is placed into the LDM queue. This key is used to assemble and gather like data records. The key is crucial to correctly assembling the records that comprise a complete volume of NEXRAD data. The LDM feedtype for Archive II is **NEXRD2**. See Appendix B - LDM Key Format for a detailed description of the format.

7.3.2 Archive II Data Stream

Within the LDM storage context, at the beginning of the Archive II data stream is an Archive II Volume Header Record. The Volume Header Record is fixed length and contains information uniquely identifying the format and the data that follows. Following the Volume Header Record are variable-length records containing the Archive II data messages. These records are referred to as LDM Compressed Record(s).

7.3.3 Volume Header Record

At the start of every volume is a 24-byte record describing certain attributes of the radar data. The first 9 bytes is a character constant of which the last 2 characters identify the version. The next 3 bytes is a numeric string field starting with the value 001 and increasing by one for each volume of radar data in the queue to a maximum value of 999. Once the maximum value is reached the value will be rolled over. The combined 12 bytes are called the Archive II filename. The next 4 bytes contain the NEXRAD-modified Julian date the volume was produced in the RDA followed by 4 bytes containing the time the volume was recorded. The date and time integer values are big Endian. The last 4 bytes contain a 4-letter radar identifier assigned by ICAO. See Figure 1 for header format.

9 bytes	3 bytes	4 bytes	4 bytes	4 bytes
Tape Filename:‘AR2V00 xx.’*	Extension Number: '001'	Date**: NEXRAD-modified Julian	Time***: Milliseconds past midnight	ICAO of radar

* Version 01: Legacy Message 1; Version 02: Message 31, Legacy Resolution; Version 03: Message 31, Super Resolution; Version 04: Message 31, Recombined Super Resolution
**Days since 1/1/1970 where 1/1/1970 equals day 1
***The Archive II data timestamp (see Figure 3) comes from the RDA.

Figure 1. Start of Volume Header Record Format

7.3.4 LDM Compressed Record

The structure of the LDM Compressed Record is a 4-byte, big-endian, signed binary control word followed by a compressed block of Archive II data messages. The control word contains the size, in bytes, of the compressed block not including the control word itself. As the control word contains a negative size under some circumstances, the absolute value of the control word must be used for determining the size of the block.

The first compressed record is the Metadata Record, consisting of 134 messages (see section 7.3.5 Metadata Record for detailed information). Following the Metadata Record is a variable number of compressed records containing 120 radial messages (type 1 or 31) plus 0 or more RDA Status messages (type 2). The method of compression used to build the compressed block is the bzip2 implementation of the Burrows-Wheeler block sorting text compression algorithm and Huffman coding.

7.3.5 Metadata Record

The first LDM Compressed Record contains the Archive II messages comprising the Archive II metadata. The size of the uncompressed metadata is fixed at 134 messages, ie. 325888 bytes. The following table contains the message types in the sequence in which they are placed in the LDM Compressed Record. It contains the number of 2432 byte message segments set aside for each message type when they are uncompressed. In those instances where the message requires fewer segments than indicated the message type field of the excess message segments will be set to zero.

Message Type	Number of Segments
15	77
13	49
18	5
3	1
5	1
2	1

7.3.6 LDM Data Processing

The end user of Archive II data can use the LDM software to collect and manage the data. Data passed to the LDM server are processed in a variety of ways; how specific data are processed is determined by data identifiers and a configuration file called pqact.conf. Processing actions include placing the data in files and running arbitrary programs on the data. Decoders are also available from Unidata that interface with the LDM and convert data into the forms required by various applications.

7.3.6.1 LDM Data Processing Example

The end user can take advantage of the LDM pqact which uses pattern matching to specify what actions are performed on each product after it is received or placed into the LDM queue. Pqact uses a configuration file called pqact.conf to set up the table of patterns and associated actions for products. This file is human-readable and editable. It contains a list of pattern-action entries, where a pattern is a (feed type, regular expression) pair. For example, the following entry could be placed into the pqact.conf file:

NEXRD2<TAB>^L2-([^/]*)/(....)/([0-9][0-9][0-9][0-9][0-1][0-9][0-3][0-9][0-2][0-9][0-5][0-9][0-9][0-9]) /(.*)/(.*)/(.)/(V0[1-4])/(.) <TAB>FILE<TAB>/export/home/ldm/data/\2/\3.raw

Note that the character string "<TAB>" is not part of the entry, rather it is used in this example to show where a horizontal tab character is required. This regular expression in the pqact.conf file is based upon the database key, and will cause all the volume data to be placed into a directory corresponding to the radar identifier (Key Field 2). Each volume of data will be in a file named after the date and time (Key Field 3) of that volume number (i.e. 20021016094746.raw). Key Field 6 is a single character denoting Start of Volume (S), Intermediate Data (I), or End of Volume (E). Key Field 7 is version number of the form Vxx where x takes on the values defined in Figure 1. Key Field 8 is a spare for future use. For more information refer to the LDM documentation. The format of this raw file is described Figure 2.

7.3.6.1.1 LDM Raw Data File Format

To exploit the Archive II data the end user must develop a program to extract and decompress the data stored in the LDM raw data file. The libbz2 library function BZ2_bzBuffToBuffDecompress can be used to decompress the LDM Compressed Record. Once decompressed each message requires 2432 bytes of storage with the exception of Message Type 31 (Digital Radar Data Generic Format) which is variable length.

Volume Header Record A 24-byte record that is described in Figure 1. This record will contain the volume number along with a date and time field.
LDM Compressed Record A record that is bzip2 compressed. It consists of Metadata message types 15, 13, 18, 3, 5, and 2. See section 7.3.5.
LDM Compressed Record A variable size record that is bzip2 compressed. It consists of 120 radial data messages (type 1 or 31) plus 0 or more RDA Status messages (type 2). The last message will have a radial status signaling “end of elevation” or “end of volume”. See paragraph 7.3.4.
Repeat (LDM Compressed Record) Or End of File (for end of volume data)

Figure 2. Raw File Format

7.3.6.2 NCDC Data Format

This document does not describe any other stored NEXRAD data formats once the data leaves the LAN. The data provided to the public by NCDC is stored in a different format. For NCDC formats, refer to NCDC documentation.

7.4 Disconnection

The RPG user can stop and start putting Archive II data into the LDM queue. It does not disconnect the LDM transfer stream. The downstream LDM server will remain connected waiting for new Archive II data to ingest.

7.5 Archive II Data

7.5.1 Functional Description

Eight (8) RDA message types are archived:

* Message Type 1	Digital Radar Data
* Message Type 2	RDA Status Data
* Message Type 3	RDA Performance/Maintenance Data
* Message Type 5	RDA Volume Coverage Data
* Message Type 13	RDA Clutter Filter Bypass Map
* Message Type 15	RDA Clutter Map Data
* Message Type 18	RDA Adaptable Parameters
* Message Type 31	Digital Radar Data Generic Format

Message types 2, 3, 5, 13, 15 and 18 constitute the Archive II metadata. The metadata describes the operational environment of the RDA at the time the Archive II Digital Radar data was recorded.

7.6 Archive II Message Types

The messages following the Archive II filename are formatted according to the RDA/RPG ICD. Each message is comprised of a message header followed by a data segment. The type of data contained within the message is identified by the message type field within the message header. Figure 3 illustrates the message header format. The contents of the message header along with the eight (8) message types contained in the Archive II file are briefly described in this ICD. See the RDA/RPG ICD for more details.

MSB	8	8	8	8	LSB
FW1	Message Size		RDA Channel	Message Type	4 FW of Message Header
FW2	ID Sequence Number		Modified Julian Date		
FW3	Milliseconds of Day				
FW4	Number of Message Segments		Message Segment Number		
	Message Data Segment				

Figure 3. Message Header Format

7.6.1 Message Type-1 Digital Radar Data

Message type 1, Digital Radar Data, contains one (1) radial of data.

7.6.2 Message Type-2 RDA Status Data

Message type 2, RDA Status Data, contains the state of operational functions within the RDA and is written out to the Archive II interface each time the status of the RDA changes. There will be at least one RDA Status Data message written to the Archive II interface per Archive II volume. The message 2 data is also written to the Archive II interface whenever the RPG requests the status of the RDA.

7.6.3 Message Type-3 RDA Performance/Maintenance Data

Message type 3, RDA Performance/Maintenance Data, is written to the Archive II interface once per Archive II volume.

7.6.4 Message Type-5 RDA Volume Coverage Pattern Data

Message type 5, RDA Volume Coverage Pattern, is written to the Archive II interface once per Archive II volume.

7.6.5 Message Type-13 RDA Clutter Filter Bypass Map Data

Message type 13, RDA Clutter Filter Bypass Map, is written to the Archive II interface once per Archive II volume.

7.6.6 Message Type-15 RDA Clutter Map Data

Message type 15, RDA Clutter Map, is written to the Archive II interface once per Archive II volume.

7.6.7 Message Type-18 RDA Adaptation Data

Message type 18, RDA Adaptation Data, is written to the Archive II interface once per Archive II volume.

7.6.8 Message Type-31 Digital Radar Data Generic Format

Message type 31, Digital Radar Data Generic Format, contains one (1) radial of data.

7.7 Message Sequence

Following the Volume Header Record is the RDA metadata for that volume. RDA metadata (Message Types 2, 3, 5, 13, 15, and 18) consists of all pertinent RDA data that was in effect when the volume of RDA Digital Radar Data was recorded (Message Type 1 or 31). This pool of metadata is compressed and written to the LDM queue at the start of every volume. After the metadata is written out, message types 1, 2, and 31 will be gathered and written to the LDM queue as described in the earlier sections.

Message types 2, 3, 5, 13, 15 and 18 are written to the Archive II queue in the following sequence (see Figure 4):

Message Type 15 – Clutter Map Data
Message Type 13 – Clutter Filter Bypass Map Data
Message Type 18 – Adaptation Data
Message Type 3 – Performance/Maintenance Data
Message Type 5 – Volume Coverage Pattern Data
Message Type 2 – RDA Status Data

Figure 4. Message Type Sequence

RDA Status Data, Message Type 2, is written to the Archive II interface as the status of the RDA changes. There will be at least one Message Type 2 written to the Archive II interface per Archive II volume containing a complete RDA Volume Scan. The structure of the data associated with Message Types 1, 2, 3, 5, 13, 15, 18, and 31 are defined in the RDA/RPG ICD.

APPENDIX A - ACRONYMNS/ABBREVIATIONS

Acronym/ Abbreviation	**Description**
ANSI	American National Standards Institute
ARP	Address Resolution Protocol
bps	Bits per Second
bzip2	Data Compression algorithm used
CCITT	Consultative Committee for International Telegraph and Telephone
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
FCS	Frame Check Sequence
FW	Full Word, four octets addressed by the location of either the high-order or low-order octet. Usually an address that is 0 modulo 4.
I/O	Input/Output
IAB	Internet Architecture Board
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ISO	International Standards Organization
LAN	Local Area Network
LDM	Unidata Local Data Manager
LLC	Logical Link Control
LSB	Least Significant Bit
MAC	Media Access Control
Mbps	Million Bits per Second
MSB	Most Significant Bit
NCDC	National Climatic Data Center
NEXRAD	Next Generation Weather Radar
NEXRD2	LDM Feedtype for Archive II data
ORDA	Open Radar Data Acquisition
OS	Operating System
OSI	Open Systems Interconnection
RDA	Radar Data Acquisition
RFC	Request for Change (IAB)
RH	NWS Regional Headquarters; Eastern, Southern, Central, and Pacific.
RPG	Radar Product Generator
SCN	Specification Change Notice
TCP/IP	Transmission Control Protocol/ Internet Protocol
VCP	Volume Coverage Pattern
WFO	Weather Forecast Office

APPENDIX B - LDM KEY FORMAT

L2-{CMPR_TYPE}/{ICAO}/{DATE_TIME}/{VOL}/{REC}/{S/E/I}/{Vxx}/0

CMPR_TYPE –Data Compression type in ASCII. At the time of publication only "BZIP2" is used.
ICAO – Radar identifier in ASCII. The four uppercase character International Civil Aviation Organization identifier of the radar producing the data.
DATE_TIME – The date and time in yyyymmddHHMMSS format. Where yyyy is year, mm is month, dd is day, HH is hour, MM is minute, and SS is second. This date and time comes from the radar time in Figure 2.
VOL – The Volume ID 1-999. This will be the same number as the extension number found in the Volume Header Record.
REC – The current record number in the volume. A record is a group of Archive II messages grouped and compressed together. The record number starts at 1.
S/E/I – Record status. **S** indicates the first record of a volume, **E** indicates the last record of a volume and **I** indicates an intermediate record.
Vxx – The version number where xx is a 2 digit integer. Version 01: Legacy Message 1; Version 02: Message 31, Legacy Resolution; Version 03: Message 31, Super Resolution; Version 04: Message 31, Recombined Super Resolution
SPARE – Last field is hard coded as "0" and reserved for future use.
Example 1: L2-BZIP2/KTLX/20021016155526/154/4/I/V03/0 This example shows a key for a BZIP2 compressed record number 4 of volume 154 from the KTLX radar on 10/16/2002 at 15:55:26. The data is Message 31, Super Resolution. **Example 2:** L2-BZIP/KTLX/20021016155526/154/43/E/V04/0 This example shows a key for a BZIP2 compressed record number 43 of volume 154 from the KTLX radar on 10/16/2002 at 15:55:26 with an "E"nd of volume marker. The next record should start volume 155. The data is Message 31, Recombined Super Resolution.