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INTERFACE CONTROL DOCUMENT FOR THE SPG TO ARCHIVE II/USER

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1 SCOPE

1.1 Identification

This document defines Terminal Doppler Weather Radar (TDWR) 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 TDWR acquires, generates, and distributes Doppler radar products for meteorological and hydrological applications. Specifically, the TDWR 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 Supplemental Product Generator (SPG). The SPG functional area receives radar data and status information from the TDWR, generates radar products, and distributes radar products for graphical and alphanumeric display systems such as the Advanced Weather Information Processing System (AWIPS). AWIPS also sends data to the SPG in the form of Model Data to be used in radar product generation.

The Archive II functionality provides TDWR radar data to the National Level-II Network via the Unidata Local Data Manager (LDM) software. The data is then distributed to various level-II top tiers and ultimately the level-II user community.

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:

2810003	SPG System Specification For NWS use of TDWR
2620063	Interface Control Document for SPG to Class 1 User
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

2.3 Request For Comments (RFCs)

Reference Number	**Title**
RFC 793	Transmission Control Protocol
RFC 4506	External Data Representation
Source:	Internet Architecture Board (IAB) Internet Engineering Task Force (IETF) URL: http://www.ietf.org/home.html

3 ARCHIVE II TRANSPORT LAYER

3.1 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.

3.2 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 TDWR/SPG system. The TCP port number used will be the well-known LDM TCP port 388.

4 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.

4.1 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.

4.1.1 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. 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.

4.1.2 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.

4.1.3 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*

4.1.4 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.

4.2 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 allow the request, the connection is made and data transferred.

4.3 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.

4.3.1 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 assemble the records that comprise a complete volume of TDWR Level II data. The LDM feedtype for Archive II is **NEXRD2**. See Appendix B - LDM Key Format for a detailed description of the format.

4.3.2 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).

4.3.3 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 SPG-modified Julian date of the start of volume radial followed by 4 bytes containing the time of the start volume radial. The date and time integer values are big Endian format. 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:'AR2V0 0xx.'*	Extension Number: '001'	Date**: SPG-modified Julian	Time***: Milliseconds past midnight	ICAO of radar

* xx indicates version where:
Version 08: TDWR/SPG Level II data
**Days since 1/1/1970 where 1/1/1970 equals day 1
***The Archive II data timestamp comes from the TDWR radar data.

Figure 1. Start of Volume Header Record Format

4.3.4 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 31) plus 0 or more TDWR/SPG 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.

Following the variable number of radial message records is an optional Model Data compressed record. This record consists of the Model Data message (type 29). The Model Data message consists of the standard RDA/SPG message header (See Appendix C) following by model data. The message size defined in the message header is expressed using an alternate method for specifying size for messages larger than 65534 halfwords (see Appendix C). The format of the model data is described in the Interface Control Document for SPG to Class 1 User, 2620063.

4.3.5 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, or 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. For the TDWR/SPG metadata record, space is reserved for potential future additions and consists of 132 2432 byte segments. Each segment has the message type field set to zero.

Message Type	**Number of Segments**
Reserved	132
5	1
2	1

4.3.6 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.

4.3.6.1 **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[8])/(.) <TAB>FILE<TAB>/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. 20191016094746.raw). Key Field 6 is a single character denoting Start of Volume (S), Intermediate Data (I), End of Volume (E) or (M) Model Data. 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.

4.3.6.1.1 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) and Message type 29 which are variable length. Message 29 is also formatted using External Data Representation (XDR).

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)
Optional LDM Compressed Record A record that is bzip2 compressed consisting of the Model Data message. See paragragh 7.3.4.

Figure 2. Raw File Format

4.3.6.2 NCEI Data Format

This document does not describe any other stored TDWR/SPG data formats once the data leaves the SPG. The data provided to the public by NCEI may be stored in a different format. For NCEI formats, refer to NCEI documentation.

4.4 Disconnection

The SPG 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.

4.5 Archive II Data

4.5.1 Functional Description

Four (4) message types are archived. Three (3) message types are TDWR/SPG and one (1) is SPG:

* Message Type 2	TDWR/SPG Status Data
* Message Type 5	TDWR Volume Coverage Data

* Message Type 29	Model Data Message
* Message Type 31	Digital Radar Data Generic Format

Message types 2 and 5 constitute the Archive II metadata. The metadata describes the operational environment of the TDWR/SPG at the time the Archive II Digital Radar data was recorded.

4.6 Archive II Message Types

The messages following the Archive II filename are formatted according to the Appendix C except message type 29 which is formatted according to the SPG to Class 1 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.

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. The Archive II raw data format contains a 28-byte header. The first 12 bytes are empty, which means the "Message Size" does not begin until byte 13 (halfword 7 or full word 4). This 12 byte offset is due to legacy compliance (previously known as the "CTM header"). See Appendix C for more details (Message Header Data).

4.6.1 Message Type-2 RDA Status Data

Message type 2, TDWR/SPG Status Data, contains the state of operational functions within the TDWR/SPG and is written out to the Archive II interface each time the status of the TDWR/SPG changes. There will be at least one TDWR/SPG Status Data message written to the Archive II interface per Archive II volume. See Appendix C for details.

4.6.2 Message Type-5 RDA Volume Coverage Pattern Data

Message type 5, TDWR Volume Coverage Pattern, is written to the Archive II interface once per Archive II volume. See Appendix C for details.

4.6.3 Message Type-29 Model Data Message

The Message Type 29, Model Data Message, is written to the Archive II interface after the Archive II volume whenever Model Data is sent to the SPG from AWIPS. Model Data is received at the SPG approximately once every hour near the top of the hour.

4.6.4 Message Type-31 Digital Radar Data Generic Format

Message type 31, Digital Radar Data Generic Format, contains one (1) radial of data. See Appendix C for details.

4.7 Message Sequence

Following the Volume Header Record is the TDWR/SPG metadata for that volume. TDWR/SPG metadata (Message Types 2, and 5) consists of all pertinent TDWR/SPG data that was in effect when the volume of TDWR/SPG Digital Radar Data was recorded (Message Type 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 2 and 31 will be gathered and written to the LDM queue as described in the earlier sections. Following the end of the volume, an optional message type 29 is written to the LDM queue.

The Reserved segments and message types 2 and 5 are written to the Archive II queue in the following sequence (see Figure 3):

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 3. Message Type Sequence

TDWR/SPG Status Data, Message Type 2, is written to the Archive II interface as the status of the TDWR/SPG changes. There will be at least one Message Type 2 written to the Archive II interface per Archive II volume containing a complete TDWR/SPG Volume Scan. The structure of the data associated with Message Types 2, 5, and 31 are defined in Appendix C.

The structure of the data associated with Message Type 29 is defined in Appendix C (for the message header) and the SPG to Class 1 User for the model data.

5 APPENDIX A ACRONYMNS/ABBREVIATIONS

Acronym/ Abbreviation	Description
ANSI	American National Standards Institute
AWIPS	Advanced Weather Information Processing System
bzip2	Data Compression algorithm used
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
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
IP	Internet Protocol
ISO	International Standards Organization
LAN	Local Area Network
LDM	Unidata Local Data Manager
LSB	Least Significant Bit
MAC	Media Access Control
Mbps	Million Bits per Second
MSB	Most Significant Bit
NCEI	National Centers for Environmental Information
NEXRAD	Next Generation Weather Radar
NEXRD2	LDM Feedtype for Archive II data
OS	Operating System
OSI	Open Systems Interconnection
RDA	TDWR Radar Data Acquisition
RFC	Request for Change (IAB)
RH	NWS Regional Headquarters; Eastern, Southern, Central, and Pacific.
SPG	Supplemental Product Generator
SCN	Specification Change Notice
TCP/IP	Transmission Control Protocol/Internet Protocol
TDWR	Terminal Doppler Weather Radar
VCP	Volume Coverage Pattern
WFO	Weather Forecast Office
XDR	External Data Representation

6 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/M – Record status. **S** indicates the first record of a volume, **E** indicates the last record of a volume and **I** indicates an intermediate record and M indicats a Model Data record.
Vxx – The version number where xx is a 2 digit integer. See text under Figure 1 for a list of version numbers and their meanings.
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 may be a Model Data record, otherwise the next record should start volume 155. The data is Message 31, Recombined Super Resolution.

7 APPENDIX C MESSAGE FIELDS DEFINED FOR SPG LEVEL II DATA

All message types include a 16 byte RDA/SPG message header that identifies the type, size and date/time of the message:

RDA/SPG Message Header Data

NAME	DESCRIPTION (3)	FORMAT	UNITS (4)	RANGE	ACCURACY/ PRECISION	BYTE LOCATION
Message Size	Message size in halfwords (1)	Integer*2	halfword	9 to 65535	1	0 and 1
RDA Redundant Channel	Channel Numbers for: 8 = Single Channel (bit 3 set) 9 = Redundant Channel 1 (bits 3 & 0 set) 10 = Redundant Channel 2 (bits 3 & 1 set)	Integer*1	N/A	0 to 10	1	2
Message Type	Integer code from Table I	Integer*1	N/A	2, 5, 29, or 31	N/A	3
I.D. Sequence Number	Message Sequence Number	Integer*2	N/A	0 to 65535 then roll over to 0	1	4 and 5
Julian Date	Julian Date - 2440586.5 (2)	Integer*2	d	1 to 65,535	1	6 and 7
Milliseconds of Day	Number of milliseconds from Midnight, Greenwich Mean Time	Integer*4	msec	0 to 86,399,999	± 2000/ ± 1	8 to 11
Number of Message Segments	Message larger than 1208 halfwords are segmented and transmitted separately except for Message 31 that has a segment size of 65535 halfwords (5)	Integer*2	N/A	1 to 65535	1	12 and 13
Message Segment Number	Segment number of this message	Integer*2	N/A	1 to 65535	1	14 and 15

Notes:

1. This is the message size for this message segment, not for the total of all segments in the message.
2. 1 January 1970 00.00 Greenwich Mean Time = 1 Modified Julian Date.
3. All bit locations are referenced to location 0 (LSB).
4. See Appendix A for unit definitions and standard symbology.
5. For all Data Message Types, the maximum segment size is 1208 halfwords except for Message Type 31, Digital Radar Data Generic Format, which can have a segment as large as 65535 halfwords.

Following the Message Header, are message data applicable to the message type. The message format for RDA Status (Message Type 2), RDA VCP Data (Message Type 5) and Radial Message (Message Type 31) are defined below. For SPG Level II data, not all message fields

are available or applicable, whereas others are set to fixed values that will not change. This Appendix describes possible values for various messages. Unless otherwise noted, fields that are not applicable or not available will be set to the value zero (0). (**Note: Not Applicable refers to those items in which the information is not pertinent, e.g., Dual Pol specific values. Not Available refers to those items which are applicable but the specific value is unknown, e.g., calibration constant**).

TDWR Status (Message Type 2):

NAME	DESCRIPTION	FORMAT (1), (2)	UNITS (5)	RANGE (OR VALUE)	ACCURACY/ PRECISION	HALFWORD LOCATION
RDA STATUS	• Start-Up • Operate • Offline-Operate	Code*2 (4)	N/A	As Listed • 2 (bit 1 set) • 16 (bit 4 set) • 64 (bit 6 set)	N/A	1
OPERABILITY STATUS	• RDA - On-line • RDA - Inoperable	Code*2	N/A	As Listed • 2 (bit 1 set) • 32 (bit 5 set)	N/A	2
CONTROL STATUS	• Local Only	Code*2	N/A	As Listed • 2 (bit 1 set)	N/A	3
AUXILIARY POWER GENERATOR STATE	Not Applicable	Integer*2	N/A	0	N/A	4
AVERAGE TRANSMITTER POWER	Not Applicable	Integer*2	W	0	+/- 1 +/- 1	5
HORIZONTAL REFLECTIVITY CALIBRATION CORRECTION (delta dBZ0)	Not Available	Integer*2	N/A	0	N/A	6
DATA TRANSMISSION ENABLED	(All Data Enabled) • Reflectivity • Velocity • Width	Code*2	N/A	• 4 (bit 2 set) • 8 (bit 3 set) • 16 (bit 4 set)	N/A	7
VOLUME COVERAGE PATTERN	• TDWR Pattern Selected	Integer*2	N/A	• -80 or -90	1	8

NUMBER						
RDA CONTROL AUTHORIZATION	Not Applicable	Integer*2	N/A	0	N/A	9
RDA BUILD NUMBER	RDA major & minor build version information	Scaled Integer*2	N/A	200(3)	N/A	10
OPERATIONAL MODE	• Operational	Code*2	N/A	As Listed • 4 (bit 2 set)	N/A	11
SUPER RESOLUTION STATUS	Not Applicable	Integer*2	N/A	0	N/A	12
CLUTTER MITIGATION DECISION STATUS	Not Applicable	Integer*2	N/A	0	N/A	13
AVSET STATUS	Not Applicable	Integer*2	N/A	0	N/A	14
RDA ALARM SUMMARY	• No Alarms • Receiver • Communication	Code*2	N/A	As Listed • 0 (no bits set) • 16 (bit 4 set) • 64 (bit 6 set)	N/A	15
COMMAND ACKNOWLEDGMENT	Not Applicable	Integer*2	N/A	0	N/A	16
CHANNEL CONTROL STATUS	Not Applicable	Integer*2	N/A	0	N/A	17
SPOT BLANKING STATUS	Status of Spot Blanking: • Not Installed • Enabled	Code*2 (4)	N/A	As Listed • 0 (no bits set) • 2 (bit 1 set)	N/A	18
BYPASS MAP GENERATION DATE	Not Applicable	Integer*2	N/A	0	N/A	19
BYPASS MAP GENERATION TIME	Not Applicable	Integer*2	N/A	0	N/A	20
CLUTTER FILTER MAP GENERATION	Not Applicable	Integer*2	N/A	0	N/A	21

DATE						
CLUTTER FILTER MAP GENERATION TIME	Not Applicable	Integer*2	N/A	0	N/A	22
VERTICAL REFLECTIVITY CALIBRATION CORRECTION	Not Applicable	Integer*2	N/A	0	N/A	23
TRANSITION POWER SOURCE STATUS	Not Applicable	Integer*2	NA	0	N/A	24
RMS CONTROL STATUS	Not Applicable	Integer*2	N/A	0	N/A	25
PERFORMANCE CHECK STATUS	Not Applicable	Integer*2	N/A	0	N/A	26
ALARM CODES	One condition per halfword (Maximum of 14 alarms sent at a time). See Alarm Message Table C-1 for individual alarm codes. MSB set indicates alarm has been cleared.(6)	Integer*2	N/A	0 to 800	N/A	27 to 40

(1) All bit references start from 0 (LSB).
(2) Unless otherwise indicated as mutually exclusive, Integer Code Formats can set multiple bits in the same message. For example, in case bits 1 and 2 are set, then the integer value passed would be 2 + 4 = 6.
(3) If value divided by 100 is greater than 2, then the Build Version is the value divided by 100. Otherwise, the Build Version is value divided by 10.
(4) Values listed are mutually exclusive.
(5) See Appendix B for unit definitions and standard symbology.
(6) For alarms, the following states are defined: IN = Inoperative, SEC = Secondary (secondary alarms are not specifically tied to a "STATE" change), and N/A = Not applicable. For alarm type, ED are alarms identified as ED (Edge Detected) and are reported every time the test associated with the alarm fails consecutively for a number of times equal to the alarm reporting count (see "Sample" column). Such alarms will be cleared (MSB set) when the test outcome first passes after the alarm is reported. The "DEVICE" column indicates the hardware device area where the alarm has occurred (if applicable); acronyms under the DEVICE column are as follows: RCV = Receiver,

COM = TDWR RDA Communications. The "SAMPLE" column indicates the number of samples (failures) that must occur before this alarm is displayed.
The "ALARM MESSAGE" column is an abbreviated description of the alarm message that is displayed at both the SPG.

Table C-1: TDWR/SPG Alarm Messages:

CODE	STATE	ALARM TYPE	DEVICE	SAMPLE	ALARM MESSAGE
0	N/A	N/A	N/A	N/A	NO ALARMS
1	IN	ED	COM	1	WIDEBAND FAILURE
2	IN	ED	COM	1	WIDEBAND DISCONTINUITY
3	SEC	ED	RCV	1	NO MOMENT DATA RADIAL COUNT EXCEEDED
4	SEC	ED	RCV	1	RADIAL DATA LOST

TDWR Volume Coverage Pattern Data (Message Type 5)

NAME	DESCRIPTION	FORMAT(4)	UNITS(10)	RANGE (OR VALUE)(7)	ACCURACY/ PRECISION	HALFWORD LOCATION
MESSAGE SIZE	Number of Halfwords in Message	Integer*2	halfword	23 to 755	1	1
PATTERN TYPE	Constant Elevation Cut (11)	Code*2	N/A	As listed • 2	N/A	2
PATTERN NUMBER	Pattern Number Values	Integer*2	N/A	80 or 90	1	3
NUMBER OF ELEVATION CUTS	Number of elevation cuts in one complete volume scan	Integer*2	N/A	16 (VCP 90) 23 (VCP 80)	1	4
VERSION	VCP version number	Integer*1	N/A	1	1	5 (1)
CLUTTER MAP GROUP NUMBER(12)	Not Applicable	Integer*1	N/A	1	1	5 (2)
DOPPLER VELOCITY RESOLUTION	Doppler Velocity Resolution Values: • 0.5 • 1.0	Code*1	m/s	As Listed • 2 (set bit 9) • 4 (set bit 10)	N/A	6 (1)
PULSE WIDTH	Pulse Width Values: • Short	Code*1	N/A	As listed • 2 (set bit 1)	N/A	6 (2)
RESERVED	N/A	N/A	N/A	N/A	N/A	7-8
VCP SEQUENCING	Not Applicable	Integer*2	N/A	0	N/A	9
VCP	Not Applicable	Integer*2	N/A	0		10

SUPPLEMENTAL DATA						
RESERVED	N/A	N/A	N/A	N/A	N/A	11
Repeat for each elevation angle (13)						
ELEVATION ANGLE (3)	The elevation angle for this cut	Code*2 (6)	deg	0.000000 to 359.956055	0.043945	E1
CHANNEL CONFIGURATION	Channel Configuration Values: • Constant Phase	Code*1	N/A	As Listed • 0	N/A	E2 (1)
WAVEFORM TYPE	Waveform Type Values: • Contiguous Surveillance • Contiguous Doppler w/o Ambiguity Resolution	Code*1	N/A	As Listed (8) • 1 • 3	N/A	E2 (2)
SUPER RESOLUTION CONTROL	Not Applicable	Integer*1	N/A	0	N/A	E3 (1)
SURVEILLANCE PRF NUMBER(5)(14)	The pulse repetition frequency number for surveillance cuts	Integer*1	N/A	0 to 8	1	E3 (2)
SURVEILLANCE PRF PULSE COUNT/RADIAL(5)(14)	The pulse count per radial for surveillance cuts	Integer*2	N/A	0 to 999	1	E4
AZIMUTH RATE	The azimuth rate of the cut	Code*2 (9)	deg/s	-30.0 to +30.0	0.1/0.1	E5
REFLECTIVITY THRESHOLD (14)	Signal to noise ratio (SNR) threshold for reflectivity	Scaled SInteger*2	dB	-12.0 to +20.0	.125	E6
VELOCITY THRESHOLD (14)	Signal to noise ratio (SNR) threshold for velocity	Scaled SInteger*2	dB	-12.0 to +20.0	.125	E7
SPECTRUM WIDTH THRESHOLD (14)	Signal to noise ratio (SNR) threshold for spectrum width	Scaled SInteger*2	dB	-12.0 to +20.0	.125	E8
DIFFERENTIAL REFLECTIVITY THRESHOLD	Not Applicable	Integer*2	N/A	0	N/A	E9
DIFFERENTIAL PHASE	Not Applicable	Integer*2	N/A	0	N/A	E10

THRESHOLD						
CORRELATION COEFFICIENT THRESHOLD	Not Applicable	Integer*2	N/A	0	N/A	E11
EDGE ANGLE (14)	Sector 1 Azimuth Clockwise Edge Angle (denotes start angle)	Code*2 (6)	deg	0.000000 to 359.956055	0.043945	E12
DOPPLER PRF NUMBER(5)(14)	Sector 1 Doppler PRF Number	Integer*2	N/A	0 to 8	1	E13
DOPPLER PRF PULSE COUNT/RADIAL(5)(14)	Sector 1 Doppler Pulse Count/Radial	Integer*2	N/A	0 to 999	1	E14
SUPPLEMENTAL DATA	Not Applicable	Integer*2	N/A	0	N/A	E15
SAME AS E12 to E14 FOR SECTOR 2						E16 to E18
EBC ANGLE	Not Applicable	Integer*2	N/A	0	N/A	E19
SAME AS E12 to E14 FOR SECTOR 3						E20 to E22
RESERVED	N/A	N/A	N/A	N/A	N/A	E23

(1) Upper byte.
(2) Lower byte.
(3) For Each Elevation Cut, repeat E1-E23
(4) A halfword is defined to be 16 bits. All specified bit locations are referenced from 0 (the LSB) to 15 (the MSB).
(5) Zero values are only to be used when the field is non-applicable.
(6) Format defined as follows:

Angle Data Format

	Angle Data Format (Degrees)
BIT #	**MEANING**
15	180 deg
14	90 deg
13	45 deg

12	22.5 deg
11	11.25 deg
10	5.625 deg
9	2.8125 deg
8	1.40625 deg
7	0.70313 deg
6	0.35156 deg
5	0.17578 deg
4	0.08789 deg
3 (LSB)	0.043945 deg
2	X
1	X
0	X

X = NOT APPLICABLE

NOTE: A positive elevation angle is defined as being up from the horizontal plane, and a positive azimuth angle is defined as being clockwise from true north, when looking down at the radar. Elevation angles greater than 90 degrees will be interpreted as a negative angle and the actual elevation angle will be computed as the angle value minus 360 degrees.

(7) Values shown are after applicable scaling and conversion is done.

(8) Values are mutually exclusive.

(9) Format defined as follows:

Azimuth and Elevation Rate Data

BIT	**WEIGHT** (1) (2)
0	X
1	X
2	X
3	0.010986328125
4	0.02197265625
5	0.0439453125
6	0.087890625
7	0.17578125
8	0.3515625
9	0.703125
10	1.40625
11	2.8125

12	5.625
13	11.25
14	22.5
15	Sign Bit (1 indicates negative) (3)

Notes:
1. X indicates not applicable
2. Units are degrees per second.
3. Format is 2's complement binary scaled integer (i.e., Signed Integer *2)
(10) See Appendix B for unit definitions and standard symbology.
(11) Currently all operational VCP patterns are constant elevation types.
(12) Clutter map groups are not currently used. The currently used value for this field is 1.
(13) E value halfword locations are determined by EX = (12 + (X-1)) + ((Cut - 1) * Number_of_E_Values). Currently the Number_of_E_Values is 23.
(14) These values are defined for TDWR/SPG VCP data but are currently not used or not applicable.

Radial Data Header (Message Type 31):

NAME	DESCRIPTION	FORMAT	UNITS (1)	RANGE (2)	ACCURACY/ PRECISION	BYTE LOCATION (3)
Radar Identifier	ICAO Radar Identifier	String	N/A	(e.g., "TOKC")	N/A	0 to 3
Collection Time	Radial data collection time in milliseconds past midnight GMT	Integer*4	msec	0 to 86,399,999	± 2000/ 1	4 to 7
Modified Julian Date	Current Julian date - 2440586.5 (4)	Integer*2	d	1 to 65,535	1	8 and 9
Azimuth Number	Radial number within elevation scan	Integer*2	N/A	1 to 720	1	10 and 11
Azimuth Angle	Azimuth angle at which radial data was collected	Real*4	deg	0 to 359.956055	± 0.1 / NA	12 to 15
Compression Indicator	Indicates if message type 31 is compressed and what method of compression is used. The Data Header Block is not compressed.	Code*1	N/A	0 = uncompressed 1 = compressed using BZIP2 2 = compressed	N/A	16

				using zlib 3 = future use		
Spare	Spare and forces halfword alignment	N/A	N/A	N/A	N/A	17
Radial Length	Uncompressed length of the radial in bytes including the Data Header block length	Integer*2	N/A	9352 to 14288 bytes	1	18 and 19
Azimuth Resolution Spacing	Azimuthal spacing between adjacent radials	Code*1	N/A	2 = 1.0	N/A	20
Radial Status	Radial Status (e.g. first, last)	Code*1	N/A	0 to 4 (6)	N/A	21
Elevation Number	Elevation number within volume scan	Integer*1	N/A	1 to 23	1	22
Cut Sector Number	PRF Sectors Not Applicable	Integer*1	N/A	1	1	23
Elevation Angle	Elevation angle at which radial radar data was collected	Real*4	deg	0.0 to 60.0	± 0.1 / NA	24 to 27
Radial Spot Blanking Status	Spot blanking status for current radial, elevation scan and volume scan	Code*1	N/A	0=none (7) 1=radial 2=elevation 4=volume	N/A	28
Azimuth Indexing Mode	Azimuth indexing value (Set if azimuth angle is keyed to constant angles)(5)	Scaled Integer*1	N/A	0=no indexing 1 to 100 means indexing angle of 0.01 to 1.00	± 0.1 / 0.01	29
Data Block Count	Number of data blocks (N)	Integer*2	N/A	6	1	30 and 31
Data Block pointer	Pointer to Data Block for Volume Data Constant Type (8)	Integer*4	N/A	44 to 64	1	32 to 35
Data Block pointer	Pointer to Data Block for Elevation Data Constant Type (8)	Integer*4	N/A	84 or greater	1	36 to 39
Data Block pointer	Pointer to Data Block for	Integer*4	N/A	92 or greater	1	40 to 43

	Radial Data Constant Type (8)					
Data Block pointer	Pointer to Data Block for Moment "REF" (9)	Integer*4	N/A	112 or greater	1	44 to 47
Data Block pointer	Pointer to Data Block for Moment "VEL" (9)	Integer*4	N/A	112 or greater	1	48 to 51
Data Block pointer	Pointer to Data Block for Moment "SW " (9)	Integer*4	N/A	112 or greater	1	52 to 55

Data Block (Volume Data Constant Type):

NAME	DESCRIPTION	FORMAT	UNITS	RANGE	ACCURACY/ PRECISION	BYTE LOCATION (3)
Data Block Type	Indicates Data Constant Type	String	N/A	"R"	N/A	0
Data Name	Volume Data Constant Block	String	N/A	"VOL"	N/A	1 to 3
LRTUP (size of data block)	Size of data block in bytes	Integer*2	N/A	44	1	4 and 5
Version Number	Major Change (12)	Integer*1	N/A	0 to 255	N/A	6
Version Number	Minor Change (13)	Integer*1	N/A	0 to 255	N/A	7
Lat	Latitude	Real*4	deg	0.0 to 90.0	TBD/NA	8 to 11
Long	Longitude	Real*4	deg	-180.0 to +180.0	TBD/NA	12 to 15
Site Height	Height of site base above sea level	Integer*2	m	0 to 12000	± 1/1	16 and 17
Feedhorn Height	Same as Site Height	Integer*2	m	0 to 12000	± 1/1	18 and 19
Calibration Constant (dBZ0)	Not Available	Real*4	N/A	0.0	± 1/ NA	20 to 23
Horizontal SHV Tx Power	Not Applicable	Real*4	N/A	0.0	NA	24 to 27
Vertical SHV Tx Power	Not Applicable	Real*4	N/A	0.0	NA	28 to 31
System Differential Reflectivity	Not Applicable	Real*4	N/A	0.0	NA	32 to 35
Initial System	Not Applicable	Real*4	N/A	0.0	± 1.0 /NA	36 to 39

Differential Phase						
Volume Coverage Pattern Number	Identifies Volume Coverage Pattern being used	Integer*2	N/A	80 or 90	1	40 and 41
Processing Status	Not Applicable	Integer*2	N/A	0	N/A	42 and 43

Data Block (Elevation Data Constant Type):

NAME	DESCRIPTION	FORMAT	UNITS	RANGE	ACCURACY/ PRECISION	BYTE LOCATION (3)
Data Block Type	Indicates Data Constant Type	String	N/A	"R"	N/A	0
Data Name	Elevation Data Constant Block	String	N/A	"ELV"	N/A	1 to 3
LRTUP (size of data block)	Size of data block in bytes	Integer*2	N/A	12	1	4 and 5
ATMOS	Atmospheric Attenuation Factor	Scaled SInteger*2	dB/km	-0.02 to -0.002	± 0.004/ 0.001	6 and 7
Calibration Constant (dBZ0)	Not Available	Real*4	N/A	0.0	N/A	8 to 11

Data Block (Radial Data Constant Type):

NAME	DESCRIPTION	FORMAT	UNITS	RANGE	ACCURACY/ PRECISION	BYTE LOCATION (3)
Data Block Type	Indicates Data Constant Type	String	N/A	"R"	N/A	0
Data Name	Radial Data Constant Block	String	N/A	"RAD"	N/A	1 to 3
LRTUP (size of data block)	Size of data block in bytes	Integer*2	N/A	28	1	4 and 5
Unambiguous Range (21)	Unambiguous range, Interval Size	Scaled Integer*2	km	75-600	± 0.1/ 0.1	6 and 7
Noise Level	Not Available	Real*4	N/A	0.0	N/A	8 to 11
Noise Level	Not Applicable	Real*4	N/A	0.0	N/A	12 to 15
Nyquist Velocity	Not Available	Integer*2	N/A	0	N/A	16 and 17
Radial Flags	Not Applicable	Integer*2	N/A	0	N/A	18 and 19
Calibration	Not Available	Real*4	N/A	0.0	N/A	20 to 23

Constant(dBZ0)						
Calibration Constant(dBZ0)	Not Applicable	Real*4	N/A	0.0	N/A	24 to 27

Data Moment Characteristics and Conversion for Data Names:

Data Name	**Data Moment Description**	**Data Word Size (bits)**	**Data Size (bits)** (14)	**Format**	**Offset** (10)	**Scale** (10)	**Data Range As coded**	**Data Range after conversion**	**Units**	**Accuracy/ Precision** (17)	**Range (km)**	**LDM** (11)
"REF "	Reflectivity (Z)	8	8	Integer *1	66.0	2.0	2 to 255 (16)	-32.0 to +94.5	dBZ	± 1.0/ 0.50	90/417 (19)	300/ 1390
"VEL "	Velocity (V)	8	8	Integer *1	129.0	2.0 or 1.0	2 to 255 (16)	-63.5 to +63.0 or -80.0 to +80.0	m/s	± 1.0/0.50 or ± 1.0/1.00	90	300
"SW "	Spectrum Width (σ)	8	8	Integer *1	129.0	2.0	129 to149 (16)	0.0 to +10.0	m/s	± 1.0/ 0.50	90	300

Data Block (Descriptor of Generic Data Moment Type)

NAME	**DESCRIPTION**	**FORMAT**	**UNITS**	**RANGE**	**ACCURACY/ PRECISION**	**BYTE LOCATION** (3)
Data Block Type	Indicates Data Moment Type	String	N/A	"D"	1	0
Data Moment Name	Name of data moment	String	N/A	"VEL", "REF", "SW"	1	1 to 3
Reserved (18)	Reserved (18)	Integer*4	N/A	Set to 0	1	4 to 7
Number of Data Moment Gates	Number of data moment gates for current radial (NG)	Integer*2	N/A	0 to 1840	1	8 and 9
Data Moment Range	Range to center of first range gate	Scaled Integer*2	km	0.000 to 32.768	± 0.05/ 0.001	10 and 11
Data Moment Range Sample Interval	Size of data moment sample interval	Scaled Integer*2	km	0.15 or 0.3	± 0.05/ 0.001	12 and 13
TOVER	Threshold parameter which specifies the minimum difference in echo power	Scaled Integer*2	dB	5.0	± 0.1/ 0.1	14 and 15

	between two resolution gates for them not to be labeled "overlayed"					
SNR Threshold	SNR threshold for valid data	Scaled SInteger*2	dB	-12.0 to +20.0	±0.1/0.125	16 and 17
Control Flags	Indicates special control features	Code*1	N/A	0 = none	1	18
Data Word Size	Number of bits (DWS) used for storing data for each Data Moment gate	Integer*1	N/A	8 or 16	1	19
Scale	Scale value used to convert Data Moments from integer to floating point data (10)	Real*4	N/A	Greater than 0.0 to 65535.0	1	20 to 23
Offset	Offset value used to convert Data Moments from integer to floating point data (10)	Real*4	N/A	2.0 to 65535.0	1	24 to 27

The first three blocks of every radial are the Volume Constant Block, followed by the Elevation Constant Block, followed by the Radial Constant Block. Following these blocks are the following blocks in the order presented. Some of data blocks may not be available based on the VCP wave form for the elevation cut.

Data Block # 3 (Reflectivity Data)

NAME	DESCRIPTION	BYTE LOC
Data Block Type	Character (“D”)	0
Data Moment Name	Characters (“REF”)	1 to 3
Reserved (18)	Reserved (18)	4 to 7
Number of Data Moment Gates	Number of range samples for current radial	8 and 9
Data Moment Range	Range to center of first range gate (m)	10 and 11
Data Moment Range Sample Interval	Size of range sample interval (m)	12 and 13 (19)
TOVER	Range folding threshold determination	14 and 15
“REF” SNR Threshold	Signal to Noise Threshold For Reflectivity	16 and 17
Control Flags	Not Used (set to 0)	18
Data Word Size	Number of bits used for each data moment sample	19
Scale	Scale to convert from integer to floating point data (10)	20 and 21
Offset	Offset to convert from integer to floating point data (10)	22 and 23

Moment Data (“REF”)	Variable length array of moment data	24 -

Data Block # 4 (Velocity Data)

NAME	DESCRIPTION	BYTE LOC
Data Block Type	Character (“D”)	0
Data Moment Name	Characters (“VEL”)	1 to 3
Reserved (18)	Reserved (18)	4 to 7
Number of Data Moment Gates	Number of range samples for current radial	8 and 9
Data Moment Range	Range to center of first range gate (m)	10 and 11
Data Moment Range Sample Interval	Size of range sample interval (m)	12 and 13 (20)
TOVER	Range folding threshold determination	14 and 15
“VEL” SNR Threshold	Signal To Noise for Velocity	16 and 17
Control Flags	Not Used (set to 0)	18
Data Word Size	Number of bits used for each data moment sample	19
Scale	Scale to convert from integer to floating point data (10)	20 and 21
Offset	Offset to convert from integer to floating point data (10)	22 and 23
Moment Data (“VEL”)	Variable length array of moment data	24 -

Data Block # 6 (Spectrum Width Data)

NAME	DESCRIPTION	BYTE LOC
Data Block Type	Character (“D”)	0
Data Moment Name	Characters (“SW”)	1 to 3
Reserved (18)	Reserved (18)	4 to 7
Number of Data Moment Gates	Number of range samples for current radial	8 and 9
Data Moment Range	Range to center of first range gate (m)	10 and 11
Data Moment Range Sample Interval	Size of range sample interval (m)	12 and 13 (20)
TOVER	Range folding threshold determination	14 and 15
“SW” SNR Threshold	Signal To Noise threshold for Spectrum Width	16 and 17
Control Flags	Not Used (set to 0)	18
Data Word Size	Number of bits used for each data moment sample	19
Scale	Scale to convert from integer to floating point data (10)	20 and 21
Offset	Offset to convert from integer to floating point data (10)	22 and 23
Moment Data (“SW”)	Variable length array of moment data	24 -

(1) See Appendix B for unit definitions and standard symbology.
(2) This field represents the range of the item after any applicable scaling and conversion is done.
(3) Byte location is relative to beginning of this message.
(4) 1 January 1970 00.00 GMT = 1 Modified Julian Date.
(5) Azimuthal spacing of radials is the commanded value not necessarily the actual spacing.
(6) Format Defined as follows (Radial status definition):

Radial Status Data Format

Radial Status Indicator (Hex)	Setting (Hex)
Start of new Elevation	00
Intermediate Radial Data	01
End of Elevation	02
Beginning of Volume Scan	03
End of Volume Scan	04

(7) Equals 0 when spot blanking disabled; equals 4 when spot blanking enabled and no spot blanking radials in current elevation cut; equals 6 when there are no spot blanked radials in current elevation cut and current radial not spot blanked; equals 7 when current radial is spot blanked.
(8) Pointer is offset relative to beginning of Data Header Block. Note the Data Header Block for data blocks "VOL", "ELV", and "RAD" must always be present but the pointers are not order or location dependent.
(9) Pointer is offset relative to beginning of Data Header Block but if the pointer value is 0, there is no Data Moment Block referenced. Normally, if the Data Moment is missing, this pointer would not be present and the Data Block Count reduced. However, it is optional to set pointers to zero or simply delete the pointer to the missing Data Moment Block.
(10) A non-zero Scale value indicates unsigned integer data that can be converted to floating point data using the Scale and Offset fields, i.e., F = (N - OFFSET) / SCALE where N is the integer data value and F is the resulting floating point value. A scale value of 0 indicates floating point moment data for each range gate.
(11) LDM is the amount of space in bytes required for a data moment array and equals ((NG * DWS) / 8) where NG is the number of gates at the gate spacing resolution specified and DWS is the number of bits stored for each gate (DWS is always a multiple of 8).
(12) Major version number. A larger major version number indicates a structural change has occurred within the ICD description. The current version is 0.
(13) Minor version number. A larger minor version number indicates that one or more data moment parameters have been added but the major structure is intact. The current version is 0.

(14) Data Size is the number of bits for the specified data moment used to offset and scale the data for recording into the Data Word Size (DWS). As long as the Offset and Scaling parameters are applied correctly to the recorded data for conversion back to engineering units, no knowledge of the Data Size is needed.
(15) The Scale and Offset values shown in **Data Moment Characteristics and Conversion for Data Names** Table are typical values for the Moments shown. The conversion of the recorded integer values to meteorological values should always use the Scale and Offset values found in the Data Moment Block for each Data Moment since they could change from radial to radial in future implementations.
(16) For all Reflectivity, Velocity, and Spectrum Width integer values N = 0 indicates received signal is below threshold and N = 1 indicates range folded data. Actual data range begins at N = 2.
(17) The precision can be calculated exactly as 1.0/Scale but is shown here with only a selected number of significant digits.
(18) "Reserved" means the field has a specific future use but not implemented at this time and must be set to zero. The field is not a "Spare" available for arbitrary future use.
(19) “REF” data has two sample interval sizes, 150 m and 300 m. For the long range surveillance scan (wave form type Contiguous Surveillance), the range sample interval is 300 m. For all other wave form types, the sample interval is 150 m.
(20) “VEL” and “SW” have range sample interval of 150 m.
(21) Unambiguous range can change from radial to radial.