

SECTION 2
Tape Format

2.1 Introduction

This section describes the format of the tapes generated by the ROS. Each tape starts with a Tape Header record, followed by Data records. If any radar configuration is changed during data recording, then a new Tape Header is written to the tape. Before each additional tape header there is an EOF mark. If display related configuration is changed, a new Tape Header is not written. Thus it is not possible to reconstruct what all the operators were watching during a flight.

Older generation 9-track tapes were written at 1600 BPI. DAT tapes are written in standard DDS format, without data compression (DDS/DC not enabled).

After the final data record on the tape will be a double EOF.

2.2 Tape Header Format

The tape header is a 2048 byte record. Table 2-1 shows the format. It is written at the beginning of every tape, and whenever the data recording is changed by the operator. Also if the INE selection changes, a new tape header will be written. Each time a forced tape header is written, there will be two partial sweeps made. The sweep before the tape header will be prematurely interrupted. The first sweep after the header will use the next sweep number, and will run until zero degrees is reached. Another source of forced tape headers are noise samples. At periodic intervals the signal processors will take time out to measure the log receiver noise and linear channel offsets. This will be synchronized with the scan, and occur while the antenna is pointed near the zenith. If data from both radars are merged onto one tape, then there will often be double tape headers when changes are made to both configurations at the same time. Changes that do not affect the recorded data will not generate a new header. This includes all user menu controls, i.e. antenna scan pattern and real time display format.

There are a number of reserved and spare words in the Tape Header. These words are all set to zero. Reserved words mean words which are not used now, but for which there is a particular purpose in mind. Spare words are completely unused. The header is broken up into several main sections, and subsections within those. The main sections are as follows: words 1-100 are general header, Words 101-400 are LF specific information, words 401-700 are TA specific information, and words 701-1024 are reserved for ASCII comments. Some words contain two things packed into the two bytes. These are described by two phrases divided by a slash. The first phrase refers to the high byte.

Word 4 is the tape header format version number. This number is changed every time the tape header format is changed. This allows programs to determine which format they are reading. In October 1988 this number was changed from 0 to 1. The following changes are in version 1: The bytes were swapped in all the data (the first bin is in the high byte of the first word). The velocities are switched to the correct direction. Words 81-88 of the tape header were added to hold a project ID. Word 159 of the tape header was added to hold the time between noise samples. In October 1997 the version number was changed to 2. The only change implemented for version 2 is the scaling of the pulse width values (words 173 & 473) from 1/100's of microseconds to 1/1000's of microseconds.

Words 47 through 54 contain the results of power up testing for the various devices. The meanings of these words are all the same. If it is zero, then the device is working fine. If bit zero is set, then the operating system is indicating that the device is down. If bit 1 is set, then a timeout has occurred during an attempt to read or write to the device. If bit 2 is set, then the read test has failed. In the read test, the HP computer issues a command which makes the device output a known barber pattern of 16 words. If the data is not correct, then the test fails. If bit 3 is set, then the read/write test has failed. In the read/write test, the HP computer writes a pattern of data to the device, and then reads it back. A failure of the read/write test without a failure of the read test indicates the error is in the data wires going to the device. If bit 4 is set, then the device has failed its own internal self-tests. Some of the devices do not have these last three tests.

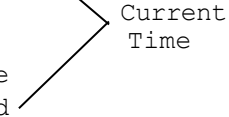
TABLE 2-1
Tape Header Format

Word **Contents**

General Information

System Info:

- 1 Tape Header Flag (0)
- 2 Number of bytes in the tape header.
- 3 Tape number
- 4 Tape Header format version number (see text above)
- 5 Reserved format version number (0)
- 6 Year
- 7 Month
- 8 Day
- 9 Hour
- 10 Minute
- 11 Second
- 12-19 File name for LF Setup Menu (8A2 format)
- 20-27 File name for TA Setup Menu (8A2 format)
- 28-35 File name for Data Menu (8A2 format)
- 36 <spare>
- 37 Nav system used by MDS, 0: CPS w/INE1, 1: INE1, 2: INE2, 3: GPS w/INE2
- 38 LU of tape drive recorded on
- 39 Aircraft identifier (either 42, 43 or (0 for ground))
- 40-43 Flight identifier (4A2 format)
- 44 Number of words in the data record header
- 45 Number of words in the ray header
- 46 Time zone of recorded time, minutes ahead of GMT



Power up test results:

- 47 MDS status
- 48 Tape 1 status
- 49 Tape 2 status
- 50 DSCC status
- 51 DSC 1 status
- 52 DSC 2 status
- 53 DSC 3 status
- 54 DSPC status

Display configuration when header written:

55 DSC1, Top of display indicator (0=north/zenith, 1=heading/up)
 56 DSC1, Which radar is displayed (0=unused, 1=LF, 2=TA)
 57 DSC1, Displayed parameter #1 (1=ref, 2=vel, 3=wid)
 58 DSC1, Displayed parameter #2
 59 DSC1, Range state/units (range:0=full, 1=half, 2=quarter)
 (Units:0=no rings, 1=km, 2=nm)
 60 DSC2, Top of display indicator 0:north/zenith, 1:heading/up
 61 DSC2, Which radar is displayed
 62 DSC2, Displayed parameter #1
 63 DSC2, Displayed parameter #2
 64 DSC2, Range state/units (same format as word'59)
 65 DSC3, Top of display indicator 0:north/zenith, 1:heading/up
 66 DSC3, Which radar is displayed
 67 DSC3, Displayed parameter #1
 68 DSC3, Displayed parameter #2
 69 DSC3, Range state/units (same format as word 59)
 70 Auto switch flag (1=switching enabled, 0=not)
 71 Drive 1, tape status (from exec 13)
 72 Drive 2, tape status
 73 Drive 1 info: bit 0: 1 means rewinding, bit 1: 1 means recording
 74 Drive 2 info: same format as above
 75 Bit 0: LF setup menu operational parameters differ from file
 76 Bit 0: TA setup menu operational parameters differ from file
 77 Bit 0: Data menu operational parameters differ from file
 78-79 <spare>
 80 Last RCU short form status received from either radar.
 (This is word 3 of the data burst) 81-88 Project identifier
 (8A2 format)
 89-100 <spare>

LF Radar Information**Signal Processor Configuration:**

101 Sample size
 102 DSP flags 0: Range normalization
 1: Doppler channel speckle remover
 2: Log channel speckle remover
 3: Pulse at end of ray
 4: Pulse at beginning of ray
 6: Use AGC (TA only)
 8-9: 0:single PRF, 1:dual PRF 2/3, 2:dual PRF 3/4
 103 Reflectivity slope 1/4096 of dB/ A/D count
 104 Reflectivity noise threshold 1/16 dB above Noise
 105 Clutter Correction threshold signed 1/16 dB
 106 SQI threshold same units as DSP
 107 Power threshold for width signed 1/16 dBZ

108 Calibration Reflectivity 1/16 dBZ
109 AGC decay code
110 Dual-PRF Stabilization delay (pulses)
111 Threshold flags for uncorrected reflectivity
112 <Reserved for systems with clutter filters>
113 Threshold flags for velocity
114 Threshold flags for width
115 Data mode: 1=processed data, 2=time series 116-120
116-120 <spare, set to 0>
121-140 <Reserved for systems with two receivers>

Range Mask Configuration:

141 Range of first bin (kilometer portion, see word 146)
142 Flag for variable range bin spacing (1=var, 0=fixed)
143 Step between input bins (in meters)
144 Number of input bins
145 Range averaging state (1,2,3 or 4) (undefined in var mode)
146 Fractional portion of range of first bin (in decimeters)
147-148 <Reserved for additional range position specs>
149 Number of output range bins
150 <spare>

Noise sample information:

151 PRT for noise sample (see DSP manual for units)
152 Range for noise sample (kilometers)
153 Log Receiver Noise Level (64 times A/D units)
154 "I" A/D offset (256 times signed A/D units)
155 "Q" A/D offset (256 times signed A/D units)
156-158 <Reserved for second receiver>
159 Time between noise samples in minutes
160 <spare>

DSP Diagnostics:

161 Signal Processor revision/serial number
162 Immediate processor status
163 Latched processor status
164 Diagnostic register #1
165 Diagnostic register #2
166 Diagnostic register #3
167 Diagnostic register #4
168 DSP status (same format as words 47-54)
169-170 <spare>

Miscellaneous Information;

171 <spare>
172 Wavelength in 1/100 of cm
173 Pulse width in 1/1000 of microseconds (@version 2)
174 PRF
175 <reserved for clutter filter number>
176 Digital Signal Simulator Flag 0:off, 1:on
177 T/R Number
178 Transmit Power
179 Gain Control Flag: 0:full gain, 1:STC, 2:AGC
180-190 <spare>

Antenna Scanning Information:

191 Antenna scan mode
192 Antenna sweep speed in 1/10 of RPM, signed.
193 Tilt angle (binary angle)
194 Sector center (degrees)
195 Sector width (degrees)
196-200 <spare>

Real Time Display Color Configuration:

201-214 Reflectivity scale numbers (lowest first)
215-216 <spare>
217-230 Reflectivity scale colors
231-232 <spare>
233-245 Velocity scale numbers (lowest first)
246-248 <spare>
249-261 Velocity scale colors
262-264 <spare>
265-271 Width scale numbers
272-280 <spare>
281-287 Width scale colors
288-300 <spare>

301 Scan recording rate (1+number of scans skipped)
302 Parameters recorded to tape 1:
 bit0=TA wid, 1=TA vel, 2=TA ref, 3=LF ref, bit4=recording on)
303 Parameters recorded to tape 2 (same format)
304 Data process state: 1=power up, 2=stop, 3=setup, 4=run, 5=run
 with simulated RCU, 6=run with simulated DSP,
 7=run, both sim, 8=exit
305-309 <spare>

310 RCU self-test (word 3 of extended status)
311 R/T self-test 1 (word 4 of extended status)
312 R/T self-test 2 (word 5 of extended status)
313 Antenna self-test 1 (word 6 of extended status)
314 Antenna self-test2 (word 7 of extended status)
315 RCU status (same format at words 47-54)
316-400 <spare>

TA Radar Information

401-700 Similar for TA radar

Comments

701-1024 Comments (648 characters, null padded)

2.3 Data Record Format

Each data record consists of a five word data record header, followed by several rays of data from one of the radars. The lengths of these records will vary in order to hold an integer number of rays. The maximum size of a data record is 8192 bytes. Each record will contain the maximum number of rays that will fit without overflowing. The rays are organized into sweeps. A sweep is all the rays from a full 360 degree scan. All sweeps must start at the beginning of a data record. Thus at the end of a sweep there may be a smaller record holding the last few rays. Successive records may come from different radars, depending on how the data arrives. Table 2-2 shows the data record header format.

TABLE 2-2
Data Record Header Format

Word 1:	Data record Flag (1)
Word 2:	Size of record in bytes
Word 3:	Sweep number on the tape for that radar (origin 1)
Word 4:	Record number in the sweep for that radar (origin 1) Low
Word 5:	byte: Record number flag (1=first, 0=middle, 2=last) High byte: Radar #: 1=LF, 2=TA

Following the data record header will be one or more rays. Each ray consists of a 22 word ray header, followed by compressed data. Because this ray header is written many times to the tape, it is desirable to conserve space. In the high 3 bits of word 2 is the data set code value. Bit 15 is on if the ray contains reflectivity, bit 14 is for velocity, and bit 13 for width. Bits 11 and 12 hold a code for which DSP the data is from. This code is 1 for the LF radar, and 2 for the TA radar. Bit 10 is on if the ray contains time series data. Note that time series and processed data cannot be recorded at the same time. Sections 2.3.1 and 2.3.2 discuss the format of the data which follows the ray header in each ray. The discussion ignores the compression, so any analysis should uncompress before looking at the data.

TABLE 2-3
Ray Header Format

1:	Number of bytes in the ray
2:	Code/Year
3:	Month/day (month in high byte, day in low byte)
4:	Raycode/Hour
5:	Minute
6:	Second (in 1/100)
7:	Latitude (binary angle)
8:	Longitude (binary angle)
9:	Radar Altitude (meters)
10:	Aircraft Velocity, East (1/10 meters/sec)
11:	Aircraft Velocity, North (1/10 meters/sec)
12:	Aircraft Velocity, Up (1/10 meters/sec)
13:	Wind Velocity, East (1/10 meters/sec)
14:	Wind Velocity, North (1/10 meters/sec)
15:	Wind Velocity, Up (1/10 meters/sec)
16:	RCU status word
17:	Elevation (binary angle)
18:	Azimuth (binary angle)
19:	Pitch (binary angle, positive is front up)
20:	Roll (binary angle, positive is right up)
21:	Drift
22:	Heading (binary angle)

2.3.1 LF Data Format

LF data consists of R bytes of data, where R is the number of range bins that are output. Each byte contains the uncorrected reflectivity for a range bin. The number in decibels is computed from the unsigned output with: **dBZ = (N-64)/2**. The overall range is from -31.5 dBZ to +95.5 dBZ in half dB steps as follows:

0: Indicates no reflectivity data available
 1: -31.5 dBZ
 64 : 0.0 dBZ
 255 : +95.5 dBZ

Note that these bytes are packed into words with the first byte going into the high byte of the first word. The diagram below shows this, where the number in parenthesis is the range bin number.

High Byte	Low Byte	
UZ(1)	UZ (2)	First Word
UZ(3)	UZ (4)	Second Word

2.3.2 TA Data Format

The TA data format varies dependent upon what parameters were recorded. It will either use 1, 2, or 3 bytes per range bins. All the bytes from one range bin will appear on the tape before the data from the next bin. If a given parameter is recorded, it will be in the order Uncorrected reflectivity first, followed by velocity, followed by width. These bytes are packed into words starting with the high byte of the first word. The format for each of these bytes is discussed below, followed by two examples of data formats.

The uncorrected reflectivity format is the same as used for the LF radar. The number in decibels is computed from the unsigned output with: **dBZ = (N-64)/2**. The overall range is from -31.5 dBZ to +95.5 dBZ in half dB steps as follows:

- 0 : Indicates no reflectivity data available
- 1 : -31.5 dBZ
- 64 : 0.0 dBZ
- 255 : +95.5 dBZ

Mean velocity is with respect to the unambiguous interval, and is expressed as follows:

- 0 : Indicates velocity data not available at this range
- 1 : Maximum velocity towards the radar
- 128 : Zero velocity
- 255 : Maximum velocity away from the radar

Spectral width is computed from the unsigned output as: $W = n/256$. The overall range is therefore a fraction between 1/256 and 255/256. The code of zero indicates that width data was not available at this range. To convert the width to meters per second, multiply by the unambiguous velocity. Thus the width has twice the resolution of the velocity.

Example of Recording Z, V, and W

High Byte	Low Byte	
UZ(1)	V(1)	First Word
W(I)	UZ(2)	Second Word
V(2)	W(2)	Third Word
UZ(3)	V(3)	Fourth Word

Example of Recording Z and V

High Byte	Low Byte	
UZ(1)	V(I)	First Word
UZ(2)	V(2)	Second Word
UZ(3)	V(3)	Third Word
UZ(4)	V(4)	Fourth Word

Example of Recording Z and W

High Byte	Low Byte	
UZ(1)	W(1)	First Word
UZ(2)	W(2)	Second Word
UZ(3)	W(3)	Third Word
UZ(4)	W(4)	Fourth Word

Example of Recording V and W

High Byte	Low Byte	
V(1)	W(1)	First Word
V(2)	W(2)	Second Word
V(3)	W(3)	Third Word
V(4)	W(4)	Fourth Word

2.3.3 TA Time Series Format

Time series data is a two dimensional array containing an I, Q, and Z triple in each element. The following example shows the first 8 words of a ray containing 4 range bins of time series. In the figure, the first dimension is the range bin number, and the second dimension is the pulse number. Note that all range bins from the first pulse come before that from the second pulse.

Example of Time Series Format

High Byte	Low Byte	
I(1,1)	Q(1,1)	First Word
Z(1,1)	I(2,1)	Second Word
Q(2,1)	Z(2,1)	Third Word
I(3,1)	Q(3,1)	Fourth Word
Z(3,1)	I(4,1)	Fifth Word
Q(4,1)	Z(4,1)	Sixth Word
I(1,2)	Q(1,2)	Seventh Word
Z(1,2)	I(2,2)	Eighth Word

RCU Status Word

Bit 15

R/T 0: R/T operational.
1: R/T fault. (Error)

Bit 14

ANT 0: Antenna operational.
1: Antenna Fault. (Error)

Bit 13

INE 0: INE data good.
1: INE data invalid (Error).

Bit 12

Not used (0)

Bit 11

Not Used (0)

Bit 10

ALN 0: Antenna alignment good.
1: Ant align out of limits. (Warn)

Bit 9

STB 0: Stabilization good.
1: Stab out of limit. (Warn)

Bit 8

DIR 0: moving CW in Azimuth
1: moving CCW in Azimuth

Bit 7

Not used (0)

Bit 6

Nav 0: INE1 data used
1: INE2 data used

Bit 5

MFC 0: AFC on.
1: AFC off (in MFC). (Mode)

Bit 4

SBY 0: R/T Radiating.
1: in standby mode. (Mode)

Bits 3-0

Mode:

0: Local Control
1: Searchlight (Fixed at Indicated Bearing and Tilt)
2: Continuous Rotation (Indicated Tilt, Indicated Speed).
3: Sector Scan (Indicated Tilt, Bearing=Center, Indicated width&Speed).
4: Fore/Aft Sector
5: Fore/Aft Continuous
6-15: Reserved (Ignored by RCU)