## 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 effect 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 contains 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 S4 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, 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       \ Current
9     Hour      /Time
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: GPS 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 (O=north/zenith, l=heading/up)
56    DSC1, Which radar is displayed (O=unused, l=LF, 2=TA)
57    DSC1, Displayed parameter #1 (lzref, 2zvel, 3=wid)
58    DSC1, Displayed parameter #2
59    DSC1, Range state/units (range:O=full, 1zhalf, 2=quarter)
                      (units:O=no rings, l=km, 2=nm)
60    DSC2, Top of display indicator O:north/zenith, l: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 O:north/zenith, l: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 (l=switching enabled, O=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>
```

<u>LF Radar Information</u>

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, l: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: l=processed data, 2=time series
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 (l=var, O=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 \ I. \
173   Pulse width in 1/1000 of microseconds (@ version2)
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: l=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 test1 (word 4 of extended status)
312   R/T self test2 (word 5 of extended status)
313   Antenna self test1 (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 or
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)
Word 5:      Low byte: Record number flag (l=first, O=middle, 2=last)
             High byte: Radar #: l=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 IS 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 user either 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 dBX 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(1)      | 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(1)     | 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, 0, 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(l,l)    | 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,l)   | Sixth Word   |
| I(1,2)    | Q(1,2)   | Seventh Word |
| Z(1,2)    | I(2,2)   | Eighth Word  |

Joe here are the definitions of the 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 and Speed).
4: Fore/Aft Sector
5: Fore/Aft Continous
6-15: Reserved (Ignored by RCU)

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