PROJECT DOCUMENTATION

POLAR DATA HEADER FORMAT

Improvement Radar Data Quality

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Product Descriptions History

Document Location

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Approvals

This document requires the following approvals. Signed approval forms are filed in the Quality section of the PCB.

Name	Signature	Title	Date of Issue	Version
Alison Smith		Processes Team Leader	05/04/02	V1.0
Alison Smith		Processes Team Leader	31/03/03	V1.1
Alison Smith		Radarnet IV project manager	04/06/04	V1.2
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		for internal review		
Alison Smith		Radarnet IV project manager for distribution to DRS		

Distribution

This document has been distributed to

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Met Office Radar team		05/04/02	V1.0
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Met Office Radar team		10/11/04	V2.21
Met Office Radar team and DRS		15/11/04	V2.3

Product Description

Relevant systems:

Cyclops
Cyclops-D
DRS (SE Radar)

Radarnet IV

This document refers to the file format for polar reflectivities, velocity moments and dual polarisation parameters collected by the processing systems at radar sites around the UK.

These data are sent to the Radarnet IV central processor to be converted to single site and composite products.

File Naming Convention

Files produced using version 5 of Cyclops (and previous versions) are named:

RADXXpolar_YYYYMMDDhhmmB.dat

where XX is the radar site number, B is the elevation number and YYYYMMDDhhmm is the time stamp of the data rounded down to the nearest one minute for the time that collection of each elevation finished. By convention Cyclops runs on a five minute cycle where highest elevations are collected first and the lowest elevation is designated beam 0 and timed to coincide with a five minute time stamp. For example, RAD03polar_2004060410340.dat is the data for site 03 and beam 0 for 4th June 2004 collected at 1034 UTC.

For version 6 of Cyclops and later versions, the file name was changed to reflect the Nimrod naming convention. This name format is:

YYYYMMDDhhmm_polar_pl_radarXXbB_reflectivity

where YYYYMMDDhhmm is the date and time strings as described above, XX is the site no and B is the elevation number. For example 200406041044_polar_pl_radar11b1_reflectivity, contains beam 1 data collected at 1044 on 4th June for site 11. The data type as defined in the filename is reflectivity.

It is recommended that the naming convention used in version 6 is maintained for future network radars.

The subscript will be altered for other data types, e.g.

YYYYMMDDhhmm_polar_pl_radarXXbB_doppler – for files containing only Doppler moments

YYYYMMDDhhmm_polar_pl_radarXXbB_augdoppler – for files containing Doppler moments and reflectivities

Derivation

The radar data format shall have three hierarchical levels of structure: Volume, Scan and Ray. A Ray is the lowest level of aggregation and consists of all the data for all the individual range bins collected for a single pointing direction. A Scan is a collection of Rays, which will normally be contiguous in either azimuth (a PPI or Plan Position Indicator scan) or elevation (a RHI or Range Height Indicator scan). A Volume is a collection of Scans, which normally form a sequence in azimuth or elevation. For example, for current network operations, a Volume would consist of the 4 PPI Scans at decreasing elevations, each of which was composed of 360 rays of 340 data bins. However, it is also possible for a Volume to consist of but a single Scan and a single Ray, as might be the case where a noise sample was required.

Each level of structure is preceded by a header record giving information, which either describes that structure or which is applicable to all lower structural levels. For example, information contained in the Volume Header should apply to all the Scans contained within that Volume. An example of the way in which these different levels of structure are organised is shown in Table 1 for a Volume consisting of 2 Scans each composed of 2 Rays.

Table 1 : Outline of Basic Structure

Volume Header
Scan Header, Scan 0
Ray Header, Scan 0, Ray 0
  data for Scan 0, Ray 0
Ray Header, Scan 0, Ray 1
  data for Scan 0, Ray 1
Scan Header, Scan 1
Ray Header, Scan 1, Ray 0
  data for Scan 1, Ray 0
Ray Header, Scan 1, Ray 1
  data for Scan 1, Ray 1

The requirement that the header information at one level should be applicable to all lower levels will necessarily impose some restrictions on what can be regarded as constituting a Volume. One example might be where a radar is configured to repeat a series of PPI scans every fifteen minutes, with the lower elevation Scans used primarily for precipitation measurement, and the higher elevation Scans used to obtain wind measurements. To provide for these two functions, the PRF might be raised at higher elevations or a secondary PRF might be employed. In this case, the two sets of Scans would be regarded as two separate Volumes, this having some merit in that the change in PRF or other parameters would impact on the quality and interpretation of quantities such as reflectivity or radial velocity.

While it is intended that the format should provide sufficient flexibility to accommodate both current and likely future developments, a balance has to be struck between this needless redundancy or over-complication. The following is a list of the principal restrictions or limitations on application:

- For archiving purposes and standard use, each Volume will be stored as a separate file. However, this does not preclude the storage of multiple Volumes within a single file where this might be more convenient (e.g. a playback sequence for a particular event).

- All the data contained within a Volume should be for a single radar site, of a single data type and for a single set of configuration parameters (e.g. pulse length and frequency, processing options). All the Scans comprising a Volume will be of the same type (PPI, RHI or unstructured).

- All the data contained within a Volume or a Scan will be for a single, contiguous time period. Rays cannot be interspersed between different Volumes or Scans.

- All the Scans and Rays within a Volume should be stored in the order in which the data was collected, with the earliest data being located at the start of the file. This would normally (although not necessarily) imply that Scans and Rays will also be ordered in terms of azimuth and elevation.

- Within a Ray, data for each bin will be stored in order of its range from the radar, with the Data Element for the bin closest to the radar immediately following the Ray header.

The majority of header information is stored as one or more unsigned 16 bit integers, this making translation between different machine architectures relatively straightforward. The first two fields in the Volume Header have fixed values and can be used both to identify the file type and to confirm bit and byte ordering. (Fields such as Radar Site Latitude, Longitude and Local Grid Easting and Northing are signed, as indicated in the tables which follow.)

Each Volume is preceded by a 256 byte Volume Header. Because of the amount of information applying at this level, related header elements are grouped into seven Sections as indicated in Table 2 below. Tables 2a to 2g detail what information is included in each Section.

Table 2 : Volume Header Overview				
Byte Offset	No. of Bytes	Section Name	Functional Description	Refer To
0	48	Identification	Provides basic information for identifying the file, including the nominal start and stop times for the volume.	Table 2a
48	24	Site Information	Provides information about the location of the radar site.	Table 2b
72	36	Hardware Configuration	Provides information about the radar hardware and capabilities.	Table 2c
108	36	Processor Configuration	Provides information about the way in which the scan has been configured.	Table 2d
144	24	Data Processing	Provides information about the data processing options and how the data has been stored.	Table 2e
168	24	Data Storage	Provides information about the type and way in which information has been stored.	Table 2f
192	64	Diagnostics	Used to report back the radar status and any problems encountered.	Table 2g

Each Scan is preceded by a 64 byte Scan Header, as described in Table 3. This gives the following information:

- the index of the Scan within the Volume.
- the start and stop, azimuth and elevation requested for the Scan.
- the start and stop times for the Scan. It is assumed that data collection is continuous within a Scan, and that the time for each Ray of data can be estimated from its position within a Scan.
- the number of rays in the Scan, the number of Bins per ray, and the range to the first Bin within each Ray.

Each Ray is preceded by an 10 byte Ray Header as described in Table 4. This gives the following information:

- the index of the Ray within the Scan.
- the azimuth and elevation angle for the ray as actually reported by the radar control unit.
- the number of bytes of data following the Ray Header. This is intended primarily to support the use of run-length compression.

Volume and Scan Headers contain a number of fields which are currently unused and reserved for future use. These will be set to zero.

Byte Orientation: The format accommodates both little endian and big endian byte orientation of 16 bit data values. The complete set of data can be stored in either one representation or the other but not mixed at the same time.

By checking the magic number and/or the bit and byte ordering bytes fields in the volume header the byte orientation of the data can be determined.

Format and Presentation - Storage of data

The data stored for each bin is stored as a Data Element. This might be a Single Parameter (e.g. the reflectivity) or Multiparameter (e.g. reflectivity, radial velocity and spectral width for Doppler measurements or reflectivity plus bitflag information for conventional systems). The structure and interpretation of each Data Element is found by reference to a number of pre-defined Data Types.

All Data Types have a four digit number. The first digit will be either 1 for Single Parameter Data Types or 2 for Multiparameter data types. The second digit will be used to distinguish between different transmit-receive combinations as follows:

1 : Transmit Channel 1, Receive Channel 1
2 : Transmit Channel 2, Receive Channel 2
3 : Transmit Channel 1, Receive Channel 2
4 : Transmit Channel 2, Receive Channel 1
5+ : Used for polarimetric quantities such as ZDR, KDP etc.

The last two digits will be used to distinguish between different quantities. As far as possible, related quantities should differ the digits used to represent a quantity for one channel, should be the same as those used for the second channel except for the second digit. Thus if data type 1111 is the reflectivity for Channel 1, the data type code giving to the reflectivity for channel 2 should be 1211.

Single Parameter Data Types are defined in Table 6a. These represent cases where there is only a single value per bin, either because only a single value is produced by the processor, the different parameters are stored as separate files, or where the information in a file has been subsequently derived from a Multiparameter Data Type.

- Single parameter data types are present in 4, 8, 12 and 16-bit resolutions.
- In all cases, missing or bad data will be represented by setting all bits to 1. This will make the missing data code 15 for 4 bit data, 255 for 8 bit data, 4095 for 12 bit data and 65535 for 16 bit data.

Multiparameter Data Types are defined in Table 6b. These represent cases where two or more values might be stored for each bin, either to minimise redundancy, to support the use of bitpacking or because this is the form in which data is output from a site processor.

- The bits used to represent individual parameters within a multiparameter data element will be permitted to cross byte boundaries. However, the total space occupied by a single data element should ideally be some multiple of 8 bits.
- As with single parameter data types, missing or bad values will be represented by setting all the bits representing that parameter to 1. Any or all of the parameters forming a multiparameter data element can be coded as missing data.

A simple, non-lossy form of run-length encoding will be included as part of the format and will be optional for all data types. This will operate with the granularity of one data element.

Table 2a : Volume Header, Identification (48 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
0	2 x 2	Magic Number	A sequence of four bytes with fixed values serving as a file type identifier. These bytes will have the values 0x41, 0x52, 0x46, 0x44 when read if the data was written as little endian and 0x52, 0x41, 0x44, 0x46 when written as big endian. Note that these are also the ASCII character codes for the string "RADF".	5
4	4 x 1	Bit and Byte Ordering	A sequence of four bytes with fixed values and serving as a check on byte and bit ordering. The first 16 bit value is 32771 (unsigned decimal), 0x8003. If incorrectly read because the byte orientation of the data does not match the byte orientation of the microprocessor being used to read the data the value of 896(unsigned decimal), 0x0380 will be read. In this case, swap over the low and high bytes in all 16 bit words read. The second 16 bit value is 49153 (unsigned decimal), 0xC001. If incorrectly read the value will be read as 448(unsigned decimal), 0x01C0, again this can be used to identify that the bytes of every 16 bit word should be swapped.	5
8	2	Version Number	The version number of the processing software.	6
10	2	Mode of Operation	Code defining the type of data collection and used primarily to distinguish between different operational scan patterns, and other types of data collection (e.g. clutter map collection, research). Used to determine what subsequent processing is applied (i.e. at some point in the future we may wish to distinguish between Volumes employed primarily for precipitation measurement and Volumes employed primarily for wind profiling). Current codes will be: 0 : Non-standard mode of operation. 1 : Operational rainfall product generation.	5
12	6 x 2	Creation Time and Date	Six 16 bit integers giving the file creation time and date. These will be in the order Year (e.g. 2000), Month (1 – 12), Day (range 1-31), Hour (0 – 23), Minute (0 – 59) and Second (0 – 59).	5
24	6 x 2	Volume Start Time and Date	Six 16 bit integers giving the time and date for which the first ray of data was collected. These will be in the order: Year (e.g. 2000), Month (1–12), Day (range 1-31), Hour (0–23), Minute (0–59) and Second (0–59).	5
36	6 x 2	Volume Stop Time and Date	Six 16 bit integers giving the time and date for which the last ray of data was collected. These will be in the order: Year (e.g. 2000), Month (1–12), Day (range 1-31), Hour (0–23), Minute (0–59) and Second (0–59).	5

Table 2b :Volume Header, Site Information (24 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
48	2	WMO Country Code	A single 16 bit integer giving the WMO block number for the radar site. For example, this would be 3 for the UK and Ireland, and 7 for France.	-
50	2	WMO Site Number	A single 16 bit integer giving the three digit WMO site number (i.e. excluding the country code). For example, this would be 953 for Clee Hill.	-
52	3 x 2	Radar Site Longitude	Three 16 bit signed integers giving the longitude of the radar site in the order degrees (-180 to +180), minutes (0-59) and seconds (0-59). The convention used is that the Greenwich meridian is 0 degrees longitude, going +ve to the east of 0 degrees, and negative to the west of 0 degrees.	6
58	3 x 2	Radar Site Latitude	Three 16 bit signed integers giving the latitude of the radar site in the order degrees (-90 to +90), minutes (0-59) and seconds (0-59). The convention used is that the equator is 0 degrees, latitudes to the north are positive, to the south negative.	6
64	2	Local Site Number	A single 16 bit integer used to hold any site number in local use. For example, within the current UK network, Clee Hill is referred to as Site No. 3 and this would be the value stored.	5
66	2	Local Grid Easting	A single 16 bit signed integer giving the local grid reference easting in tenths of a kilometre. Local grid is assumed to be UKNG.	5
68	2	Local Grid Northing	A single 16 bit signed integer giving the local grid reference northing in tenths of a kilometre. Local grid is assumed to be UKNG.	5
70	2	Sensor Height	A single 16 bit integer giving the height of the antennae in metres above mean sea level.	5

Table 2c : Volume Header, Hardware Configuration (36 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
72	2	Hardware Type	A 16 bit integer defining the type of radar hardware. Valid codes are defined as: 0: Unknown 1: Plessey Type 45C 2: Plessey Type 46C 3: DRS (to be defined)	5
74	2	Software Type	A 16 bit integer defining the type of operating software. Valid codes are defined as: 0: Unknown 1: Cyclops Site Processor 2: Cyclops-D Processor 3: DRS SDP Processor	5
76	2	No Of Channels	A 16 bit integer defining the type of radar system, particularly with reference to the reason for a secondary transmit-receive channel. Valid codes are: 0: Single-Channel. 1: Dual Polarisation (Two Channels). 2: Dual Frequency (Two Channels).	5
78	2	Unused	Reserved for future use and set to 0.	-
80	2	Channel 1 Polarisation Mode	A 16 bit integer giving a code defining what type of polarisation has been used for Channel 1. 0: Non-standard polarisation. 1: Linear, Vertical (0^o) 2: Linear, Forwards Slant ($+45^o$) 3: Linear, Horizontal (90^o) 4: Linear, Backwards Slant (-45^o) 5: Circular, Lefthand 6: Circular, Righthand For the current operational hardware configuration this would be set to 1.	5
82	2	Channel 2 Polarisation Mode	As for Channel 1, but used where there is a second transmit/receive channel. Otherwise set to 0.	5
84	2	Channel 1 Radar Constant	A 16 bit integer giving either the measured or estimated radar constant for Channel 1 in units of 0.1 dBZ.	5
86	2	Channel 2 Radar Constant	As for Channel 1, but used where there is a second transmit/receive channel. Otherwise set to 0.	5
88	2	Channel 1 Wavelength	A single 16 bit integer giving the radar wavelength in millimetres. For current systems this would be 0053.	5
90	2	Channel 2 Wavelength	As for Channel 1, but used where there is a second transmit/receive channel. Otherwise set to 0.	5
92	2	Channel 1 Beam Width	A single 16 bit integer value giving the nominal, half-power (or 3 dB) beam width in hundredths of a degree. For current systems this would be 100.	5
94	2	Channel 2 Beam Width	As for Channel 1, but used where there is a second transmit/receive channel. Otherwise set to 0.	5
96	6 x2	Unused	Reserved for future use and set to 0.	-

Table 2d : Volume Header, Processor Configuration (36 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
108	2	Type of Scan	A single 16 bit integer giving a code indicating the type of scan. These codes will be : 0: indicating an unstructured scan where neither the azimuth or elevation angles are fixed (e.g. helical scanning). 1: indicating a PPI scan where the requested elevation angle is fixed and the azimuth varies from ray to ray. 2: indicating an RHI scan where the requested azimuth angle is fixed and the elevation angle varies from ray to ray.	5
110	21	No. of Scans In Volume	A single 16 bit integer giving the number of separate scans comprising the volume. For example, for the current operational scan configuration this would be the value 4, indicating four separate PPI scans at different elevations.	5
112	2	No. of Rays Per Scan	A single 16 bit integer giving the number of rays comprising each scan, where this is fixed. For example, for the current operational scan configuration this would be the value 360, indicating that each of the four scans comprised 360 rays. This will be set to 0 if the number of Rays can vary from Scan to Scan.	5
114	2	No. of Bins Per Ray	A single 16 bit integer giving the number of bins comprising each ray. For example, this would be 340 for the current operational scan configuration. This will be set to 0 if the number of Bins per Ray can vary from Scan to Scan.	5
116	2	Processed Range Bin Length	A single 16 bit integer giving the bin length in metres. Note that this is the bin length as output from the signal processor and following any averaging in range. For the current operational scan configuration, this would be 750.	5
118	2	PulseLength	A single 16 bit integer giving the pulse length in nanoseconds. For current systems this would be 2000.	5
120	2	Antennae RotationRate	A single 16 bit integer giving the requested antennae rotation rate in degrees per minute. For example, this would be 396 for 1.1 rpm.	5
122	2	No. of Samples	A single 16 bit integer giving the average number of azimuthal samples averaged for each bin output from the signal processor. (e.g. 40 or so at 1.2 rpm is a typical value for the UK network)	5
124	2	PrimaryPRF	A single 16 bit integer value giving the sole or higher Pulse Repetition Frequency used in Hertz. For the current operational scan configuration this would be 300.	5
126	2	Secondary PRF	A single 16 bit integer value giving the lower Pulse Repetition Frequency used in Hertz. Where only a single Pulse Repetition Frequency is employed, this should be set to 0.	5

Table 2d (continued): Volume Header, Processor Configuration (36 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
128	2	Unambig. Range	A single 16 bit integer value giving the unambiguous range in steps of 0.1 km. This will include the effects of any unfolding done in the signal processor through the use of techniques such as random phase processing. Where two PRFs are employed, this should be the unambiguous range for the lowest or secondary PRF.	-
130	2	Unambig Velocity	A single 16 bit integer value giving the unambiguous velocity in steps of 0.01 ms^{-1}. This will include the effects of any unfolding done in the signal processor through the use of dual or staggered PRF techniques but excludes any subsequent unfolding that might be done in product generation. This value is used to translate phase measurements.	-
132	6 x 2	Unused	Reserved for future use and set to 0.	-

Table 2e : Volume Header, Data Processing (24 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
144	2	Processor Flags	A single 16 bit integer value used to store a bitflag array identifying what data quality options have been employed during signal processing. Individual bits will be allocated as follows: Bit 0: Set if information is available. Bit 1: Set if a noise threshold has been employed. Bit 2: Set if a clutter power threshold has been employed. Bit 3: Set if a SQI threshold has been employed. Bit 4: Set if a speckle filter has been employed. Bit 5: Set if range normalisation applied. Bit 6: Set if gaseous attenuation correction applied. Bit 7: Set if precipitation attenuation correction applied. Unallocated bits will be set to 0.	5
146	2	Clutter Filter Type	A single 16 bit integer value giving a code for the clutter removal or suppression method used. These codes will be: 0: indicating that no clutter removal or suppression has been employed. 1: indicating that a static clutter map has been employed. 2: indicating that a dynamic clutter map has been employed. 3: indicating that statistical (incoherent) clutter filter has been employed during signal processing. 4: indicating that a Doppler pulse-pair clutter filter has been employed during signal processing. 5: indicating that a Doppler FFT clutter filter has been employed during signal processing.	5
148	2	Clutter Filter Response	For systems using clutter suppression, a single 16 bit integer value used to store a number indicating the filter response setting. For example, for a pulse pair processor this would indicate the set of coefficients defining the depth and width of the filter stop band. Set to 0 for systems, which do not employ clutter suppression.	5
150	2	Clutter Power Threshold	For systems using clutter suppression, a single 16 bit integer value giving the clutter power threshold in tenths of a decibel, at which the values for individual bins are rejected. The clutter power is the difference in decibels between the reflectivity estimates before and after clutter suppression. Set to 0 for systems, which do not employ clutter suppression.	5
152	2	Noise Threshold	A single 16 bit integer value giving the threshold in tenths of a decibel at which the values for individual bins will be rejected on the basis of a poor Signal To Noise Ratio (SNR). The SNR is defined as the difference in decibels between the measured reflectivity and the noise level.	-

Table 2e (continued): Volume Header, Data Processing (24 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
154	2	SQI Threshold	For Doppler systems, the threshold in thousandths at which the values for individual bins are rejected on the basis of a poor Signal Quality Index (SQI), (i.e. 0 corresponds with an uncorrelated signal and 1000 is a coherent signal). The SQI is a test of signal coherency calculated as the ratio between the first and second autocorrelation lags. Set to 0 for non-Doppler systems.	5
156	2	Allocated for use on Radarnet IV. Unused by site processor	Set to 0	5
158	5 x 2	Unused	Reserved for future use and set to 0.	5

Table 2f : Volume Header, Data Storage (24 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
168	2	Derived Data Type	A single 16 bit integer, giving the code for the type of data actually stored. Lists of valid codes for signal and multiparameter data types are given in Tables 6a and 6b respectively.	5
170	2	SourceData Type	A single 16 bit integer, used to store the source data type in instances where a single parameter has been derived from a multiparameter data type. This will be set to 0 where there is no source data type.	5
172	2	No. of Bytes per Element	A single 16 bit integer value giving the number of bytes of data stored for each bin. At present, this will always be 1 for single parameter data types. For multiparameter data types, this is defined in Table 6b.	5
174	2	No. of Values per Element	A single 16 bit integer value giving the number of separate parameters stored for each bin. Naturally, this will always be 1 for single parameter data types. For multiparameter data types, this is defined in Table 6b.	5
176	2	Compression	A single 16 bit integer value used to indicate whether compression has been employed. This will be set to 1 if run length encoding has been employed, or 0 if the data is uncompressed.	5
178	2	Allocated for use on Radarnet IV. Unused by site processor	Set to 0.	-
180	2	Allocated for use on Radarnet IV. Unused by site processor	Set to 0.	
182	5 x 2	Unused	Reserved for future use and set to 0.	-

Table 2g : Volume Header, Diagnostics Section (64 bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
192	2	Diagnostic Flags	Bitflag array indicating whether particular problems have been detected (e.g. EHT Resets, FIFO Overflow). To be defined.	5
194	31 x 2	Unused	Reserved for future use and set to 0.	-

Table 3 : Scan Header Structure (64 Bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
0	2	Scan Index	A single 16 bit integer value giving the index of the scan within each volume. The first scan will have the value 0.	5
2	2	No. of Rays in Scan	A single 16 bit integer giving the number of rays comprising each scan, where this is fixed. For example, for the current operational scan configuration this would be the value 360, indicating that each of the four scans comprised 360 rays.	5
4	2	No. of Bins per Ray	A single 16 bit integer giving the number of bins comprising each ray. For example, this would be 340 for the current operational scan configuration.	5
6	2	Range To First Bin.	A single 16 bit integer giving the range to the start of the first bin in metres. This would be 0 for the current operational scan configuration.	5
8	2	Scan Start Seconds	16 bit integer giving the time is seconds from the volume start time and date recorded for the first ray of data comprising the scan. Note that this will normally be slightly later than the stop time recorded for any previous scan.	5
10	2	Scan Stop Seconds	16 bit integer giving the time is seconds from the volume start time and date recorded for the last ray of data comprising the scan. Since data collection will be continuous within a scan, the time for each individual ray can be estimated from its position within the scan.	5
12	2	Scan Start Azimuth	16 bit integer representing the requested starting azimuth angle for the scan. Tenths of a degree from North; range 0-3600. Note that the requested azimuth will not necessarily be the same as the actual azimuth of the first ray as reported by the radar control unit.	6
14	2	Scan Stop Azimuth	16 bit integer representing the requested ending azimuth angle for the scan. Tenths of a degree clockwise from North; range 0-3600	6
16	2	Scan Requested Elevation	16 bit integer giving the elevation requested for a scan. Tenths of a degree above the horizontal; range 0-900	6
18	2	Scan Average Elevation	16 bit integer giving the average elevation measured during a scan. Tenths of a degree above the horizontal; range 0-900	6
20	2	Beam No.	Beam number, used for Cyclops systems.	5
22	21 x 2	Unused	Reserved for future use and set to 0.	-

Table 4 : Ray Header Structure (10 Bytes)				
Offset	Size	Field	Description of Field	First coded in Cyclops version -
0	2	Ray Index	A single 16 bit integer value giving the index of the ray within each scan. The first ray will have the value 0.	5
2	2	Azimuth centre Angle	A single 16 bit integer giving the average antennae azimuth for the ray as reported by the dsp card. Hundredths of degrees; range 0-36000	5
4	2	Elevation Angle	A single 16 bit binary integer giving the average antennae elevation angle for the ray as reported by the dsp card. Hundredths of degrees; range 0-9000	5
6	2	No. of Bytes of Data	A single 16 bit integer value giving the number of bytes occupied by the data for the ray subsequent to any run-length compression. Where no compression has been employed this will be equivalent to the number of bins per ray x data element size in bytes.	5
8	2	No. of Ray per degree	A single 16 bit binary number giving the number of ray use in the averaging process at 300m bin resolution, as reported by the dsp card. In the current scheme this value will have to be multiplied by 2.5 to represent 750m x 1 degree resolution bin.	5

Table 6a : Single Parameter Data Types					
Data Type	No. of Bytes	Parameter Name	Physical Offset	Physical Increment	Parameter Description
1101	1	Power Spectra	None	None	Raw sample data truncated to 8 bit resolution.
1102	1	Time Series Inphase	None	None	Raw sampled "I" values truncated to 8 bit resolution.
1103	1	Time Series Quadrature	None	None	Raw sampled "Q" values truncated to 8 bit resolution.
1111	1	Reflectivity	-32 dBZ	0.5 dBZ	The byte value 255 is used to represent missing or rejected data and this would be equivalent to a physical value of 95.5 dBZ.
1112	1	Corrected Reflectivity	-32 dBZ	0.5 dBZ	Corrected refers to the reflectivity estimate subsequent to clutter suppression (i.e. after the clutter power has been subtracted).
1113	1	Clutter Power	0 dB	0.2 dB	The difference in decibels between the reflectivity estimate prior to and subsequent to clutter suppression.
1114	1.5	Reflectivity	32 dBZ	0.1dB	Twelve bit data. The value fff (hex) is used to represent missing or rejected data and this would be equivalent to a physical value of 406.35 dBZ.
1115	2	Reflectivity	32 dBZ	0.1dB	Sixteen bit data. The value ffff (hex) is used to represent missing or rejected data and this would be equivalent to a physical value of 6521.5 dBZ.
1121	1	Radial Velocity	-π	$^{\pi}/_{128}$	Where π is the unambiguous velocity given in the volume header. Since -π is equivalent to +π, -π is used to represent real values and +π will represent missing or rejected data.
1122	1	Spectrum Width	0	$^{\pi}/_{256}$	Where π is the unambiguous velocity given in the volume header. The missing data code is equivalent to +π.
1123	0.5	SQI	0	$^{1}/_{24}$	Signal Quality Index
1124	1	Absolute phase H	-π	$^{\pi}/_{256}$	Absolute phase measurement linear horizontal polarisation.
1125	1	Absolute phase V	-π	$^{\pi}/_{256}$	As above but for vertical polarisation.
1126	1.5	Radial Velocity	-π	$^{\pi}/_{2048}$	Where π is the unambiguous velocity given in the volume header. Since -π is equivalent to +π, -π is used to represent real values and +π will represent missing or rejected data.
1127	2	Radial Velocity	-π	$^{\pi}/_{32768}$	Where π is the unambiguous velocity given in the volume header. Since -π is equivalent to +π, -π is used to represent real values and +π will represent missing or rejected data.
1191	0.5	Ci (clutter indicator)	None	$^{1}/_{24}$	Signal variance converted to dB using a look-up table (to give variable resolution).

Table 6a (continued): Single Parameter Data Types					
Data Type	No. of Bytes	Parameter Name	Physical Offset	Physical Increment	Parameter Description
1511	1	ZDR (Differential Reflectivity)	-8 dB	0.0625dB	The difference in reflectivity between linear horizontal and linear vertical polarisations.
1512	1	KDP	-10	0.07812	Specific differential phase. Degrees per Km.
1513	1	Phi DP	-π	$^{\pi}/_{256}$	Differential phase.
1514	1	Rho HV	-0.2	0.005	Cross-correlation coefficient.
1515	1	LDR	-40 dB	0.2 dB	Linear depolarisation ratio.

Table 6b : MultiParameter Data Types

Data Type	Multi-parameter	No. of Bytes	No. of Elements	Data Subtypes	Bits Used	Parameter Name	Physical Offset	Physical Increment
2111	Augmented Reflectivity	2	2	1114	0 - 11	Reflectivity (V)	-32 dBZ	0.1 dBZ
				1191	12 - 15	Ci	None	$^{1}/_{24}$
2121	Doppler Moments	3	3	1111	0 - 7	Reflectivity	-32 dBZ	0.5 dBZ
				1121	8 - 15	Radial Velocity	$-\pi$	$^{\pi}/_{128}$
				1122	16 - 23	Spectral Width	0	$^{\pi}/_{256}$
2122	Augmented Doppler	4	4	1114	0 - 11	Reflectivity (V)	-32 dBZ	0.1 dBZ
				1191	12 - 15	Ci	None	$^{1}/_{24}$
				1126	16 - 27	Radial Velocity	$-\pi$	$^{\pi}/_{211}$
				1123	28 - 31	SQI	None	$^{1}/_{24}$
2211	Augmented Sidpol	9	9	1114	0 - 11	Reflectivity (H)	-32 dBZ	0.1 dBZ
					12 - 15	reserved	-	-
				1126	16 - 27	Radial Velocity	$-\pi$	$^{\pi}/_{211}$
				-	28 - 31	reserved	-	-
				1122	32 - 39	Spectral Width	0	$^{\pi}/_{256}$
				1511	40 - 47	ZDR	-12.8 dB	0.1 dB
				1512	48 - 55	KDP	-10	0.07812
				1513	56 - 63	Phi DP	$-\pi$	$^{\pi}/_{256}$
				1514	64 - 71	Rho HV	-0.2	0.005
2212	Augmented LDR	7	7	1111	0 - 11	Reflectivity (H)	-32 dBZ	0.1 dBZ
				-	12 - 15	reserved	-	-
				1121	16 - 27	Radial Velocity	$-\pi$	$^{\pi}/_{211}$
				-	28 - 31	reserved	-	-
				1122	32 - 39	Spectral Width	0	$^{\pi}/_{256}$
				1515	40 - 47	LDR	-40 dB	0.2 dB
				1125	48 - 55	Absolute phase - V	$-\pi$	$^{\pi}/_{256}$