VISTA DATA FLOW SYSTEM (VDFS)

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for VISTA & WFCAM data

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WSA Interface Control Document

author
N.C.Hambly (WFAU Edinburgh)
Science Archive Project Scientist
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co-authors
M.J.Irwin & J.R.Lewis, CASU

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1 SCOPE

This Interface Control Document (ICD) for the WFCAM Science Archive (WSA) describes the data flow subsystem interface between the data processing centre (CASU at the IoA, Cambridge) and the archive centre (WFAU at the IfA, Edinburgh). Details of the types and specifications of processed WFCAM data to be transfered, along with the transfer protocols (file naming, transfer method and procedure), are given. The details of this ICD have been agreed between CASU and WFAU; the formalities are being overseen by the JAC and the VISTA Data Flow System (VDFS) project.

The ICD is intended to be a formal interface control agreement between the WFCAM data processing centre at CASU and the archive centre at WFAU in Edinburgh. The processing centre/archive centre interface is the final subsystem interface in the WFCAM data flow chain, and is subject to the rules laid out herein. The ICD concerns WFCAM data only; all other data ingested into the WFCAM Science Archive (WSA) are outside the scope of interface control (the WSA will also ingest publicly released data products, eg. SDSS and 2MASS etc., from other non-CASU sources).

The ICD is meant to be a technical reference: its intended audience is software engineers and scientists working on processing and archiving in the data flow. It takes the form of a formal agreement between CASU and WFAU, but must also satisfy other external bodies, namely JAC, the UKIDSS survey science consortium and the VDFS. The ICD is, therefore, a major component of the documentation for the WSA critical design review.

2 OVERVIEW

This document is structured as follows. In Section 3, we describe the fundamental rules that the interface will adhere to, including a statement of the primary data format, FITS. Then, in Section 4, we describe the top-level specifications for data that will be transfered between Cambridge and Edinburgh, including a description of FITS conventions, keywords, file naming conventions, units, systems of physical quantities, and unified column descriptors. Section 5 goes on to describe in explicit detail the data structures that will be transfered. Then, Section 6 describes the transfer methods and procedures that will achieve the data flow from Cambridge to Edinburgh. Finally, security issues are dealt with in Section 7.

Generally, this document is modelled on the ESO Data Interface Control Document [1], and with the exception of the ESO hierarchical FITS keyword definition, follows as closely as possible the specifications provided therein. A data flow system overview is provided in [2]. Fundamental 'meta' data description (ie. FITS frame headers and keywords) are described in [3]. The JAC/CASU interface is defined and described in [4]; CASU pipeline processing is described in [5].

Applicable WSA documents are listed in Section 10.

3 FUNDAMENTALS

3.1 WFAU Ingest

The WSA at WFAU will ingest WFCAM data from CASU; there will be no transfer of WFCAM data between JAC and WFAU for example.

3.2 Data transfer method

The WSA will ingest data via the internet; tapes and/or 'pluggable' disks will not be employed. The implications for required network bandwidth are discussed in AD01. More details are given in Section 6

3.3 Format

Data output from CASU will be provided in standard FITS format (as specified in [7]) only. Data will not be expressed in any 'hierarchical' system, eg. ESO hierarchical FITS, or the UK Starlink Hierarchical Data Structure format (NDFs). The FITS standard is mature, universally accepted and ideal for transporting both bulk pixel and catalogue data.

3.4 Content

Data transfered from CASU will consist of processed pixels (where the processing steps are specified by the observing protocol used), confidence maps, derived source catalogues and associated description data; no raw pixel data will be transfered to (or held in) the WSA. Where irreversible stages such as stacking or mosaicing have been done as part of the reduction procedure, the individual component images and catalogues will also be transferred. Library calibration frames will also be transfered into the WSA (eg. dark frames, flat fields, master skies) for use by users (not for any processing at the archive end).

4 TOP–LEVEL DATA SPECIFICATION

4.1 Preliminaries

Processed frames will be stored in FITS format, following the guidelines set out in [1]:

- The images comprising a WFCAM superframe will be stored in different image extensions of the same FITS container file (a multi–extension FITS, or MEF, file); data pixels belonging to one chips' image(s) will be stored in one image extension (guideline–2);
- The primary data array in the MEF file will be empty (guideline–3);
- Keywords describing the dataset in the MEF file as a whole will be written into the primary header, while keywords that are related to the data in a particular extension will be written into the HDU of that extension (guideline–5).

Derived source catalogues corresponding to each image extension will be written as FITS binary tables in extensions of a single, separate MEF file with a similarly empty primary array. The headers for the catalogue MEF will contain all the information of image MEF headers plus ancilliary processing keywords and values.

4.2 General FITS keywords

Keywords will follow the standards set out in [1] and [7] as described (for WFCAM data) in [3]. All keywords and associated values written to the HDS container files produced by the WFCAM DAS

must be propagated through the JAC/CASU interface, through the data processing pipeline and into the WSA.

The first keyword in any extension HDU must be `XTENSION`, and it's value will take on only `'IMAGE   '` or `'BINTABLE'`; the EXTNAME keyword will be used to identify the extension with a particular device detector and a unique ID for each device used in WFCAM must be propagated through the data flow via an assigned keyword. Binary tables will have every column described by keywords `TTYPEn`, `TFORMn` and `TUNITn` (see later).

World Co-ordinate System (WCS; ie. astrometric) information will be propagated using a set of keywords described in the latest FITS WCS proposals [8, 9] by Greisen and Calabretta.

4.3 Physical units

Physical units will comply with SI units and their derivatives with a few exceptions for astronomical convenience (see [1] Section 9, Table 14).

Celestial co-ordinates will be expressed in a time system described by primary HDU keyword RADECSYS; it is anticipated that this will have value `'FK5'` (ie. Hipparcos/Tycho ICRS) over the lifetime of WFCAM, but this may of course change for VISTA.

4.4 File naming conventions

CASU/JAC/ATC have an agreed policy on filenames[10]; furthermore, it is UKIRT policy to use run numbers that reset back to 1 each night. For ease of tracking files through the data flow system, it is proposed that the CASU/WFAU interface follows the same policy, which is as follows.

At telescope files will be called `wayyyymmdd_12345.sdf`, `wbyyyymmdd_12345.sdf` and so on, where the a,b,c,d correspond to detector, w stands for wfcam and the 5 digit run number is just that.

CASU will create 2D raw MEF files with names of the form `w_yyyymmdd_nnnnn.fit` and processed filenames of the form `w_yyyymmdd_nnnnn_suffix.fit` where `yyyymmdd` is the UT date of observation, `nnnnn` is the UKIRT DAS running number (reset to 1 on a nightly basis) and suffix is a combination of underscore plus two–letter abbreviations indicating pipeline processing actions: `_sf` = interleaved superframe, `_st` = stack, `_sf_st` = stacked superframe, `_sf_tl` = tiled superframe etc. Catalogues generated from frames will be `rootname_cat.fits` and confidence maps for frames `rootname_conf.fit`.

5 DETAILED DATA SPECIFICATION

5.1 Data obtained at the time of observation

Observations will be described via the keywords `OBSERVER`, `USERID`, `OBSREF`, `PROJECT`, `MSBID` and `OBJECT` keywords.

Note that the `OBJECT` keyword MUST be a field identifier for survey observations for the purposes of curation within the archive.

Instrumental characteristics, set–ups and parameters will be described by keywords as detailed in [3], including instrument detector configuration (eg. array used `DETECTOR`; number of integrations `NINT`), detector controller information (eg. camera read mode `READMODE`; read–out application `CAPPLICN`), optical configuration (eg. filter name `FILTER`; base focus position `FOC_MM`) and observing conditions/environment (eg. air temperature `AIRTEMP`; relative humidity `HUMIDITY`; opacity data `CSOTAU`).

All these FITS keys will be propagated through the data flow chain from the DAS to the WSA.

5.2 Data products (ie. derived data)

5.2.1 Corrected pixel data

The CASU pipeline will instrumentally correct WFCAM pixels into an product that is instrument–signature free. The reduction steps involved in doing so, the derived astrometric and (first–cut) photometric calibrations and resulting DQC information generated will be propagated into the WSA using FITS keys detailed in the appendices in Section 8. Appendix 8.1 shows example FITS keys for the primary HDU; appendix 8.2 shows an example of an extension set.

5.2.2 Source catalogues

The standard set of CASU source detection parameters can be found in [5]. An example FITS header for a catalogue MEF is given in appendix 8.3. The following are an extract of the corresponding FITS binary table details for each catalogue attribute (`TFORM` is 1E throughout):

No.	Name	TTYPE	TUNIT
1	Seq. no.	Sequence_number	-
2	Isophotal flux	Isophotal_flux	ADU
3	X co-ordinate	X_coordinate	pixels
4	Error in X	X_coordinate_error	pixels
5	Y co-ordinate	Y_coordinate	pixels
6	Error in Y	Y_coordinate_error	pixels
7	Gaussian sigma	Gaussian_sigma	pixels
8	Ellipticity	Ellipticity	-
9	Position angle	Position_angle	degrees
10	Areal profile 1	Areal_1_profile	pixels
.			
.			
.			
17	Areal profile 8	Areal_8_profile	pixels
18	Peak height	Peak_height	ADU
19	Peak height error	Peak_height_error	ADU
20	Aperture flux 1	Aperture_flux_1	ADU
21	Aperture flux 1 error	Aperture_flux_1_error	ADU
22	Aperture flux 2	Aperture_flux_2	ADU
23	Aperture flux 2 error	Aperture_flux_2_error	ADU
.			
.			
.			
44	Aperture flux 13	Aperture_flux_13	ADU
45	Aperture flux 13 error	Aperture_flux_13_error	ADU
46	Petrosian radius	Petrosian_radius	pixels
47	Kron radius	Kron_radius	pixels
48	FWHM radius	FWHM_radius	pixels
49	Petrosian flux	Petrosian_flux	ADU
50	Petrosian flux error	Petrosian_flux_error	ADU
51	Kron flux	Kron_flux	ADU
52	Kron flux error	Kron_flux_error	ADU
53	FWHM flux	FWHM_flux	ADU

```
54   FWHM flux error        FWHM_flux_error        ADU
55   Error bit flag         Error_bit_flag        flag
56   Sky level              Sky_level              ADU
57   Sky variance           Sky_variance           ADU
58   Child/parent           Parent_or_child_flag  flag
59   Right Ascension        RA                   radians
60   Declination            DEC                  radians
61   Classification         Classification        flag
62   Profile statistic      Profile_statistic    N-sigma
63   PSF flux               PSF_flux               ADU
64   PSF flux error         PSF_flux_error         ADU
65   PSF fitted X           PSF_fit_X             pixels
66   PSF fitted X error     PSF_fit_X_error       pixels
67   PSF fitted Y           PSF_fit_Y             pixels
68   PSF fitted Y error     PSF_fit_y_error       pixels
69   PSF fit chi-squared    PSF_fit_chi2            -
70   nu                     PSF_fit_dof             -
71   1D/2D Sersic profile fit parameters [TBD]
.
.
.
80
```

5.3 Other data product conventions

- attributes for list driven photometry output: subset of flux measures from standard list?

- differences in FITS keys in primary/extension HDUs for: a) calibration frames (dark/conf/flat/fringe/sky) b) stacked/dithered/mosaiced frames

- allowed/logged ranges for attributes, again for verification

- convention for null or n/a values

6 TRANSFER METHODS & PROCEDURES

6.1 Method

Transfer will be via the internet using standard methods. The data to be transferred will reside in Cambridge on specific RAID arrays attached to a linux PC cluster. WFAU will have an account on this system. Directories of processed nights data will be setup as the pipeline is running. While the processing is still running a directory lock file will be used to denote the 'in progress' operations. After completion the lock file will be unset/removed enabling a remote client task to automatically initiate data transfer to Edinburgh. In AD?? we give details of on–going network bandwidth experiments with large data volumes and employing various transfer protocols; transfer methods being tested include scp, GridFTP and sftp (standard ftp will not be used because of it's inherent insecurities).

6.2 Procedure

Location of data is guaranteed by the pipeline and will be in a observation date driven directory structure to which WFAU will have secure, direct access. 'Handshaking', eg. notification of readiness,

will be achieved using a lockfile system as outlined above; verification of successful transfer will included automatic checking within the transfer utility employed via the number and size of files transferred. Checksum verification will be employed using standard `cfitsio` routines.

In AD02, we give more details of the transfer task software, including error handling and transfer logging.

6.3 Updates

In the event of pipeline reruns over previous data (eg. because of improvements in instrumental correction and/or source extraction software) the interface as a whole will be the same regardless of whether data being transfered is first–run or re–run as long as the archive system can cope with overwriting issues within and storage of repeat data. These are dealt with in the database design presented in AD02.

7 SECURITY ISSUES

Nightly processed data will be held online at CASU until transfer of those data to WFAU is verified. As noted before, secure transfer protocols will be employed between CASU and WFAU to protect data from malicious corruption or access by unauthorised users. Although not strictly speaking a CASU/WFAU interface issue, raw data will be held in Cambridge as the primary UK backup in case of any catastrophic data loss further down the data flow (raw data will of course also be archived offline at JAC).

References

[1] ESO Data Interface Control Document, GEN–SPE–ESO–19940–794/2.0; http://archive.eso.org/DICB/dic-2.0/dic-2.0.4.pdf

[2] VDFS document

[3] ATC WFCAM HDS container and FITS headers, WFCAM project Document No. ??, http://www.jach.hawaii.edu/JACpublic/UKIRT/instruments/wfcam/ICD/headers_0p5.html

[4] JAC-CASU Interface Control Document, http://www.jach.hawaii.edu/JACpublic/UKIRT/instruments/wfcam/ICD/

[5] WFCAM Pipeline Design, http://www.ast.cam.ac.uk/~wfcam/docs/wfcampipedoc_v2.ps.gz

[6] WFCAM/VISTA Science Archive Development, http://www.roe.ac.uk/~nch/wfcam/

[7] Definition of the Flexible Image Transport System (FITS), document NOST 100–2.0 http://fits.gsfc.nasa.gov/fits_home.html

[8] Representations of world co-ordinates in FITS, Greisen E.W., Calabretta M.R., A&A, 395, 1061 (2002)

[9] Representations of celestial co-ordinates in FITS, Calabretta M.R., Greisen E.W., A&A, 395, 1077 (2002)

[10] ??

8 APPENDICES

8.1 Primary HDU FITS keys from CASU pipeline–processed image data

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
INHERIT =                    T
TELESCOP= 'UKIRT             ' / Telescope name
INSTRUME= 'WFCAM             ' / Instrument
CAMNUM  =                    1 / Number of WFCAM array
DHSVER  = 'UKDHS 2002 Oct 31 ' / Data handling version
HDTFILE = 'wfcam.hdt         ' / Name of hdt file
HDTFILE2= 'wfcam_w.hdt       ' / Name of camera specific hdt file
OBSERVER= 'Daffy Duck        ' / Observers names
USERID  = 'DD      '           / Userid logged in as
OBSREF  = 'notPATT99'          / PATT or other reference
PROJECT = 'Example WFCAM data' / Time-allocation code
MSBID   = 'b44d9b4e3b90e6f99b7c3a032301600b' / Id min.-schedulable block
OBJECT  = 'CIRSI_NGC135A'      / Object name from telescope
RECIPE  = 'SOME_WFCAM_RECIPE'  / Data reduction recipe to be used
OBSTYPE = 'OBJECT  '           / Type (BIAS|DARK|ARC|FLAT|OBJECT|SKY)
OBSNUM  =                    9 / Observation number
GRPNUM  =                    8 / Group number applied to all members
GRPMEM  =                    T / Group membership
STANDARD=                    F / Is the target a standard star observation?
NOFFSETS=                    4 / Number of offset positions in a pattern
NJITTER =                    4 / Number of positions in tel pattern
JITTER_I=                    1 / Serial number in this tel jitter pattern
JITTER_X=                 0.00 / [arcsec] X (RA) offset in tel jitter pattern
JITTER_Y=                 0.00 / [arcsec] Y (Dec) offset in tel jitter pattern
NUSTEP  =                    4 / Number of positions in microstep pattern
USTEP_I =                    1 / Serial number in this microstep pattern
USTEP_X =                 0.00 / [arcsec] X (RA) offset in microstep pattern
USTEP_Y =                 0.00 / [arcsec] Y (Dec) offset in microstep pattern
NFOC    =                    0 / Number of positions in focus scan
NFOCSCAN=                    0 / Number of focus scans in focus test
UTDATE  = '20010607'           / UT date as integer in yyyymmdd format
DATE-OBS= '2001-06-07T21:23:46Z' / Date and time (UTC) of start of observation
DATE-END= '2001-06-07T21:24:10Z' / Date and time (UTC) of end of observation
WCSAXES =                    2 / Number of axes in world co-ordinate system
RADESYS = 'FK5     '           / Mean IAU 1984 equatorial co-ordinates
EQUINOX =             2000.000 / [yr] Equinox of object position
RABASE  =             217.4049 / [h] Right ascension of base position
DECBASE =           0.06174444 / [deg] Declination of base position
TRAOFF  =                0.000 / [arcsec] Right ascension telescope offset
TDECOFF =                0.000 / [arcsec] Declination telescope offset
AMSTART =                1.312 / Airmass at start of observation
```

```
AMEND   =               1.310 / Airmass at end of observation
TELRA   =            217.4049 / [h] Current telescope right ascension
TELDEC  =          0.06174444 / [deg] Current telescope declination
GSRA    =            217.4049 / [h] Right ascension of guide star
GSDEC   =          0.06174444 / [deg] Declination of guide star
READMODE= 'CDS_v1  '          / Name of camera readmode
CAPPLICN= 'dunno   '          / Name of camera readout application
READOUT = 'CDS     '          / Camera readout (CDS|NDR|SAR|RRR)
EXP_TIME=               24.08 / [s] Integration time per exposure
NEXP    =                   1 / Number of exposures in integration
READINT =            0.300000 / [s] Interval between reads
NREADS  =                   0 / Number of reads per exposure
FILTER  = 'J       '          / Combined filter name
FOC_MM  =              2.4992 / [mm] Focus position
AIRTEMP =              -0.013 / [degC] Air temperature
BARPRESS=             650.000 / Ambient pressure
DEWPOINT=              2.000 / [degC] Dewpoint
DOMETEMP=              1.101 / [degC] Dome temperature
HUMIDITY=             45.816 / Relative Humidity
MIRRBSW =              7.123 / [degC] Temperature mirror B SW
MIRRNE  =              7.124 / [degC] Mirror temperature NE
MIRRNW  =              7.124 / [degC] Mirror temperature NW
MIRRSE  =              7.124 / [degC] Mirror temperature SE
MIRRSW  =              7.124 / [degC] Mirror temperature SW
MIRRBTNW=              7.128 / [degC] Mirror bottom temp. NW
MIRRTPNW=              7.128 / [degC] Mirror top temp. NW
SECONDAR=              7.133 / [degC] Temperature of secondary
TOPAIRNW=              7.134 / [degC] Top air NW
TRUSSENE=              3.286 / [degC] Truss leg ENE
TRUSSWSW=              2.048 / [degC] Truss leg WSW
WINDDIR =            265.958 / [deg] Wind direction, azimuth
WINDSPD =             48.915 / [km/h] Wind speed
CSOTAU  =              0.047 / Tau at 225 GHz from CSO
TAUDATE = '2001-11-30T04:07'   / Time and date opf Tau reading
TAUSRC  = 'CSO     '          /Source of opacity data
CNFINDEX=                   1 / Configuration index
END
```

8.2 Extension HDU FITS keys from CASU pipeline–processed image data

```
XTENSION= 'IMAGE   '          / IMAGE extension
EXTNAME = '                  '/ Extension name/detector name...?
BITPIX  =                  -32 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                 1091 / length of data axis 1
NAXIS2  =                 1091 / length of data axis 2
PCOUNT  =                    0 / required keyword; must = 0
GCOUNT  =                    1 / required keyword; must = 1
DETECTOR= 'ALADDIN'           / Detector array used
NINT    =                    1 / Number of integrations in observation
DROWS   =                 1024 / [pixel] Number of detector rows
```

```
DCOLUMNS=                 1024 / [pixel] Number of detector columns
RDOUT_X1=                    1 / Start column of array readout
RDOUT_X2=                 1024 / Start column of array readout
RDOUT_Y1=                    1 / Start row    of array readout
RDOUT_Y2=                 1024 / Start row    of array readout
PIXLSIZE=                0.454 / [arcsec] Pixel size
FLATCOR = 'Done with: J_flat_1.fit'
RSTANOM = 'Done with medlinfilt: 50 25'
CIR_CPM = 'wfcam_6523_conf.fit[1]' / Confidence map
SKYSUB  = 'Done TILE_SKY: sky_6523.fits[0] 1.104' / Sky subtraction info
PROJP1  =                   1.
PROJP3  =                 220.
CIRMED  =              1881.53 / Latest estimate of background
CIR_BVAR=             182.6193 / Latest estimate of background variance
CIR_ZERO=            -73.88457 / Pedestal value relative to group average
CIR_SCAL=                   1. / Background scale relative to group maximum
CIR_OPM = 'irx_6523_c1_012_opm.fits[0]' / Object mask
CTYPE1  = 'RA---ZPN'
CTYPE2  = 'DEC--ZPN'
CRVAL1  =     217.409246142543
CRVAL2  =   0.0631388007913921
CRPIX1  =     1569.17568234834 / Dither offset Y
CRPIX2  =    -402.446920842832 / Dither offset Y
CD1_1   = -1.66959860113266E-06
CD2_1   = 0.000126195921150401
CD1_2   = 0.000126124625720947
CD2_2   =  1.4709458469656E-06
WCSPASS =                   1 / Pass level of WCS
CIR_XOFF=             35.40594 / Dither offset X
CIR_YOFF=              33.1044 / Dither offset Y
NUMBRMS =                  30
STDCRMS =     0.32526138905959
HISTORY 20030305 10:28:46
HISTORY    $Id: cir_imcore.c,v 1.4 2003/02/03 09:32:36 jim Exp $
END
```

8.3 Example FITS keys from a catalogue MEF

Primary HDU (excluding keys inherited from corresponding image data):

```
SIMPLE  =                   T / file does conform to FITS standard
BITPIX  =                   8 / number of bits per data pixel
NAXIS   =                   0 / number of data axes
EXTEND  =                   T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
END
```

Each extension HDU:

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                  264 / width of table in bytes
NAXIS2  =                  141 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                   66 / number of fields in each row

[NB: from here onwards needs altering for the full WFCAM enhanced 66
attribute set - let me know what you think of my Table 2]

TTYPE1  = 'No.     '           / label for field   1
TFORM1  = '1E      '           / data format of field: 4-byte REAL
TUNIT1  = '        '           / physical unit of field
TTYPE2  = 'Isophotal_flux'     / label for field   2
TFORM2  = '1E      '           / data format of field: 4-byte REAL
TUNIT2  = 'Counts  '           / physical unit of field
TTYPE3  = 'Total_flux'         / label for field   3
TFORM3  = '1E      '           / data format of field: 4-byte REAL
TUNIT3  = 'Counts  '           / physical unit of field
TTYPE4  = 'Core_flux'          / Fitted flux within 1x core radius
TFORM4  = '1E      '           / data format of field: 4-byte REAL
TUNIT4  = 'Counts  '           / physical unit of field
TTYPE5  = 'X_coordinate'       / label for field   5
TFORM5  = '1E      '           / data format of field: 4-byte REAL
TUNIT5  = 'Pixels  '           / physical unit of field
TTYPE6  = 'Y_coordinate'       / label for field   6
TFORM6  = '1E      '           / data format of field: 4-byte REAL
TUNIT6  = 'Pixels  '           / physical unit of field
TTYPE7  = 'Gaussian_sigma'     / label for field   7
TFORM7  = '1E      '           / data format of field: 4-byte REAL
TUNIT7  = 'Pixels  '           / physical unit of field
TTYPE8  = 'Ellipticity'        / label for field   8
TFORM8  = '1E      '           / data format of field: 4-byte REAL
TUNIT8  = '        '           / physical unit of field
TTYPE9  = 'Position_angle'     / label for field   9
TFORM9  = '1E      '           / data format of field: 4-byte REAL
TUNIT9  = 'Degrees '           / physical unit of field
TTYPE10 = 'Peak_height'        / label for field  10
TFORM10 = '1E      '           / data format of field: 4-byte REAL
TUNIT10 = 'Counts  '           / physical unit of field
TTYPE11 = 'Areal_1_profile'    / label for field  11
TFORM11 = '1E      '           / data format of field: 4-byte REAL
TUNIT11 = 'Pixels  '           / physical unit of field
TTYPE12 = 'Areal_2_profile'    / label for field  12
TFORM12 = '1E      '           / data format of field: 4-byte REAL
TUNIT12 = 'Pixels  '           / physical unit of field
TTYPE13 = 'Areal_3_profile'    / label for field  13
TFORM13 = '1E      '           / data format of field: 4-byte REAL
TUNIT13 = 'Pixels  '           / physical unit of field
```

```
TTYPE14 = 'Areal_4_profile'    / label for field  14
TFORM14 = '1E      '           / data format of field: 4-byte REAL
TUNIT14 = 'Pixels  '           / physical unit of field
TTYPE15 = 'Areal_5_profile'    / label for field  15
TFORM15 = '1E      '           / data format of field: 4-byte REAL
TUNIT15 = 'Pixels  '           / physical unit of field
TTYPE16 = 'Areal_6_profile'    / label for field  16
TFORM16 = '1E      '           / data format of field: 4-byte REAL
TUNIT16 = 'Pixels  '           / physical unit of field
TTYPE17 = 'Areal_7_profile'    / label for field  17
TFORM17 = '1E      '           / data format of field: 4-byte REAL
TUNIT17 = 'Pixels  '           / physical unit of field
TTYPE18 = 'Areal_8_profile'    / label for field  18
TFORM18 = '1E      '           / data format of field: 4-byte REAL
TUNIT18 = 'Pixels  '           / physical unit of field
TTYPE19 = 'Core1_flux'         / Fitted flux within 1/2x core radius
TFORM19 = '1E      '           / data format of field: 4-byte REAL
TUNIT19 = 'Counts  '           / physical unit of field
TTYPE20 = 'Core2_flux'         / Fitted flux within sqrt(2)x core radius
TFORM20 = '1E      '           / data format of field: 4-byte REAL
TUNIT20 = 'Counts  '           / physical unit of field
TTYPE21 = 'Core3_flux'         / Fitted flux within 2x core radius
TFORM21 = '1E      '           / data format of field: 4-byte REAL
TUNIT21 = 'Counts  '           / physical unit of field
TTYPE22 = 'Core4_flux'         / Fitted flux within 2sqrt(2)x core radius
TFORM22 = '1E      '           / data format of field: 4-byte REAL
TUNIT22 = 'Counts  '           / physical unit of field
TTYPE23 = 'RA      '           / label for field  23
TFORM23 = '1E      '           / data format of field: 4-byte REAL
TUNIT23 = 'RADIANS '           / physical unit of field
TTYPE24 = 'DEC     '           / label for field  24
TFORM24 = '1E      '           / data format of field: 4-byte REAL
TUNIT24 = 'RADIANS '           / physical unit of field
TTYPE25 = 'Classification'     / label for field  25
TFORM25 = '1E      '           / data format of field: 4-byte REAL
TUNIT25 = 'Flag    '           / physical unit of field
TTYPE26 = 'Statistic'          / label for field  26
TFORM26 = '1E      '           / data format of field: 4-byte REAL
TUNIT26 = 'N-sigma '           / physical unit of field
TTYPE27 = 'Blank   '           / label for field  27
TFORM27 = '1E      '           / data format of field: 4-byte REAL
TUNIT27 = 'Blank   '           / physical unit of field
TTYPE28 = 'Blank   '           / label for field  28
TFORM28 = '1E      '           / data format of field: 4-byte REAL
TUNIT28 = 'Blank   '           / physical unit of field
TTYPE29 = 'Blank   '           / label for field  29
TFORM29 = '1E      '           / data format of field: 4-byte REAL
TUNIT29 = 'Blank   '           / physical unit of field
TTYPE30 = 'Blank   '           / label for field  30
TFORM30 = '1E      '           / data format of field: 4-byte REAL
TUNIT30 = 'Blank   '           / physical unit of field
```

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TTYPE31 = 'Blank   '           / label for field  31
TFORM31 = '1E      '           / data format of field: 4-byte REAL
TUNIT31 = 'Blank   '           / physical unit of field
TTYPE32 = 'Blank   '           / label for field  32
TFORM32 = '1E      '           / data format of field: 4-byte REAL
TUNIT32 = 'Blank   '           / physical unit of field
EXTNAME = 'APM-BINARYTABLE'    / name of this binary table extension
DATE    = '2003-03-05T10:28:46' / file creation date (YYYY-MM-DDThh:mm:ss UT)
SKYLEVEL=              1880.99 / Median sky brightness (counts/pixel)
SKYNOISE=                 4.54 / Pixel noise at sky level (counts)
THRESHOL=                 9.07 / Isophotal analysis threshold (counts)
MINPIX  =                    5 / Minimum size for images (pixels)
CROWDED =                    1 / Crowded field analysis flag (0 none, 1 active)
RCORE   =                  3.5 / Core radius for default profile fit (pixels)
SEEING  =             2.061935 / Average FWHM (pixels)
COMMENT   FITS (Flexible Image Transport System) format is defined in Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
INHERIT =                    T
.
.
.
ELLIPTIC=           0.06848837 / Average stellar ellipticity (1-b/a)
CLASSIFD=                    T / Class flag: -1 stellar, 1 non-stellar, 0 noise
SATURATE=                30000. / Average saturation level in frame
APCORPK =              1.852217 / Stellar aperture correction - peak height
APCOR1  =             0.3795509 / Stellar aperture correction - core1 flux
APCOR   =           0.08592701 / Stellar aperture correction - core flux
APCOR2  =           0.03884411 / Stellar aperture correction - core2 flux
APCOR3  =           0.01241398 / Stellar aperture correction - core3 flux
APCOR4  =                   0. / Stellar aperture correction - core4 flux
COMMENT Symbolic translation for GAIA ellipse plotting........
SYMBOL1 = '{Ellipticity Position_angle Areal_1_profile Classification} {el'
SYMBOL2 = 'lipse blue (1.0-$Ellipticity) $Position_angle+90 {} $Classific'
SYMBOL3 = 'ation==1} {sqrt($Areal_1_profile*(1.0-$Ellipticity)/3.142)} : {'
SYMBOL4 = 'Ellipticity Position_angle Areal_1_profile Classification} {el'
SYMBOL5 = 'lipse red (1.0-$Ellipticity) $Position_angle+90 {} $Classific'
SYMBOL6 = 'ation==-1} {sqrt($Areal_1_profile*(1.0-$Ellipticity)/3.142)} :'
SYMBOL7 = '{Ellipticity Position_angle Areal_1_profile Classification} {el'
SYMBOL8 = 'lipse green (1.0-$Ellipticity) $Position_angle+90 {} $Classifi'
SYMBOL9 = 'cation==0} {sqrt($Areal_1_profile*(1.0-$Ellipticity)/3.142)}'
HISTORY 20030305 10:28:46
HISTORY    $Id: cir_classify.c,v 1.3 2003/02/03 09:32:36 jim Exp $
END
```

9 ACRONYMS & ABBREVIATIONS

ADnn : Applicable Document No. nn
CASU : Cambridge Astronomical Survey Unit
DAS : Data Acquisition System
ESO : European Southern Observatory

FITS : Flexible Image Transport System
HDS : Hierarchical Data System
HDU : Header Data Unit (FITS nomenclature)
JAC : Joint Astronomy Centre
MEF : Multi–Extension FITS
RAID : Redundant Array of Inexpensive Disks
SDSS : Sloan Digitial Sky Survey
VDFS : VISTA Data Flow System
UKIDSS : UKIRT Deep Infrared Sky Survey
UKIRT : United Kingdom Infrared Telescope
VISTA: Visible and Infrared Survey Telescope for Astronomy
WCS : World Co-ordinate System
WFAU : Wide Field Astronomy Unit (Edinburgh)
WSA : WFCAM Science Archive
2MASS : 2 Micron All–Sky Survey

10 APPLICABLE DOCUMENTS

AD01	WSA Hardware Design Document	VDF-WFA-WSA-CDR-006 Issue:
AD02	WSA Database Design Document	VDF-WFA-WSA-CDR-007 Issue:

11 CHANGE RECORD

Issue	**Date**	**Section(s) Affected**	**Description of Change/Change Request Reference/Remarks**
Draft	17/03/03	All	New document

12 NOTIFICATION LIST

The following people should be notified by email whenever a new version of this document has been issued:

WFAU: P Williams, N Hambly
CASU: M Irwin, J Lewis
QMUL: J Emerson
ATC: M. Stewart
JAC: A. Adamson