Document Title	**WFCAM HDS container and FITS headers**
Document Number	
Issue	0.6
Date	2003-Mar-05

Document Prepared By:	Alan Pickup	**Signature and Date**	
Document Approved By:		**Signature and Date**	
Document Released By:		**Signature and Date**	

CHANGE RECORD

Issue	**Date**	**Section affected**	**Change Description**
0.1	2002-Oct-16	all	1st version for time of Software CDR
0.2	2003-Feb-10	all	Tables include comment records; new headers including “TSCAN”s
0.3	2003-Feb-13	all	Correction of typos (thanks to Jim Lewis); some additional comments; addition of sections listing example headers.
0.4	2003-Feb-14	all	“TSCAN” becomes “JITTER”; added READOUT; expanded environment headers (from JAC); updated examples.
0.5	2003-Feb-24	all	Document title changed form *WFCAM FITS headers* to *WFCAM HDS container and FITS headers*
			New section on contents of HDS container
			New astrometric (WCS) headers: CDi_j and PV1_n
			New examples
0.6	2003-Mar-05	all	Removed NOFFSETS header
			Added SURVEY, SURVEY_I, DETECTID, PCSYSID, SDSUID, CAMROLE and GAIN headers
			New HDSTRACE and examples

APPLICABLE DOCUMENTS

Reference	Document Title	Document Number	Issue & Date

TABLE OF CONTENTS

2. INTRODUCTION

This document illustrates the contents of a typical HDS container file into which WFCAM data is written and provides a list of FITS headers for that instrument. The FITS headers were based initially on those used for imaging with UIST but have been modified in the light of discussions, primarily in the area of the World Coordinate System headers.

3. WFCAM HDS CONTAINER

Data from each of the four WFCAM cameras is to be written as NDF structures into separate HDS container files, usually as one file for each camera for each frame in a microstep pattern.

For a microstep frame, each container holds two NDF structures:

- The first, named ***I1***, holds the image data frame, typically a 2048 by 2048 array of type _REAL. Associated with this is an array of character strings in ***MORE.FITS*** that contains the FITS headers specifically associated with this frame.

- The second NDF structure is named ***HEADER*** and is a repository for a more comprehensive array FITS headers associated with the observation, again in a ***MORE.FITS*** extension. As all NDF structures must, ***HEADER*** contains its own ***DATA_ARRAY*** but in this case it is simply a dummy one.

The reason for having separate ***HEADER*** and ***I1*** structures is to make it possible to add additional ***I2***, ***I3*** etc structures in the same container, with the contents of ***HEADER*** being common to all the frames. At present, this facility will be exploited for focus tests, with frames at multiple focus positions being written as separate NDF structures into the one container, each with its own focus setting encoded in its own *frame level* ***MORE.FITS***.

See the following section for a listing of the typical structure of a WFCAM HDS container file.

3.1 Example HDSTRACE of WFCAM container file

The following listing illustrates the structure of a typical WFCAM container file, generated using the HDSTRACE command.

```
W20030305_00005  <UKIRT_HDS>

   I1             <NDF>            {structure}
      DATA_ARRAY     <ARRAY>          {structure}
         DATA(2048,2048)  <_REAL>        0,1,2,3,4,5,6,7,8,9,10,11,12,13,
                                         ... 4194300,4194301,4194302,4194303
         ORIGIN(2)      <_INTEGER>       1,1

      HISTORY        <HISTORY>        {structure}
         CREATED        <_CHAR*24>       '2003-MAR-05 15:41:51.000'
         CURRENT_RECORD  <_INTEGER>      1
         RECORDS(10)    <HIST_REC>       {array of structures}

         Contents of RECORDS(1)
            DATE           <_CHAR*24>       '2003-MAR-05 15:41:53.000'
            COMMAND        <_CHAR*9>        '<unknown>'
            USER           <_CHAR*3>        'dap'
            HOST           <_CHAR*14>       'ness.roe.ac.uk'
            DATASET        <_CHAR*56>       '/net/vaila/vaila2/wfcam/raw/20...'
            TEXT(2)        <_CHAR*72>       'Arguments: <unknown>','Softwar...'

      AXIS(2)        <AXIS>           {array of structures}

      Contents of AXIS(1)
         DATA_ARRAY     <ARRAY>          {structure}
            DATA(2048)     <_REAL>          0.5,1.5,2.5,3.5,4.5,5.5,6.5,
                                            ... 2044.5,2045.5,2046.5,2047.5
            ORIGIN(1)      <_INTEGER>       1

      MORE           <EXT>            {structure}
         FITS(4)        <_CHAR*80>       'UTSTART =           15.696944 /...'
                                         ... 'FOC_OFF =                  0.00...'

   HEADER         <NDF>            {structure}
      DATA_ARRAY     <ARRAY>          {structure}
         DATA(1,1)      <_REAL>          0
         ORIGIN(2)      <_INTEGER>       1,1

      HISTORY        <HISTORY>        {structure}
         CREATED        <_CHAR*24>       '2003-MAR-05 15:41:53.000'
         CURRENT_RECORD  <_INTEGER>      1
         RECORDS(10)    <HIST_REC>       {array of structures}

         Contents of RECORDS(1)
            DATE           <_CHAR*24>       '2003-MAR-05 15:41:53.000'
            COMMAND        <_CHAR*9>        '<unknown>'
            USER           <_CHAR*3>        'dap'
            HOST           <_CHAR*14>       'ness.roe.ac.uk'
            DATASET        <_CHAR*60>       '/net/vaila/vaila2/wfcam/raw/20...'
            TEXT(2)        <_CHAR*72>       'Arguments: <unknown>','Softwar...'

      MORE           <EXT>            {structure}
         FITS(133)      <_CHAR*80>       ' ','                            ...'
                                         ... 'DET_TEMP=                   25....'

End of Trace.
```

4. WFCAM FITS HEADERS

Two tables are provided:

- A table in section 3.1 of *top level* headers which appears in the MORE.FITS section of an NDF structure called HEADER in the HDS container file;
- A table in section 3.2 of *frame level* headers that appear in the MORE.FITS section of each integration within the HDS container file.

Each table lists:

- the FITS keyword of the header;
- the comment field in the FITS string;
- the source of the FITS value when WFCAM is used on UKIRT (see below);
- the usual source of the FITS value during engineering tests.

The possible sources of the FITS value are:

- fix - the value is fixed in the header definition table;
- om - set from the sequencer level of observation control via the OM Translator and the OOS task. This is likely to be blank (see below) when WFCAM is run from its non-OM engineering interface;
- inst - set from the instrument control level (the WFIS);
- TCS - read from the telescope control system;
- EPICS - obtained from an EPICS database;
- data - obtained as attribute alongside data received from camera controller;
- DHS - set within the DHS system;
- CSOMON - obtained from CSO monitor task;
- blank - the FITS value field will be blank

Note that these sources are as seen from the point of view of the DHS. The ones in the “om” may, in turn, originate in some aspect of a survey definition, be specified by the Observer, or be specified or derived in some other way, for example from an entry in a lookup table read by the OT.

4.1 Definition of top level FITS headers

FITS name	*FITS comment*	*UKIRT source*	*Engineering source*
	Identification:		
TELESCOP	Telescope name	fix	fix
INSTRUME	Instrument	fix	fix
CAMNUM	Number of this camera	data	data
DHSVER	Data handling version	fix	fix
HDTFILE	Name of global hdt file	fix	fix
HDTFILE2	Name of camera-specific hdt file	fix	fix
OBSERVER	Observers names	om	om
USERID	Userid logged in as	om	om
OBSREF	PATT or other reference	om	om
PROJECT	Time-allocation code	om	om
SURVEY	Survey name	om	om
SURVEY_I	Pointing ID within survey	om	om
MSBID	Id min.schedulable block	om	om
OBJECT	Object name from telescope	TCS	blank
	Data reduction:		
RECIPE	Data reduction recipe to be used	om	om
OBSTYPE	Type (BIAS|DARK|FLAT|OBJECT|SKY|FOCUS)	inst	inst
OBSNUM	Observation number	DHS	DHS
GRPNUM	Group number applied to all members	DHS	DHS
GRPMEM	Group membership	om	om
STANDARD	Is the target a standard star	om	om
NJITTER	Number of positions in telescope jitter pattern	om	om
JITTER_I	Serial number in this telescope jitter pattern	om	om
JITTER_X	[arcsec] X (RA) offset in telescope jitter pattern	om	om
JITTER_Y	[arcsec] Y (Dec) offset in telescope jitter pattern	om	om
NUSTEP	Number of positions in microstep pattern	om	om
USTEP_I	Serial number in this microstep pattern	om	om
USTEP_X	[arcsec] X (RA) offset in microstep pattern	om	om
USTEP_Y	[arcsec] Y (Dec) offset in microstep pattern	om	om
NFOC	Number of positions in focus scan	inst	inst
NFOCSCAN	Number of focus scans in focus test	inst	inst
	Astrometric and time information:		
UTDATE	UT date as integer in yyyymmdd format	inst	inst
DATE-OBS	Date and time (UTC) of start of observation	data	data
DATE-END	Date and time (UTC) of end of observation	data	data
WCSAXES	Number of axes in world co-ordinate system	fix	fix
RADESYS	Mean IAU 1984 equatorial co-ordinates	fix	fix
EQUINOX	[yr] Equinox of object position	TCS	fix
CTYPE1	Algorithm type for axis 1	fix	fix
CTYPE2	Algorithm type for axis 2	fix	fix
CRPIX1	[pixel] Reference pixel along axis 1 (RA)	inst	inst
CRPIX2	[pixel] Reference pixel along axis 2 (Dec)	inst	inst
CRVAL1	[deg] Right ascension at the reference pixel	TCS	fix

CRVAL2	[deg] Declination at the reference pixel	TCS	fix
CRUNIT1	Unit of right ascension co-ordinates	fix	fix
CRUNIT2	Unit of declination co-ordinates	fix	fix
CD1_1	Transformation matrix element	inst	inst
CD1_2	Transformation matrix element	inst	inst
CD2_1	Transformation matrix element	inst	inst
CD2_2	Transformation matrix element	inst	inst
PV1_1	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_2	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_3	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_4	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_5	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_6	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_7	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_8	Pol. coeff. for pixel -> celestial coord.	inst	inst
PV1_9	Pol. coeff. for pixel -> celestial coord.	inst	inst
RABASE	[h] Right ascension of base position	TCS	fix
DECBASE	[deg] Declination of base position	TCS	fix
TRAOFF	[arcsec] Right ascension telescope offset	TCS	fix
TDECOFF	[arcsec] Declination telescope offset	TCS	fix
AMSTART	Airmass at start of observation	TCS	fix
AMEND	Airmass at end of observation	TCS	fix
TELRA	[h] Current telescope right ascension	TCS	fix
TELDEC	[deg] Current telescope declination	TCS	fix
GSRA	[h] Right ascension of guide star	TCS	fix
GSDEC	[deg] Declination of guide star	TCS	fix
	Instrument detector configuration:		
DETECTOR	Type of detector array used	fix	fix
DETECTID	Serial number of detector array	data	data
NINT	Number of integrations in observation	data	data
DROWS	[pixel] Number of detector rows	data	data
DCOLUMNS	[pixel] Number of detector columns	data	data
RDOUT_X1	Start column of array readout	data	data
RDOUT_X2	End column of array readout	data	data
RDOUT_Y1	Start row of array readout	data	data
RDOUT_Y2	End row of array readout	data	data
PIXLSIZE	[arcsec] Pixel size	inst	inst
	Detector controller:		
PCSYSID	PC system identifier	inst	inst
SDSUID	Serial number of SDSU controller	inst	inst
READMODE	Name of camera readmode	inst	inst
CAPPLICN	Name of camera readout application	data	data
CAMROLE	Camera role (master|slave|unsync)	inst	inst
READOUT	Camera readout (CDS|NDR|SAR|RRR)	data	data
EXP_TIME	[s] Integration time per exposure	inst	inst
NEXP	Number of exposures in integration	inst	inst
READINT	[s] Interval between reads	data	data
NREADS	Number of reads per exposure	data	data
GAIN	[electrons/ADU] Detector gain	data	data

	Instrument optical configuration:		
FILTER	Filter name	EPICS	EPICS or fix
FOC_MM	[mm] Base focus position	EPICS	EPICS or fix
	Environment:		
AIRTEMP	[degC] Air temperature	EPICS	fix
BARPRESS	Ambient pressure	EPICS	fix
DEWPOINT	[degC] Dewpoint	EPICS	fix
DOMETEMP	[degC] Dome temperature	EPICS	fix
HUMIDITY	Relative humidity	EPICS	fix
MIRRBSW	[degC] Temperature mirror B SW	EPICS	fix
MIRR_NE	[degC] Mirror temperature NE	EPICS	fix
MIRR_NW	[degC] Mirror temperature NW	EPICS	fix
MIRR_SE	[degC] Mirror temperature SE	EPICS	fix
MIRR_SW	[degC] Mirror temperature SW	EPICS	fix
MIRRBTNW	[degC] Mirror bottom temp. NW	EPICS	fix
MIRRTPNW	[degC] Mirror top temp. NW	EPICS	fix
SECONDAR	[degC] Temperature of secondary	EPICS	fix
TOPAIRNW	[degC] Top air NW	EPICS	fix
TRUSSENE	[degC] Truss leg ENE	EPICS	fix
TRUSSWSW	[degC] Truss leg WSW	EPICS	fix
WIND_DIR	[deg] Wind direction, azimuth	EPICS	fix
WIND_SPD	[km/h] Wind speed	EPICS	fix
CSOTAU	Tau at 225 GHz from CSO	CSOMON	fix
TAUDATE	Time and date of Tau reading	CSOMON	fix
TAUSRC	Source of opacity data	CSOMON	fix
	Engineering:		
CNFINDEX	Configuration index	EPICS	EPICS or fix
DET_TEMP	[K] Array temperature	EPICS	EPICS or fix
	< More camera engineering data may go here >		

4.1.1 Example of top level FITS headers

```
TELESCOP= 'UKIRT                 ' / Telescope name
INSTRUME= 'WFCAM                 ' / Instrument
CAMNUM  =                      1 / Number of WFCAM camera (1, 2, 3 or 4)
DHSVER  = 'UKDHS 2002 Oct 31     ' / Data handling version
HDTFILE = 'wfcam.hdt             ' / Name of global hdt file
HDTFILE2= 'wfcam2.hdt            ' / Name of camera-specific hdt file
OBSERVER= 'Mrs Observer'           / Observers names
USERID  = 'abc     '               / Userid logged in as
OBSREF  = 'notPATT99'              / PATT or other reference
PROJECT = 'Example WFCAM data'     / Time-allocation code
SURVEY  = 'Demo survey 123'        / Survey name
SURVEY_I= 'B1.99.4 '               / Pointing ID within survey
MSBID   = '42      '               / Id min.-schedulable block
OBJECT  = 'Laboratory wall'        / Object name from telescope

                                     Data Reduction:
RECIPE  = 'QUICK_LOOK'             / Data reduction recipe to be used
OBSTYPE = 'OBJECT  '               / Type (BIAS|DARK|FLAT|OBJECT|SKY|FOCUS)
OBSNUM  =                      5 / Observation number
GRPNUM  =                      5 / Group number applied to all members
GRPMEM  =                      T / Group membership
STANDARD=                      F / Is the target a standard star observation?
NJITTER =                      4 / Number of positions in tel jitter 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

                                     Astrometric and time information:
UTDATE  = '20030305'               / UT date as integer in yyyymmdd format
DATE-OBS= '2003-03-05T15:41:49Z' / Date and time (UTC) of start of observation
DATE-END= '2003-03-05T15:41:50Z' / 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
CTYPE1  = 'RA---ZPN'               / Algorithm type for axis 1
CTYPE2  = 'DEC--ZPN'               / Algorithm type for axis 2

CRPIX1  =                 1000.0 / [pixel] Reference pixel along axis 1 (RA)
CRPIX2  =                -1000.0 / [pixel] Reference pixel along axis 2 (Rec)
CRVAL1  =              300.16419 / [deg] Right ascension at the reference pixel
CRVAL2  =             29.9749447 / [deg] Declination at the reference pixel
CRUNIT1 = 'deg     '               / Unit of right ascension co-ordinates
CRUNIT2 = 'deg     '               / Unit of declination co-ordinates

CD1_1   =           0.000000E+00 / Transformation matrix element
CD1_2   =           1.000000E+00 / Transformation matrix element
CD2_1   =           5.000000E-01 / Transformation matrix element
CD2_2   =          -5.000000E-01 / Transformation matrix element

PV1_1   =           0.000000E+00 / Pol.coeff. for pixel -> celestial coord
PV1_2   =           1.000000E-02 / Pol.coeff. for pixel -> celestial coord
PV1_3   =           2.000000E-02 / Pol.coeff. for pixel -> celestial coord
PV1_4   =           3.000000E-02 / Pol.coeff. for pixel -> celestial coord
PV1_5   =           4.000000E-02 / Pol.coeff. for pixel -> celestial coord
PV1_6   =           5.000000E-02 / Pol.coeff. for pixel -> celestial coord
PV1_7   =           6.000000E-02 / Pol.coeff. for pixel -> celestial coord
PV1_8   =           7.000000E-02 / Pol.coeff. for pixel -> celestial coord
PV1_9   =           8.000000E-02 / Pol.coeff. for pixel -> celestial coord

RABASE  =             20.0109458 / [h] Right ascension of base position
DECBASE =             29.9749447 / [deg] Declination of base position
TRAOFF  =                  0.000 / [arcsec] Right ascension telescope offset
```

```
TDECOFF =                  0.000 / [arcsec] Declination telescope offset
AMSTART =                  1.771 / Airmass at start of observation
AMEND   =                  1.769 / Airmass at end of observation
TELRA   =             20.0123456 / [h] Current telescope right ascension
TELDEC  =             29.9876543 / [deg] Current telescope declination
GSRA    =             20.0103456 / [h] Right ascension of guide star
GSDEC   =             29.9806543 / [deg] Declination of guide star

                                   Instrument detector configuration:
DETECTOR= 'RSC Hawaii 2'         / Type of detector array used
DETECTID= 'a.bc.123'             / Serial number of detector array
NINT    =                      1 / Number of integrations in observation
DROWS   =                   2048 / [pixel] Number of detector rows
DCOLUMNS=                   2048 / [pixel] Number of detector columns
RDOUT_X1=                      1 / Start column of array readout
RDOUT_X2=                   2048 / Start column of array readout
RDOUT_Y1=                      1 / Start row    of array readout
RDOUT_Y2=                   2048 / Start row    of array readout
PIXLSIZE=                 0.4000 / [arcsec] Pixel size

                                   Detector controller:
PCSYSID = 'ness    '             / PC system identifier
SDSUID  = '00222   '             / Serial number of SDSU controller
READMODE= 'CDS_v1  '             / Name of camera readmode
CAPPLICN= 'applic01'             / Name of camera readout application
CAMROLE = 'master  '             / Camera role (master|slave|unsync)
READOUT = 'CDS     '             / Camera readout (CDS|NDR|SAR|RRR)
EXP_TIME=               1.000000 / [s] Integration time per exposure
NEXP    =                      1 / Number of exposures in integration
READINT =               1.000000 / [s] Interval between reads
NREADS  =                      0 / Number of reads per exposure
GAIN    =                    1.0 / [electrons/ADU] Detector gain

                                   Instrument optical configuration:
FILTER  = 'whatever'             / Filter name
FOC_MM  =                  12.34 / [mm] Base focus position

                                   Environment:
AIRTEMP =                  5.785 / [degC] Air temperature
BARPRESS=                650.000 / Ambient pressure
DEWPOINT=                  2.000 / [degC] Dewpoint
DOMETEMP=                  7.095 / [degC] Dome temperature
HUMIDITY=                 35.450 / Relative humidity
MIRRBSW =                  7.123 / [degC] Temperature mirror B SW
MIRRNE  =                  7.124 / [degC] Mirror temperature NE
MIRRNW  =                  7.125 / [degC] Mirror temperature NW
MIRRSE  =                  7.126 / [degC] Mirror temperature SE
MIRRSW  =                  7.127 / [degC] Mirror temperature SW
MIRRBTNW=                  7.128 / [degC] Mirror bottom temp. NW
MIRRTPNW=                  7.129 / [degC] Mirror top temp. NW
SECONDAR=                  7.130 / [degC] Temperature of secondary
TOPAIRNW=                  7.131 / [degC] Top air NW
TRUSSENE=                  7.132 / [degC] Truss leg ENE
TRUSSWSW=                  7.133 / [degC] Truss leg WSW
WIND_DIR=                106.987 / [deg] Wind direction, azimuth
WIND_SPD=                 16.089 / [km/h] Wind speed
CSOTAU  =                  0.047 / Tau at 225 GHz from CSO
TAUDATE = '2001-11-30T04:07'     / Time and date of Tau reading
TAUSRC  = 'CSO     '             / Source of opacity data

                                   Engineering:
CNFINDEX=                      1 / Configuration index
DET_TEMP=                   25.0 / [K] Detector array temperature
```

4.2 Definition of frame level FITS headers

FITS name	*FITS comment*	*UKIRT source*	*Engineering source*
UTSTART	[h] Start time of integration	data	data
UTEND	[h] End time of integration	data	data
FOC_I	Serial number in focus scan	data	data
FOC_OFF	[mm] Offset from base focus position	data	data

4.2.1 Example of frame level FITS headers

```
UTSTART =             15.696944 / [h] Start time of integration
UTEND   =             15.697222 / [h] End time of integration
FOC_I   =                     0 / Serial number in focus scan
FOC_OFF =                 0.000 / [mm] Offset from base focus position
```