EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

ESO Phase 3 user documentation[1]

CONTENTS

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1 Purpose and Scope

This documentation describes the policies, the data standard and the procedure for the submission of reduced data products applicable to the ESO phase 3 process. (http://www.eso.org/sci/observing/phase3). The target audience are principal investigators and their collaborators who return reduced data products resulting from ESO observations for public release to the astronomical community through the ESO archive. This document is intended to provide the necessary information for the user to prepare for and, then, successfully carry out the ESO phase 3 process. This version of the document has been prepared to support the ESO Public Surveys Phase 3 workshop, in Garching, on November 30, 2010. The same information will be made available through the ESO web site.

2 Policies

2.1 ESO public surveys

2.1.1 Introduction

In accordance with the ESO Council document on the VLT/VLTI science operation policies (104 meeting, Dec. 17/18, 2004), *the ESO/ST-ECF Science Archive Facility (SAF) is the collection point for the survey products and the primary point of publication/availability of these products to the ESO community.* ESO assists the survey teams to define and package their data products in a manner consistent with SAF and Virtual Observatory standards and integrates the products into the SAF.

The general policies on the delivery of data products for the ESO public surveys, the links to the information specifying the format, products' types and timelines for delivery are described in the current pages.

The allocation of observing time for the scientific follow up of the surveys will be subject to the timely delivery of the surveys' products and their compliance to the specifications. The Public Survey Panel will periodically review the progress of the surveys and will assess the compliance to the specification of the surveys' products.

2.1.2 General policies on the delivery of data products from VISTA public surveys

Survey products will be delivered to the ESO archive in a format specified in the Phase 3 web page (link). The following data products form part of the core delivery to the ESO archive:

- astrometrically and photometrically calibrated, co-added, re-gridded tiles, along with their respective confidence maps, in all of the project-relevant filters;
- source catalogues for a tile based on individual, co-added bands, as well as associated source catalogues linking the parameters of individual objects across all of the observed filter bands; the single band catalogs will be ingested and accessible from the ESO web pages as FITS files.
- Survey data products must be supported and characterized by additional information, i.e. meta-data, which provides a full description for their scientific exploitation. For a description and definition of the meta-data we refer to the Phase 3 web pages .
- In the case of VISTA the tile is defined to be the basic building block of the survey, because it allows a better synergy with the VST optical data products which will be present in the ESO archive also. This will also ensure that there is a unique entry in the source catalogue for any objects within the same VISTA pointing[2]. For programs which

[2] The standard 6-pawprint sequence for a tile covers each sky position twice. Therefore, catalogues from single pawprints from the same tile (or pointing on the sky) will be degenerate and not of optimal depth, since it is exposed for only half of the total exposure time.

do not observe a full tile in an OB, the partially filled tiles should be the basic building block, although when these partial tiles can be combined to make the full tiles this should be done.

The precise content of the catalogs to be delivered will depend on the scientific goals and exploitation possibilities of each VISTA PS. In coordination with the Public Survey Panel, ESO reserves the right to request from the PIs the expansion of the catalog contents with additional items that could enhance the scientific value of the data products, or their use by the community at large.

The following Section contains the presentation of the timeline and a short description of the Data Products delivered from each of the VISTA public surveys.

2.1.3 Timeline of the Data Products delivery from the ESO public surveys

2.1.3.1 Raw data from ESO - VISTA public surveys

The raw data will be made public worldwide immediately after passing quality control tests at ESO. Given the practical limitations on the ability of the archive to distribute large volumes of data, will ensure that the risks of other groups being able to scoop the science goals of the survey are very small. To ensure that this is even less likely, ESO may consider imposing further restrictions on the maximum amount of data that can be downloaded by a user not associated with the public surveys.

2.1.3.2 External Data Products from ESO - VISTA public surveys

In what follows, t_0 refers to the date of the official start of science operations for surveys with VISTA. According to the current schedule, it is April 2010.

Following from the agreement signed by the ESO Director General and the PIs of the VISTA public surveys, the delivery of the data products to the ESO archive from an ESO Public Survey is the responsibility of the PI, which certifies the scientific quality and accuracy of the data products.

The tables hereafter list a short description of the deliverables and the external data products, their initial deadline for submission and the frequency of the expected new releases.

The description of the product types and their specific format, the Phase 3 concepts and the support documentation for the submission and validation of the external data products for the VISTA public surveys are available on the Phase 3 web page (link).

Table 1: Summary of the deliverables at t_0+12 months, and the frequency of new releases

Survey	**Deliverable #1** **Tiles and confidence maps**	**Deliverable #2** **Single band catalogues for each tile**	**Deliverable #3** **Aperture Matched multi band catalogues**	**Deliverable #4** **Source variability catalogues and light curves**	**When?** **1st delivery: April 2011**	**Frequency** **Every six months**
ULTRA-VISTA deep	Y, J, H, Ks , NB118	✘	✘		✘	✘
ULTRA-VISTA ultra-deep	Y, J, H, Ks , NB118 (stripes)	✘	✘		✘	✘
VHS	Y, J, H , Ks	✘	✘		✘	✘
VIDEO	Z, Y, J, H, Ks	✘	✘		✘	✘
VVV	Z, Y, J, H, Ks	✘	✘[1]	✘	✘	✘
VIKING	Z, Y, J, H, Ks	✘	✘		✘	✘
VMC	Y, J, Ks	✘	✘[1]	✘	✘	✘

[1]: variable stars should be flagged in these catalogues
Calibrations: Deliverables #1, #2, and #3 have single-night based calibrations.

Table 2: Summary of the External Data-Products (EDPs) Survey releases at t_0+18 months, and the frequencies of new releases

Survey	EDP: Stacked tiles[2]	EDP: Catalogues	EDP: Multi-epoch catalogues and light curves	When? t_0+18 months	Frequency yearly	Survey final release (after 5th year)
ULTRA-VISTA	Stacked image of all data up to that date (tile for deep part, and stripes for the ultra-deep one)	Aperture-matched multi-band catalogue from deep stack	No	✘	✘	Yes
VHS[3]	No	Source catalogue on the whole survey area available at the delivery date	No	✘	✘	Yes
VIDEO	Stacked images of the fields up to the delivery date	Aperture-matched multi-band catalogue from deep stack of the fields	Yes	✘	✘	Yes
VVV	✘	Source catalogue on the whole survey area available at the delivery date	Yes – Multi epoch catalogue in Ks band for the survey area available at delivery date	✘	✘	Yes
VIKING[3]	✘	✘	Yes	✘	✘	Yes
VMC	✘	✘	Yes – Multi epoch catalogue for the survey area available at delivery date	✘	✘	Yes

[2]: for the bands see Table 1

[3]: For VHS and VIKING, the Deliverable#1, Table1, the image tile, already has the depth and S/N targeted for that pointing position on the sky. The Survey release would then provide the revised astrometry and photometry globally calibrated. It may imply an update of the metadata associated with the deliverable#1, rather than a resubmission of the FITS files for these tiles.

Calibrations: delivered EDPs must have uniform photometric and astrometric calibrations that are checked globally.

3 ESO External Data Products Standard

The structure and format of external data products (EDPs) has to comply with the standards defined herein in order to successfully integrate them into the ESO science archive. The procedures and tools that support the data provider in validating the compliancy of data products with the EDP standard before submission will be discusses in the Section 4.

3.1 Level of reduction

External data products are high-level data products based on ESO observations, provided by the astronomical community, generally consisting of fully reduced and calibrated imaging and spectroscopic data, ancillary products, catalogues etc., which enable immediate scientific exploitation. Therefore, it is generally required for EDPs that instrumental signatures have been removed in a first data reduction step.

3.2 Data calibration

As a general guideline, scientific data products should be processed and, possibly, calibrated so that the data can be interpreted in (astro-)physical units with respect to an appropriate standard reference system. In practical terms, this translates into the following requirements.

3.2.1 Astrometry

- For imaging data, celestial coordinates shall be assigned to image pixels using the FITS convention for world coordinates (Calabretta & Greisen, 2002, Astronomy & Astrophysics, 395, 1077-1122) in which image distortions should be taken into account if need be.
- For celestial coordinates the International Celestial Reference System (ICRS) is the preferred standard.
- It is recommended to quantify the uncertainties of the astrometric registration using the FITS keywords CSYER*i* and CRDER*i* for the systematic and random parts to the error budget, respectively (see below for more details).
- Accurate target coordinates, e.g. for spectral observations, must be provided as part of the metadata.

3.2.2 Photometry

- The flux scale of imaging data should refer to a suitable photometric system. It should be specified either logarithmically in terms of the zero point magnitude or in terms of the linear scaling factor depending on the usual practice for the type of observation under consideration.
- The zero point magnitude can be defined with respect to the Johnson system where fluxes are normalized with respect to Vega, or using the AB photometric system (Oke & Gunn, 1983).
- It is recommended to provide an estimate of the uncertainty of the photometric/flux calibration.
- For imaging data the ESO filter designation must be recorded in the data product.

3.2.3 Spectral calibration

- The spectral axis of spectral data should be calibrated to proper physical units, e.g. Angstrom or Nanometer, using the respective FITS WCS convention (cf. Greisen et al. 2006, Astronomy & Astrophysics, 446, 747-771).
- In case the spectral data have been calibrated to absolute flux density, the flux scale should be given in physical units, e.g. in erg/s/cm^2/A.

3.2.4 Temporal characterization

- Any data product must record the time of observation in terms of Julian days. This basically requires properly propagating this information from the raw data to the final product.

3.3 Data characterization

Each external data product should be characterized by the following quality parameters at least.

3.3.1 Imaging data

- RMS astrometric accuracy
- Limiting magnitude
- Saturation limit
- PSF width
- Mean ellipticity

3.3.1.1 Weight maps

Many observational techniques, for instance the common *jitter* or *dither* techniques, imply that several exposures, with mutual offsets, are co-added to form the final product and the statistical significance of the pixel data may significantly vary across the image array. In this case it is required to provide the statistical significance of each pixel, usually in terms of a number that is proportional to the inverse variance of the signal. This additional data array is often called weight map or confidence map. It has the same dimensions as the image array and can be submitted as an associated data product with product category declared as ASSOC*i*='ancillary.weightmap'.

3.3.2 Spectra

- RMS accuracy of the spectral axis' calibration
- Signal-to-noise ratio

3.4 FITS file format

All types of scientific data products must generally conform to the FITS standard (Version 3.0, July 2008, http://fits.gsfc.nasa.gov/iaufwg/). Furthermore, the data format must comply with the specifications published in the ESO Data Interface Control Document, DICB, Doc. No.: GEN-SPE-ESO-19400-0794, Issue: 4, Date: 8 April 2008, if applicable in the context of EDPs.
For *ancillary files*, which are associated to science products without being directly searchable, any file format including the FITS format is accepted.
Integer format imaging data may be submitted in compressed FITS format using the Rice compression algorithm as implemented in the *fpack* utility (http://heasarc.gsfc.nasa.gov/fitsio/fpack/).

3.5 File naming convention

3.5.1 Maximum filename size

For any file the total length of its name, including the suffix, is limited to a maximum of 68 characters.

3.5.2 Uniqueness of filenames

Filenames must be unique for a given data release.

3.5.3 Filename suffixes

The filenames of science data products are subject to the permitted set of filename suffixes:

*.fits	FITS, uncompressed,
*.fits.fz	FITS, compressed (using *fpack*).

3.6 FITS keywords for External Data Products

The FITS keywords used to characterize External Data Products must comply with the following standard to ensure successful ingestion into the ESO science archive. A given keyword should be considered mandatory or optional depending on the context, i.e. on the specific data product, as specified in the definitions of data product formats in Section 3.8.
Normally, for a given EDP, the keywords defined herein just form a subset of keywords characterizing the data; in fact, the data provider is encouraged to include further keywords to

characterize the data in more detail, to a level that seems to be adequate from the scientific point of view.

3.6.1 Propagation of original keywords

External Data Products can be considered at the top of the hierarchy of data products in terms of processing level, and their metadata values must be obtained from the information present in the lower level products. Therefore, it is generally requested for proper archive ingestion that EDPs carry over keyword information from the original raw observational data as elaborated in the next sections.

Furthermore, it is recommended to preserve as much of the original information about the observation as possible. If the product was generated based on a single raw science file, the original keywords can be propagated in a one-to-one fashion. If the product is based on more than one raw science file, the keywords of the raw file, which had been acquired first in terms of MJD-OBS, can be propagated to the product. However, keywords that do not apply to the data product as a whole should not be propagated.

The propagation of keywords should have no bearing on the keywords that are being updated in the course of the data calibration process, e.g. the WCS keywords.

3.6.2 Primary EDP keywords

These keyword definitions generally apply to any EDP independent of the specific observational technique or the type of data product. Primary EDP keywords must go into the primary HDU of the FITS file.

Table 1: Primary EDP keywords

Type[3]	**Keyword**	**Description**
(S)	ORIGIN	Observatory or facility where the data were originally obtained (not where data processing was done). Can be adopted from the original data. Normally, set to 'ESO' or 'ESO-PARANAL'.
(S)	TELESCOP	ESO Telescope designation. To be adopted from the original data.
(S)	INSTRUME	Instrument name. To be adopted from the original data.
(S)	FILTER	Filter name. To be adopted from the appropriate keyword of the raw data, e.g. HIERARCH ESO INS FILT1 NAME
(S)	OBJECT	Should be set to the target designation as given by the Principal Investigator, for instance OBJECT = 'NGC3603 '.
(R)	EQUINOX	Standard FK5 (years). EQUINOX is mandatory if the reference frame is FK5 or FK4. EQUINOX = 2000.0 is tolerated for the ICRS coordinate reference frame.
(S)	RADECSYS	Coordinate reference frame. Preferentially ICRS or FK5.

[3] The capital letters I, L, R, and S indicate the keyword's data type integer number, boolean, floating point number, and string type, respectively.

(R)	EXPTIME	Total integration time per pixel (in seconds). For an imaging data product resulting from the co-addition of multiple exposures pointing at the same sky position (with a tolerance given by a small fraction of the instrumental field of view), EXPTIME should represent the total integration time per pixel obtained in the centre of the image. If the product has been constructed from exposures whose positions were offset from each other in order to sample a region of the sky being larger than the instrumental FOV then the total integration time may vary across the image array. In this case EXPTIME should be set to the nominal total integration time obtained in at least 50% of the image array taking into account the chosen offset pattern. Note that EXPTIME as given in the original raw data almost never represents the proper number of EXPTIME for the product, specifically if detector sub-integrations are involved.
(R)	TEXPTIME	Arithmetic sum of the integration time of all exposures included in this product (in seconds). Note that an exposures integration time is DIT*NDIT if sub-integrations are involved.
(R)	MJD-OBS	Specifies the start of the observation in terms of the modified Julian day; the start of the earliest observation if the data product results from the combination of multiple observations. To be adopted from the original data.
(R)	MJD-END	Specifies the end of the observation; the end of the latest observation if the data product results from the combination of multiple observations.
(S)	PROG_ID	The identification code assigned to each observing run by the Observing Programme Committee (OPC) in the format ppp.c-nnnn(r). Normally, PROG_ID should be copied from the keyword HIERARCH ESO OBS PROG ID of the original data.
(I)	OBID*i*	Set of Observation block IDs to identify the original observations this product results from. The Observation block IDs is a unique numeric ID that was assigned to the observation block by the Observation Handling Subsystem. Normally, OBID*i* should be copied from the keyword HIERARCH ESO OBS ID of the original data. If the product includes data from *n* observations, OBID*i* with index *i* running from 1 to *n* should be provided. On the contrary, a given Observation block ID must be listed in all the products that are based on this observation.
(L)	M_EPOCH	TRUE if resulting from a combination of multiple epochs. This flag indicates that the data product includes observations obtained in more than one epoch. The exact definition of an epoch, particularly the associated time scale, depends on the scientific goals and is at the discretion of the programme P.I. The VISTA public survey programmes UltraVISTA, Video and VVV are expected to deliver multi-epoch data products.
(L)	SINGLEXP	TRUE if resulting from single exposure.
(I)	NCOMBINE	Number of raw science data files that were combined to generate this data product. Calibration data files do not contribute to this count.
(S)	PROV*i*	Processing provenance, i.e. the list of science files originating this data product. *i* is a sequential number starting from 1. PROV*i* should appear as many times as needed to identify the complete set of science data files this product has been generated from.

(S)	OBSTECH	Technique used during the observation according to Table 2. OBSTECH can each take more than one value; it is recommended to limit the number of entries to at most three. The values should be separated with commas, with no blank spaces. This provides the means to describe a wide range of observations. If more than one value is present, the entries should as a rule follow the "general-to-specific" order. Normally, OBSTECH should be adopted from the keyword HIERARCH ESO DPR TECH of the original data.
(S)	PRODCATG	This mandatory keyword specifies the top-level category and data format of the product in terms of the set of predefined values listed in Table 13.
(S)	FLUXCAL	Certifies the validity of PHOTZP if set to 'ABSOLUTE', otherwise 'UNCALIBRATED'.
(S)	PROCSOFT	Indicates the reduction software system including its version number used to produce this data product.
(S)	REFERENC	Should point to the primary scientific publication associated to this data product describing content, coverage, process of creation and scientific quality. According to the FITS Standard, it is recommended that either the 19-digit bibliographic identifier used in the Astrophysics Data System bibliographic databases (http://adswww.harvard.edu/) or the Digital Object Identifier (http://doi.org) be included in the value string when available.
(S)	ASSON*i*	The list of files associated to this data product. *i* is a sequential number starting from 1. If *n* files are associated to the product, the indexed keywords ASSON*i* and ASSOC*i* should appear *n* times (*i*=1,...,*n*).
(S)	ASSOC*i*	Specifies the category of the associated file given by ASSON*i*.

Table 2: Examples of principal values (first group) and qualifiers (second group) for keyword OBSTECH describing the technique of observation.

Value	Explanation
IMAGE	any picture
SPECTRUM	single-order spectrum
ECHELLE	cross-dispersed spectrum
MOS	observation with spectra of several objects
MXU	observation with spectra of several objects using a pre-manufactured mask
IFU	Integral Field Unit observation
POLARIMETRY	polarimetric exposure
CORONOGRAPHY	coronography exposure
INTERFEROMETRY	coherent exposure with more than one telescope beam
ABSORPTION-CELL	absorption lines included (e.g. Iodine cell)
FABRY-PEROT	exposure using Fabry-Perot technique
WOLLASTON	Wollaston polarimetry
WIRE_GRID	Wire grid polarimetry
DIRECT	qualifier indicating direct imaging/spectroscopy
CHOPPING	exposure utilising M2 chopping
NODDING	exposure utilising telescope nodding
CHOPNOD	exposure utilising both chopping and nodding
JITTER	exposure utilising source jittering technique

Table 3: Examples for categories of associated ancillary files given by the indexed keyword ASSOC*i*.

Category	Description
ancillary.weightmap	Weight map describing the pixel-to-pixel variation of the statistical significance of the image array in terms of the inverse variance. The weight map should be a FITS file having the same structure, i.e. number of FITS extensions, if any, and dimensions as the FITS file that contains the image data array.
ancillary.preview	Preview of the data product normally using one of the common graphics file formats such as JPEG, PNG, GIF, etc. For image data products the preview usually consists of an appropriately downscaled version of the image. For spectra the preview typically consists of a line plot for which the PS or PDF formats may be considered.

3.6.3 Data-specific keywords

Table 4: Data-specific keywords

Type	Keyword	Description
(S)	BUNIT	Describes the physical unit of the array value. The value of this keyword should conform to the recommendations outlined in the ESO DICD, Chapter 8. For imaging data "ADU" (Analog-to-Digital converter Unit), or "ADU/s" for exposure time-normalised data are widely used, and the actual physical scale is given in terms of the photometric zeropoint (PHOTZP). For data that is calibrated to absolute flux BUNIT may be, for instance, `'W m^-2'` or `'Jy'`.
(R)	DATAMIN	Specifies the minimum valid physical value across the pixel array in units defined by BUNIT.
(R)	DATAMAX	Specifies the maximum valid physical value across the pixel array in units defined by BUNIT.
(R)	GAIN	Specifies the detector sensitivity in number of electrons per data unit (averaging across all exposures making up this data product). Thus, if the data was normalized by exposure time, the 'Effective gain' is the detector gain scaled by the total exposure time.

3.6.4 World coordinate system

Table 5: World coordinate system keywords

Type	Keyword	Description
(R)	CRVAL*i*	Coordinate value at reference pixel.
(R)	CRPIX*i*	Reference pixel in axis *i*.
(S)	CTYPE*i*	Pixel coordinate system.
(S)	CUNIT*i*	Specifies the unit of the coordinate transformation. For celestial coordinate systems the default unit is "degree", i.e., CUNIT1='deg' and CUNIT2='deg'.
(R)	CD*i_j*	Transformation matrix element.
(R)	CDELT*i*	Alternative for the CD*i_j* matrix representation. Deprecated for images, but may be used for extracted, i.e. one-dimensional, spectra.
(R)	CSYER*i*	Systematic error in axis *i* (unit given by CUNIT*i*, usually degree)
(R)	CRDER*i*	Random error in axis *i* (unit given by CUNIT*i*, usually degree).

- CRDER1 and CRDER2 may be set both to $1/\sqrt{2}$ times the RMS accuracy of the astrometric registration if errors are isotropic (and similarly for CSYER*i*).

Example of WCS keywords for an image:

```
CRVAL1  =              53.11604 / 03:32:27.8, RA at ref pixel
CRVAL2  =               -27.791 / -27:47:27.6, DEC at ref pixel
CRPIX1  =               433.780 / Ref pixel in X
CRPIX2  =               410.550 / Ref pixel in Y
CTYPE1  = 'RA---TAN'            / pixel coordinate system
CTYPE2  = 'DEC--TAN'            / pixel coordinate system
CD1_1   =     4.12200000000E-05 / Transformation matrix element
CD1_2   =                    0. / Transformation matrix element
CD2_1   =                    0. / Transformation matrix element
CD2_2   =    -4.12200000000E-05 / Transformation matrix element
EQUINOX =                 2000. / Standard FK5 (years)
RADECSYS= 'ICRS    '            / Coordinate reference frame
```

3.6.5 Imaging data products

Table 6: Keywords specific to imaging data products

Type	Keyword	Description
(S)	IMATYPE	Specific image type, according to Table 15.
(L)	ISAMP	Flag to indicate if the imaging data represents multiple disconnected regions, i.e. a *sampling* of the sky (ISAMP='T'), or one *contiguous* fraction of the sky (ISAMP='F' or unset).

Table 7: Keywords specifying the flux scale of an image in terms of the photometric zeropoint

Type	Keyword	Description
(R)	PHOTZP	Photometric zeropoint that relates the pixel data to total magnitudes (MAG) according to the equation MAG=-2.5*log(data)+PHOTZP, i.e. any applicable scaling with exposure time should be absorbed into PHOTZP.
(R)	PHOTZPER	Optional keyword to indicate the (1 sigma) uncertainty of the photometric zeropoint PHOTZP.
(S)	PHOTSYS	may take either the value `'VEGA'` or `'AB'` to indicate whether the photometric zero point is expressed in Johnson magnitudes or in Oke's AB photometric system, respectively.

Table 8: Keywords specific to near-infrared observations and VISTA

Type	Keyword	Description
(R)	DIT	Detector integration time, if uniform for all exposures included in this product. To be obtained from the keyword HIERARCH ESO DET DIT of the original data.
(I)	NDIT	Number of sub-integrations, if uniform for all exposures included in this product. To be obtained from the keyword HIERARCH ESO DET NDIT of the original data.
(I)	NJITTER	Number of jitter positions per observation if uniform.
(I)	NOFFSET	Number of offset positions per observation if uniform.
(I)	NUSTEP	Number of microstep positions per observation if uniform.

NIR image data products qualify for the keywords listed in Table 8 if, and only if, all exposures and observations contributing to the given product share the same value for the respective parameter. If, for example, the product has been created from exposures taken with different detector integration time, the keyword DIT should *not* be defined in the FITS header.

3.6.6 Data quality parameters

Table 9: Keywords describing the data quality

Type	Keyword	Description
(R)	ABMAGLIM	5-sigma limiting AB magnitude for point sources. The quoted magnitude should refer to the total flux of a point source.
(R)	ABMAGSAT	Saturation limit for point sources (AB magnitude).
(R)	PSF_FWHM	Spatial resolution (arcsec). Quality parameter measured from the image. Average size of the point spread function expressed as the full width at half maximum in arcseconds.
(R)	ELLIPTIC	Average ellipticity of point sources defined as (1-b/a) with a and b denoting the major and minor axes of the source profile, resp.
(R)	SNR	Signal to noise ratio per pixel.
(R)	SPEC_RES	Average spectral resolution (resolving power) as determined for this spectrum.

3.6.7 ESO public imaging surveys

For VISTA public surveys the tiling of the sky has been defined at the beginning of the preparation of observations using the Survey Area Definition Tool (SADT). The respective coordinates identifying each survey tile on the sky in terms of RA, DEC and PA, are given in the original observational data by the following header keywords.

HIERARCH ESO OCS SADT TILE RA = 180121.456 / Tile RA [HHMMSS.TTT]
HIERARCH ESO OCS SADT TILE DEC = -312956.4 / Tile Declination [DDMMSS.TTT]
HIERARCH ESO OCS SADT TILE OFFANGLE = 60.598 / Tile rotator offset angle [deg]

For public surveys it is required that the survey tile coordinates are propagated to the resulting data products like tile images and source lists.

Table 10: Keywords specific to ESO public imaging surveys

Type	Keyword	Description
(R)	TL_RA	Tile RA as defined using the Survey Area Definition Tool [HHMMSS.TTT].
(R)	TL_DEC	Tile Declination as defined using the Survey Area Definition Tool [DDMMSS.TTT].
(R)	TL_OFFAN	Tile rotator offset angle as defined using the Survey Area Definition Tool (in degrees). Note: Orientation on the sky, opposite sign convention than the position angle on the sky.
(L)	M_TILE	TRUE if data covers more than one survey tile.
(S)	EPS_REG	ESO public survey region name; to be specified for survey programmes targeting multiple regions like the VIDEO survey.

3.6.8 Checksums and reserved header keywords

The keywords CHECKSUM and DATASUM should be included in the submitted data products; they will be used to validate the integrity of the data before archival storage. Improper checksums will prevent successful ingestion into the archive.

Keywords that are reserved to record certain information related to the ESO archival process are listed in Table 11. If these keywords exist in the header of the submitted data, their content may be overwritten in the course of archival with new information. As a consequence any previous content will get lost. Therefore, the data creator should not use these keywords to deliver any relevant information.

Table 11: List of reserved header keywords

Type	Keyword	Description
(S)	ARCFILE	Provides the name under which the file is stored in the ESO science archive.
(S)	CHECKSUM	Provides a Cyclic Redundant Check (CRC) calculation for each HDU. It uses the ASCII encoded 1's complement algorithm.
(S)	DATASUM	Data unit checksum.
(S)	ORIGFILE	Records the original file name, as assigned at the instrument workstation; for EDPs ORIGFILE records the filename as given by the data provider.

Example of reserved header keywords:

```
ARCFILE = 'ADP.2010-08-19T09:33:11.951.fits' / Archive file name
CHECKSUM= 'CYMRAEGLLENYDDOL'    / HDU checksum
DATASUM = '3141592653'          / Data unit checksum
ORIGFILE= 'FORS1-IMG231.19.fits' / Original file name
```

3.7 Top-level category for data products

Any data product must be classified according to the following scheme either as "science" or as "ancillary" (Table 12). Scientific data products represent the primary category. The ESO archive is directly searchable for science data products using, e.g., the respective query forms available on the ESO web.

Table 12: Top-level data product category.

Category	Description
Science	*Science data products* must be compliant with the ESO data standard and fully characterized in terms of FITS keywords as specified in the standard.
Ancillary	*Ancillary data products* support the scientific exploitation by providing further information about the scientific data. Each ancillary data product must be associated to at least one scientific data product. Certain science data products mandate the submission of specific ancillary products as given in the data format definitions (Section 3.8). The VISTA tile image, for example, requires a weight map image to be associated. Moreover, depending on the kind of scientific data, the data provider can deliver additional ancillary products. Typical examples are preview images, graphics or reports generated in the course of the data reduction process. The file type of ancillary products may be, for instance, JPEG or PNG image, PS or PDF graphics, or ASCII text.

The category of *science data products* is declared in the FITS header using the PRODCATG keyword as explained in the next section.
In case ancillary data products are in FITS format, they shall *not* contain the header keyword PRODCATG. Instead, the category should be defined by the keywords ASSOC* of the referencing science data product.

3.8 Data format definitions

This section defines the data product formats of which the PI has to choose the appropriate one for any given science product to be submitted as EDP. Any science data product must comply with one of the formats specified herein. For VISTA public imaging surveys sections 3.8.1 through 3.8.4 apply in particular. This list of formats will grow with time as more and more types of scientific data products are being integrated into the ESO archive.

To specify required and optional FITS header keywords, the following style is used throughout this document. *Mandatory* header keywords are typeset in bold face, for example:

```
NAXIS1   =                   %d / Number of pixels along axis 1
```

Optional header keywords, in contrast, are typeset in normal face, for example:

```
CSYER1   =                   %f / Systematic error
```

The format strings %c, %d, %f, and %s correspond to the data types boolean, integer number, floating point number, and character string, respectively.

To add further explanation to the metadata definitions as needed, examples are provided using the following style:

```
PRODCATG= 'science.spectrum'    / Data product category
```

Any science data product must comply with one of the generic data formats listed in Table 13. This provides the framework for more specific formats being defined hereafter.

Table 13: Generic data formats.

Data format	Characteristics	PRODCATG
Single image	Single image stored in the primary HDU.	science.image
MEF image	Multiple images stored in multi-extension FITS format (MEF).	science.MEFimage
Source list	FITS binary table resulting from the detection of sources on an image (both single image or MEF image).	science.srctbl
Scientific catalogue	FITS binary table, possibly partitioned in multiple files. Normally, the final product of a survey programme.	science.catalog

For *science data products* the category and data format must be declared in the FITS header using the keyword

```
PRODCATG= 'science.*'           / Data product category
```

for example

```
PRODCATG= 'science.image'       / Data product category
```

3.8.1 Overview of VISTA imaging data products

Table 14 gives an overview of the specific VISTA/VIRCAM data product types and their characteristics. The corresponding header keyword settings are listed in Table 15 . The *footprint shape* specifies the sky coverage of the imaging data as given by the combination of the instrumental design and the observing strategy. For VISTA the three footprint shapes, "Pawprint", "Vertical stripes", and "Tile", cover the variety of products resulting from the ESO public survey programmes. The attribute "deep" in the product description indicates if the data product is based on multiple observations. The flag ISAMP indicates if the imaging data represents multiple disconnected regions, i.e. a *sampling* of the sky (ISAMP='T'), or one *contiguous* fraction of the sky (ISAMP='F' or unset). The flag SINGLEXP indicates if the product is the result of one single exposure. The column labeled "Source list" indicates the potential availability of source tables extracted from the imaging products.

Table 14: Overview of VISTA data product types and their characteristics

Data product description	VISTA footprint shape	Single/ multiple OBs	Sampled/ contiguous sky	Number of disconnected regions sampled	Source list
VISTA tile	Tile	Single	contiguous	1	✓
VISTA deep tile	Tile	Multi	contiguous	1	✓
VISTA pawprint	Pawprint	Single	sampled	16	✓
VISTA deep pawprint	Pawprint	Multi	sampled	16	✓
VISTA stripes[4]	Vertical stripes	Single	sampled	4	✓
VISTA deep stripes	Vertical stripes	Multi	sampled	4	✓
VISTA single exposure[5]	Pawprint	Single	sampled	16	n/a

Table 15: Summary of VISTA data product formats and corresponding keyword settings

Data product description	PRODCATG	IMATYPE	ISAMP	SINGLEXP
VISTA tile VISTA deep tile	science.image	TILE	F	F
VISTA pawprint VISTA deep pawprint	science.MEFimage	PAWPRINT	T	F
VISTA stripes VISTA deep stripes	science.MEFimage	VSTRIPES	T	F
VISTA single exposure	science.MEFimage	PAWPRINT	T	T
VISTA tile's source list VISTA deep tile's source list	science.srctbl	TILE	F	F
VISTA pawprint's source list VISTA deep pawprint's source list	science.srctbl	PAWPRINT	T	F
VISTA stripes's source list VISTA deep stripes's source list	science.srctbl	VSTRIPES	T	F

3.8.2 VISTA tile image

The VISTA tile is the basic building block of VISTA public surveys. The tile is a filled area of sky fully sampled (filling in the gaps in a pawprint) by combining multiple pawprints. Because of the detector spacing the minimum number of pointed observations (with fixed offsets) required for reasonably uniform coverage is 6, which would expose each piece of sky, except for the edges of the tile, on at least 2 camera pixels. An observation executed with the VISTA/VIRCAM template "VIRCAM_img_obs_tile6" results in a tile as data product.

[4] The ultra deep part of the UltraVISTA public imaging survey is expected to result in *stripes* as data products.

[5] Single exposures acquired with VISTA are usually not considered final data products, which is why this product type will be insignificant in view of VISTA public survey deliveries.

The VISTA tile image comes in two flavors to distinguish whether data have been combined from one or from multiple observations. The “normal” VISTA tile is based on a single observation, which has to be identified by the keyword OBID1. If the original data, which has been combined to form the final tile, was obtained in more than one observation block, the data product is termed VISTA *deep* tile image, and the complete set of original observations should be listed using the indexed keyword OBID*i*. The presence of the keyword OBID2 indicates the multi-OB character, i.e. the fact that the respective data product forms a deep tile image.

The VISTA tile stores the data array in the FITS file’s primary HDU. The VISTA tile requires a number of specific keywords related to data acquisition, data quality and public surveys as listed below.

List of header keywords specific to the VISTA tile image including the VISTA deep tile image

```
TELESCOP= 'ESO-VISTA'           / ESO Telescope designation
INSTRUME= 'VIRCAM   '           / Instrument name
OBSTECH = 'IMAGE,JITTER'        / Technique of observation
PRODCATG= 'science.image'       / Data product category
IMATYPE = 'TILE'                / Specific image type
```

Comprehensive list of header keywords for the VISTA tile

```
SIMPLE  =                    T / Standard FITS format (NOST-100-2.0)
BITPIX  =                   %d / Number of bits per data pixel
NAXIS   =                    2 / Number of data axes
NAXIS1  =                   %d / Length of data axis 1
NAXIS2  =                   %d / Length of data axis 2
EXTEND  =                    T / Extensions may be present
BZERO   =                   %f / real = fits-value*BSCALE+BZERO
BSCALE  =                   %f / real = fits-value*BSCALE+BZERO
BUNIT   =                   %s / Physical unit of array values
BLANK   =                   %d / Value used for NULL pixels
ORIGIN  = 'ESO-PARANAL'        / European Southern Observatory
DATE    =                   %s / Date the file was written
DATAMAX =                   %f / Maximum pixel value
DATAMIN =                   %f / Minimal pixel value
TELESCOP= 'ESO-VISTA'          / ESO Telescope designation
INSTRUME= 'VIRCAM   '          / Instrument name
FILTER  =                   %s / Filter name
OBJECT  =                   %s / Target designation
RA      =                   %f / Telescope Pointing (J2000.0)
DEC     =                   %f / Telescope Pointing (J2000.0)
EQUINOX =                 %.0f / Standard FK5 (years)
RADECSYS=                   %s / Coordinate reference frame
EXPTIME =                   %f / Total integration time per pixel (s)
TEXPTIME=                   %f / Total integration time of all exposures (s)
MJD-OBS =                 %.8f / Start of observations (days)
MJD-END =                 %.8f / End of observations (days)
DATE-OBS=                   %s / Date the observation was started (UTC)
TIMESYS = 'UTC     '           / Time system used
PROG_ID =                 %20s / ESO programme identification
OBID1   =                   %d / Observation block ID
M_EPOCH =                   %c / TRUE if resulting from multiple epochs
NCOMBINE=                   %d / # of combined raw science data files
PROV1   =                   %s / Originating science file
PROV2   =                   %s / Originating science file
PROV3   =                   %s / Originating science file
OBSTECH = 'IMAGE,JITTER'       / Technique of observation
PRODCATG= 'science.image'      / Data product category
IMATYPE = 'TILE'               / Specific image type
FLUXCAL = 'ABSOLUTE'           / Certifies the validity of PHOTZP
CRVAL1  =                   %f / Coordinate value at ref pixel
CRVAL2  =                   %f / Coordinate value at ref pixel
CRPIX1  =                   %f / Ref pixel in X
CRPIX2  =                   %f / Ref pixel in Y
CTYPE1  =                   %s / pixel coordinate system
CTYPE2  =                   %s / pixel coordinate system
```

```
CUNIT1   =                   %s / Unit of coordinate transformation
CUNIT2   =                   %s / Unit of coordinate transformation
CD1_1    =                   %f / Transformation matrix element
CD1_2    =                   %f / Transformation matrix element
CD2_1    =                   %f / Transformation matrix element
CD2_2    =                   %f / Transformation matrix element
CSYER1   =                   %f / Systematic error
CSYER2   =                   %f / Systematic error
CRDER1   =                   %f / Random error
CRDER2   =                   %f / Random error
PHOTZP   =                   %f / Photometric zeropoint MAG=-2.5*log(data)+PHOTZP
PHOTZPER=                    %f / Uncertainty on PHOTZP
PHOTSYS =                    %s / Photometric system VEGA or AB
GAIN     =                   %f / Number of electrons per data unit
ABMAGLIM=                    %f / 5-sigma limiting AB magnitude for point sources
ABMAGSAT=                    %f / Saturation limit for point sources (AB mags)
PSF_FWHM=                    %f / Spatial resolution (arcsec)
ELLIPTIC=                    %f / Average ellipticity of point sources
PROCSOFT=                    %s / Data reduction software/system with version no.
REFERENC=                    %s / Bibliographic reference
ASSON1   =                   %s / Name of associated file
ASSOC1   =                   %s / Category of associated file
ASSON2   =                   %s / Name of associated file
ASSOC2   =                   %s / Category of associated file
TL_RA    =                   %f / Tile RA [HHMMSS.TTT]
TL_DEC   =                   %f / Tile Declination [DDMMSS.TTT]
TL_OFFAN=                    %f / Tile rotator offset angle [deg]
EPS_REG =                    %s / ESO public survey region name
NJITTER =                    %d / Number of jitter positions
NOFFSETS=                    %d / Number of offset positions
NUSTEP   =                   %d / Number of microstep positions
DIT      =                   %f / Integration Time
NDIT     =                   %d / Number of sub-Integrations
DATASUM =                    %s / Data unit checksum
COMMENT
END
```

Comprehensive list of header keywords for the VISTA deep tile image

```
SIMPLE   =                    T / Standard FITS format (NOST-100-2.0)
BITPIX   =                   %d / Number of bits per data pixel
NAXIS    =                    2 / Number of data axes
NAXIS1   =                   %d / Length of data axis 1
NAXIS2   =                   %d / Length of data axis 2
EXTEND   =                    T / Extensions may be present
BZERO    =                   %f / real = fits-value*BSCALE+BZERO
BSCALE   =                   %f / real = fits-value*BSCALE+BZERO
BUNIT    =                   %s / Physical unit of array values
BLANK    =                   %d / Value used for NULL pixels
ORIGIN   = 'ESO-PARANAL'        / European Southern Observatory
DATE     =                   %s / Date the file was written
DATAMAX =                    %f / Maximum pixel value
DATAMIN =                    %f / Minimal pixel value
TELESCOP= 'ESO-VISTA'           / ESO Telescope designation
INSTRUME= 'VIRCAM   '           / Instrument name
FILTER   =                   %s / Filter name
OBJECT   =                   %s / Target designation
RA       =                   %f / Telescope Pointing (J2000.0)
DEC      =                   %f / Telescope Pointing (J2000.0)
EQUINOX =                  %.0f / Standard FK5 (years)
RADECSYS=                    %s / Coordinate reference frame
EXPTIME =                    %f / Total integration time per pixel (s)
TEXPTIME=                    %f / Total integration time of all exposures (s)
MJD-OBS =                  %.8f / Start of observations (days)
MJD-END =                  %.8f / End of observations (days)
DATE-OBS=                    %s / Date the observation was started (UTC)
TIMESYS = 'UTC     '            / Time system used
PROG_ID =                  %20s / ESO programme identification
OBID1    =                   %d / Observation block ID
OBID2    =                   %d / Observation block ID
OBIDn    =                   %d / Observation block ID
M_EPOCH =                    %c / TRUE if resulting from multiple epochs
NCOMBINE=                    %d / # of combined raw science data files
PROV1    =                   %s / Originating science file
PROV2    =                   %s / Originating science file
```

```
PROV3    =                    %s / Originating science file
OBSTECH = 'IMAGE,JITTER'         / Technique of observation
PRODCATG= 'science.image'        / Data product category
IMATYPE = 'TILE'                 / Specific image type
FLUXCAL = 'ABSOLUTE'             / Certifies the validity of PHOTZP
CRVAL1   =                    %f / Coordinate value at ref pixel
CRVAL2   =                    %f / Coordinate value at ref pixel
CRPIX1   =                    %f / Ref pixel in X
CRPIX2   =                    %f / Ref pixel in Y
CTYPE1   =                    %s / pixel coordinate system
CTYPE2   =                    %s / pixel coordinate system
CUNIT1   =                    %s / Unit of coordinate transformation
CUNIT2   =                    %s / Unit of coordinate transformation
CD1_1    =                    %f / Transformation matrix element
CD1_2    =                    %f / Transformation matrix element
CD2_1    =                    %f / Transformation matrix element
CD2_2    =                    %f / Transformation matrix element
CSYER1   =                    %f / Systematic error
CSYER2   =                    %f / Systematic error
CRDER1   =                    %f / Random error
CRDER2   =                    %f / Random error
PHOTZP   =                    %f / Photometric zeropoint MAG=-2.5*log(data)+PHOTZP
PHOTZPER=                     %f / Uncertainty on PHOTZP
PHOTSYS =                     %s / Photometric system VEGA or AB
GAIN     =                    %f / Number of electrons per data unit
ABMAGLIM=                     %f / 5-sigma limiting AB magnitude for point sources
ABMAGSAT=                     %f / Saturation limit for point sources (AB mags)
PSF_FWHM=                     %f / Spatial resolution (arcsec)
ELLIPTIC=                     %f / Average ellipticity of point sources
PROCSOFT=                     %s / Data reduction software/system with version no.
REFERENC=                     %s / Bibliographic reference
ASSON1   =                    %s / Name of associated file
ASSOC1   =                    %s / Category of associated file
TL_RA    =                    %f / Tile RA [HHMMSS.TTT]
TL_DEC   =                    %f / Tile Declination [DDMMSS.TTT]
TL_OFFAN=                     %f / Tile rotator offset angle [deg]
EPS_REG =                     %s / ESO public survey region name
NJITTER =                     %d / Number of jitter positions
NOFFSETS=                     %d / Number of offset positions
NUSTEP   =                    %d / Number of microstep positions
DIT      =                    %f / Integration Time
NDIT     =                    %d / Number of sub-Integrations
DATASUM =                     %s / Data unit checksum
COMMENT
END
```

Notes regarding keyword definitions

- MJD-OBS should be set to MJD-OBS of the first exposure contributing to this data product.
- MJD-END—the end of observations can be obtained in an approximate fashion using MJD-OBS of the last exposure contributing to this data product and adding the total exposure time of this exposure, i.e. MJD-END = MJD-OBS+(DIT*NDIT)/86400 in which MJD-OBS, DIT and NDIT refer to the last exposure.
- EXPTIME—for a VISTA tile being filled using the standard pattern of 6 pointed observations with fixed offsets with NJITTER exposures per pointing, EXPTIME should be set to the product 2*NJITTER*NDIT*DIT. The factor 2 reflects that most of the pixels of the final co-added image receive the contributions of at least two observations except for two narrow stripes along the edges, which receive just 'single' exposure time.
  For a VISTA deep tile image resulting from the co-addition of N_OBS observations, each of them using the standard pattern of 6 pointed observations with fixed offsets with NJITTER exposures per pointing, EXPTIME should be set to the product 2*N_OBS*NJITTER*NDIT*DIT. The factor 2 reflects that most of the pixels of the final co-added image receive the contributions of at least two observations except for two narrow stripes along the edges, which receive just 'single' exposure time.
  If the N_OBS observations do not share the same individual exposure time, i.e. NJITTER, NDIT, and DIT, then EXPTIME should be set to the sum

$$\sum_{i=1}^{N\_OBS} 2 \times NJITTER(i) \times NDIT(i) \times DIT(i)$$

If individual exposures were rejected before combination into the tile, EXPTIME should be adjusted accordingly.

- TEXPTIME—for a VISTA tile being filled using the standard pattern of 6 pointed observations with fixed offsets with NJITTER exposures per pointing, TEXPTIME should be set to the product 6*NJITTER*NDIT*DIT. If individual exposures were rejected before combination into the tile, TEXPTIME should be adjusted accordingly.
  For a VISTA deep tile image resulting from the co-addition of N_OBS observations, each of them using the standard pattern of 6 pointed observations with fixed offsets with NJITTER exposures per pointing, EXPTIME should be set to the product 6*N_OBS*NJITTER*NDIT*DIT. If the N_OBS observations do not share the same individual exposure time, i.e. NJITTER, NDIT, and DIT, then TEXPTIME should be set to the arithmetic sum of 6*NJITTER*NDIT*DIT. If individual exposures were rejected before combination into the tile, TEXPTIME should be adjusted accordingly.
- ASSON1 and ASSOC1 are compulsory for VISTA tiles to associate the respective weight image, also known as confidence map (see Sect. 3.3.1.1). Further instances of the indexed keywords ASSON*i* and ASSON*i* may be used to associate more data products if needed.

Header example for the VISTA tile image

```
SIMPLE  =                    T / Standard FITS format (NOST-100-2.0)
BITPIX  =                   32 / Number of bits per data pixel
NAXIS   =                    2 / Number of data axes
NAXIS1  =                12711 / Length of data axis 1
NAXIS2  =                15605 / Length of data axis 2
EXTEND  =                    F / Extensions may be present
BZERO   =                   0. / real = fits-value*BSCALE+BZERO
BSCALE  =           0.17677670 / real = fits-value*BSCALE+BZERO
BUNIT   = 'ADU     '           / Physical unit of array values
ORIGIN  = 'ESO-PARANAL'        / European Southern Observatory
DATE    = '2009-10-19T08:51:39'         / Date the file was written
TELESCOP= 'ESO-VISTA'          / ESO Telescope designation
INSTRUME= 'VIRCAM  '           / Instrument name
FILTER  = 'Z       '           / Filter name
OBJECT  = 'Orion   '           / Target designation
RA      =            84.589675 / Telescope Pointing (J2000.0)
DEC     =             -1.66818 / Telescope Pointing (J2000.0)
EQUINOX =                2000. / Standard FK5 (years)
RADECSYS= 'FK5     '           / Coordinate reference frame
EXPTIME =                 48.0 / Total integration time per pixel (s)
TEXPTIME=                144.0 / Total integration time of all exposures (s)
MJD-OBS =       55123.36921823 / Start of observations (days)
MJD-END =       55123.37191074 / End of observations (days)
DATE-OBS= '2009-10-19T08:51:40.4482'    / Date the observation was started (UTC)
TIMESYS = 'UTC     '           / Time system used
PROG_ID = '60.A-9285(B)'       / ESO programme identification
OBID1   =               429633 / Observation block ID
M_EPOCH =                    F / TRUE if resulting from multiple epochs
NCOMBINE=                    6 / # of combined raw science data files
PROV1   = 'VCAM.2009-10-19T08:51:40.455.fits' / Originating science file
PROV2   = 'VCAM.2009-10-19T08:52:22.519.fits' / Originating science file
PROV3   = 'VCAM.2009-10-19T08:53:06.147.fits' / Originating science file
PROV4   = 'VCAM.2009-10-19T08:53:48.218.fits' / Originating science file
PROV5   = 'VCAM.2009-10-19T08:54:28.653.fits' / Originating science file
PROV6   = 'VCAM.2009-10-19T08:55:09.089.fits' / Originating science file
OBSTECH = 'IMAGE,JITTER'       / Technique of observation
PRODCATG= 'science.image'      / Data product category
IMATYPE = 'TILE'               / Specific image type
FLUXCAL = 'ABSOLUTE'           / Certifies the validity of PHOTZP
CRVAL1  =   8.452566863325E+01 / Coordinate value at ref pixel
CRVAL2  =  -1.557574307279E+00 / Coordinate value at ref pixel
CRPIX1  =        6.3555000E+03 / Ref pixel in X
CRPIX2  =        7.8025000E+03 / Ref pixel in Y
CTYPE1  = 'RA---TAN'           / pixel coordinate system
CTYPE2  = 'DEC--TAN'           / pixel coordinate system
CD1_1   =       -2.4540050E-05 / Transformation matrix element
CD1_2   =        9.1546004E-05 / Transformation matrix element
```

```
CD2_1   =        -9.1547488E-05 / Transformation matrix element
CD2_2   =        -2.4447898E-05 / Transformation matrix element
CRDER1  =             0.0000108 / Random error (degree)
CRDER2  =             0.0000108 / Random error (degree)
PHOTZP  =                23.844 / Photom. ZP MAG=-2.5*log(data/EXPTIME)+PHOTZP
PHOTZPER=                  0.01 / Uncertainty on PHOTZP
PHOTSYS = 'VEGA    '            / Photometric system VEGA or AB
ABMAGLIM=                 22.58 / 5-sigma limiting AB magnitude for point sources
ABMAGSAT=                 15.41 / Saturation limit for point sources (AB mags)
PSF_FWHM=                  0.97 / Spatial resolution (arcsec)
ELLIPTIC=            0.05619717 / Average ellipticity of point sources
PROCSOFT= 'CASU VDFS v1.0'      / Data reduction software/system with version no.
REFERENC= '2010Msngr.139....6A'      / Bibliographic reference
ASSON1  = 'v20091018_00296_st_tl_conf.fits'    / Name of associated file
ASSOC1  = 'ancillary.weightmap'      / Category of associated file
TL_RA   =             53805.976 / Tile RA [HHMMSS.TTT]
TL_DEC  =            -13321.600 / Tile Declination [DDMMSS.TTT]
TL_OFFAN=              -15.0050 / Tile rotator offset angle [deg]
NJITTER =                     1 / Number of jitter positions
NOFFSETS=                     6 / Number of offset positions
NUSTEP  =                     1 / Number of microstep positions
DIT     =             6.0000000 / Integration Time
NDIT    =                     4 / Number of sub-Integrations
DATASUM = '1123581321'          / Data unit checksum
END
```

3.8.3 VISTA pawprint image

The 16 non-contiguous images of the sky produced by the VISTA IR camera, with its 16 non-contiguous detector chips are termed *VISTA pawprint image*. The data are stored in 16 image extensions of the multi-extension FITS file. According to the usual technique of observation in the NIR regime (jitter mode or offset sky), typically, the pawprint is the result of multiple exposures. An observation executed with the VISTA/VIRCAM template “VIRCAM_img_obs_tile1” for example results in a pawprint as data product.

Similar to the VISTA tile, the VISTA pawprint image comes in two flavors to distinguish whether data have been combined from one or from multiple observations. The “normal” VISTA pawprint is based on a single observation, which has to be identified by the keyword OBID1. If the original data, which has been combined to form the final pawprint image, was obtained in more than one observation block, the data product is termed *VISTA deep pawprint image,* and the complete set of original observations should be listed using the indexed keyword OBID*i*. The presence of the keyword OBID2 indicates the multi-OB character, i.e. the fact that the respective data product forms a deep pawprint image. OBID*i* should appear as many times as needed to identify the full set of observations of which data have been included to generate this product.
The data of the VISTA deep pawprint image are stored in 16 image extensions of the multi-extension FITS file.

The VISTA pawprint image requires a number of specific keywords related to data acquisition, data quality and public surveys as listed below.

List of header keywords specific to the VISTA pawprint image

```
TELESCOP= 'ESO-VISTA'           / ESO Telescope designation
INSTRUME= 'VIRCAM  '            / Instrument name
OBSTECH = 'IMAGE,JITTER'        / Technique of observation
PRODCATG= 'science.MEFimage'    / Data product category
IMATYPE = 'PAWPRINT'            / Specific image type
ISAMP   =                     T / TRUE if image represents partially sampled sky
```

Comprehensive list of header keywords for the VISTA pawprint in the primary HDU

```
SIMPLE  =                     T / Standard FITS format (NOST-100-2.0)
```

```
BITPIX  =                    8 / Number of bits per data pixel
NAXIS   =                    0 / Number of data axes
EXTEND  =                    T / Extensions may be present
ORIGIN  = 'ESO-PARANAL'        / European Southern Observatory
DATE    =                   %s / Date the file was written
TELESCOP= 'ESO-VISTA'          / ESO Telescope designation
INSTRUME= 'VIRCAM  '           / Instrument name
FILTER  =                   %s / Filter name
OBJECT  =                   %s / Target designation
RA      =                   %f / Telescope Pointing (J2000.0)
DEC     =                   %f / Telescope Pointing (J2000.0)
EQUINOX =                 %.0f / Standard FK5 (years)
RADECSYS=                   %s / Coordinate reference frame
EXPTIME =                   %f / Total integration time per pixel (s)
TEXPTIME=                   %f / Total integration time of all exposures (s)
MJD-OBS =                 %.8f / Start of observations (days)
MJD-END =                 %.8f / End of observations (days)
DATE-OBS=                   %s / Date the observation was started (UTC)
TIMESYS = 'UTC      '          / Time system used
PROG_ID =                 %20s / ESO programme identification
OBID1   =                   %d / Observation block ID
M_EPOCH =                   %c / TRUE if resulting from multiple epochs
SINGLEXP=                   %c / TRUE if resulting from single exposure
NCOMBINE=                   %d / # of combined raw science data files
PROV1   =                   %s / Originating science file
PROV2   =                   %s / Originating science file
PROV3   =                   %s / Originating science file
OBSTECH = 'IMAGE,JITTER'       / Technique of observation
PRODCATG= 'science.MEFimage'   / Data product category
IMATYPE = 'PAWPRINT'           / Specific image type
ISAMP   =                    T / TRUE if image represents partially sampled sky
FLUXCAL = 'ABSOLUTE'           / Certifies the validity of PHOTZP
PROCSOFT=                   %s / Data reduction software/system with version no.
REFERENC=                   %s / Bibliographic reference
ASSON1  =                   %s / Name of associated file
ASSOC1  =                   %s / Category of associated file
ASSON2  =                   %s / Name of associated file
ASSOC2  =                   %s / Category of associated file
TL_RA   =                   %f / Tile RA [HHMMSS.TTT]
TL_DEC  =                   %f / Tile Declination [DDMMSS.TTT]
TL_OFFAN=                   %f / Tile rotator offset angle [deg]
EPS_REG =                   %s / ESO public survey region name
NJITTER =                   %d / Number of jitter positions
NOFFSETS=                   %d / Number of offset positions
NUSTEP  =                   %d / Number of microstep positions
DIT     =                   %f / Integration Time
NDIT    =                   %d / Number of sub-Integrations
COMMENT
END
```

Comprehensive list of header keywords for the VISTA pawprint[6] in the image extensions.

```
XTENSION= 'IMAGE   '           / FITS Extension first keyword
BITPIX  =                   %d / Number of bits per data pixel
NAXIS   =                    2 / Number of data axes
NAXIS1  =                   %d / Length of data axis 1
NAXIS2  =                   %d / Length of data axis 2
PCOUNT  =                    0 / Parameter count
GCOUNT  =                    1 / Group count
EXTNAME =                   %s / FITS Extension name
INHERIT =                    T / Primary header keywords are inherited
BZERO   =                   %f / real = fits-value*BSCALE+BZERO
BSCALE  =                   %f / real = fits-value*BSCALE+BZERO
BUNIT   =                   %s / Physical unit of array values
BLANK   =                   %d / Value used for NULL pixels
DATAMAX =                   %f / Maximum pixel value
DATAMIN =                   %f / Minimal pixel value
CRVAL1  =                   %f / Coordinate value at ref pixel
CRVAL2  =                   %f / Coordinate value at ref pixel
CRPIX1  =                   %f / Ref pixel in X
CRPIX2  =                   %f / Ref pixel in Y
CTYPE1  =                   %s / pixel coordinate system
```

[6] Applicable to the VISTA deep pawprint image in the same way.

```
CTYPE2   =                    %s / pixel coordinate system
CUNIT1   =                    %s / Unit of coordinate transformation
CUNIT2   =                    %s / Unit of coordinate transformation
CD1_1    =                    %f / Transformation matrix element
CD1_2    =                    %f / Transformation matrix element
CD2_1    =                    %f / Transformation matrix element
CD2_2    =                    %f / Transformation matrix element
CSYER1   =                    %f / Systematic error
CSYER2   =                    %f / Systematic error
CRDER1   =                    %f / Random error
CRDER2   =                    %f / Random error
PHOTZP   =                    %f / Photometric zeropoint MAG=-2.5*log(data)+PHOTZP
PHOTZPER=                     %f / Uncertainty on PHOTZP
PHOTSYS  =                    %s / Photometric system VEGA or AB
GAIN     =                    %f / Number of electrons per data unit
ABMAGLIM=                     %f / 5-sigma limiting AB magnitude for point sources
ABMAGSAT=                     %f / Saturation limit for point sources (AB mags)
PSF_FWHM=                     %f / Spatial resolution (arcsec)
ELLIPTIC=                     %f / Average ellipticity of point sources
DATASUM  =                    %s / Data unit checksum
END
```

Comprehensive list of header keywords for the VISTA deep pawprint in the primary HDU

```
SIMPLE   =                     T / Standard FITS format (NOST-100-2.0)
BITPIX   =                     8 / Number of bits per data pixel
NAXIS    =                     0 / Number of data axes
EXTEND   =                     T / Extensions may be present
ORIGIN   = 'ESO-PARANAL'         / European Southern Observatory
DATE     =                    %s / Date the file was written
TELESCOP= 'ESO-VISTA'            / ESO Telescope designation
INSTRUME= 'VIRCAM  '             / Instrument name
FILTER   =                    %s / Filter name
OBJECT   =                    %s / Target designation
RA       =                    %f / Telescope Pointing (J2000.0)
DEC      =                    %f / Telescope Pointing (J2000.0)
EQUINOX =                   %.0f / Standard FK5 (years)
RADECSYS=                     %s / Coordinate reference frame
EXPTIME =                     %f / Total integration time per pixel (s)
TEXPTIME=                     %f / Total integration time of all exposures (s)
MJD-OBS =                   %.8f / Start of observations (days)
MJD-END =                   %.8f / End of observations (days)
DATE-OBS=                     %s / Date the observation was started (UTC)
TIMESYS = 'UTC     '             / Time system used
PROG_ID =                   %20s / ESO programme identification
OBID1    =                    %d / Observation block ID
OBID2    =                    %d / Observation block ID
OBIDn    =                    %d / Observation block ID
M_EPOCH =                     %c / TRUE if resulting from multiple epochs
NCOMBINE=                     %d / # of combined raw science data files
PROV1    =                    %s / Originating science file
PROV2    =                    %s / Originating science file
PROV3    =                    %s / Originating science file
OBSTECH = 'IMAGE,JITTER'         / Technique of observation
PRODCATG= 'science.MEFimage'     / Data product category
IMATYPE = 'PAWPRINT'             / Specific image type
ISAMP    =                     T / TRUE if image represents partially sampled sky
FLUXCAL = 'ABSOLUTE'             / Certifies the validity of PHOTZP
PROCSOFT=                     %s / Data reduction software/system with version no.
REFERENC=                     %s / Bibliographic reference
ASSON1   =                    %s / Name of associated file
ASSOC1   =                    %s / Category of associated file
ASSON2   =                    %s / Name of associated file
ASSOC2   =                    %s / Category of associated file
TL_RA    =                    %f / Tile RA [HHMMSS.TTT]
TL_DEC   =                    %f / Tile Declination [DDMMSS.TTT]
TL_OFFAN=                     %f / Tile rotator offset angle [deg]
EPS_REG =                     %s / ESO public survey region name
NJITTER =                     %d / Number of jitter positions
NOFFSETS=                     %d / Number of offset positions
NUSTEP   =                    %d / Number of microstep positions
DIT      =                    %f / Integration Time
NDIT     =                    %d / Number of sub-Integrations
COMMENT
END
```

Notes regarding keyword definitions

- MJD-OBS should be set to MJD-OBS of the first exposure contributing to this data product.
- MJD-END—the end of observations can be obtained in an approximate fashion using MJD-OBS of the last exposure contributing to this data product and adding the total exposure time of this exposure, i.e. MJD-END = MJD-OBS+(DIT*NDIT)/86400 in which MJD-OBS, DIT and NDIT refer to the last exposure.
- EXPTIME—for a VISTA pawprint being the result of NJITTER exposures, EXPTIME should be set to the product NJITTER*NDIT*DIT. If individual exposures were rejected before combination into the pawprint image, EXPTIME should be adjusted accordingly. For a VISTA deep pawprint image resulting from the co-addition of N_OBS observations, each of them consisting of NJITTER exposures, EXPTIME should be set to the product N_OBS*NJITTER*NDIT*DIT. If the N_OBS observations do not share the same individual exposure time, i.e. NJITTER, NDIT, and DIT, then EXPTIME should be computed by direct summing of the individual exposure times. If individual exposures were rejected before combination into the pawprint image, EXPTIME should be adjusted accordingly.
- TEXPTIME should equal EXPTIME for the VISTA pawprint image (including the deep pawprint).
- SINGLEXP—must be set TRUE if the pawprint image results from one single exposure. Otherwise, SINGLEXP does not have to be included.
- ASSON1 and ASSOC1 are compulsory for the VISTA pawprint to associate the respective weight image, also known as confidence map (see Sect. 3.3.1.1). Further instances of the indexed keywords ASSON*i* and ASSON*i* may be used to associate more data products if needed.

3.8.4 VISTA stripes image

The *VISTA stripes image* consists of 4 vertical stripes sampling a total of about 0.73 square degrees of the 1˚ by 1.5˚ patch of one VISTA tile. The VISTA stripes image results from the co-addition of 3 pointed observations vertically offset by ca. 1/3 of the detector size. The dedicated VIRCAM/VISTA template “VIRCAM_img_obs_tile3” allows preparing the respective sequence within a single observation. The data of the VISTA stripes image are stored in 4 image extensions of a multi-extension FITS file.

The stripes image is the baseline layout for the ultra deep part of the UltraVISTA public imaging survey. According to the observing strategy chosen for this particular programme, the VISTA stripes image will consist of 3 OBs each at least, corresponding to the 3 pointing positions. Following the terminology introduced earlier for VISTA tiles and pawprints resulting from multiple OBs, the respective UltraVISTA products are called *deep* stripes image. It is not foreseen that VISTA public imaging programmes deliver the stripes image resulting from a single OB.

List of header keywords specific to the VISTA stripes image

```
TELESCOP= 'ESO-VISTA'          / ESO Telescope designation
INSTRUME= 'VIRCAM  '           / Instrument name
OBSTECH = 'IMAGE,JITTER'       / Technique of observation
PRODCATG= 'science.MEFimage'   / Data product category
IMATYPE = 'VSTRIPES'           / Specific image type
ISAMP   =                    T / TRUE if image represents partially sampled sky
```

Comprehensive list of header keywords for the VISTA stripes image in the primary HDU

```
SIMPLE  =                    T / Standard FITS format (NOST-100-2.0)
BITPIX  =                    8 / Number of bits per data pixel
NAXIS   =                    0 / Number of data axes
```

```
EXTEND  =                    T / Extensions may be present
ORIGIN  = 'ESO-PARANAL'        / European Southern Observatory
DATE    =                   %s / Date the file was written
TELESCOP= 'ESO-VISTA'          / ESO Telescope designation
INSTRUME= 'VIRCAM  '           / Instrument name
FILTER  =                   %s / Filter name
OBJECT  =                   %s / Target designation
RA      =                   %f / Telescope Pointing (J2000.0)
DEC     =                   %f / Telescope Pointing (J2000.0)
EQUINOX =                 %.0f / Standard FK5 (years)
RADECSYS=                   %s / Coordinate reference frame
EXPTIME =                   %f / Total integration time per pixel (s)
TEXPTIME=                   %f / Total integration time of all exposures (s)
MJD-OBS =                 %.8f / Start of observations (days)
MJD-END =                 %.8f / End of observations (days)
DATE-OBS=                   %s / Date the observation was started (UTC)
TIMESYS = 'UTC     '           / Time system used
PROG_ID =                 %20s / ESO programme identification
OBID1   =                   %d / Observation block ID
OBID2   =                   %d / Observation block ID
OBIDn   =                   %d / Observation block ID
M_EPOCH =                   %c / TRUE if resulting from multiple epochs
NCOMBINE=                   %d / # of combined raw science data files
PROV1   =                   %s / Originating science file
PROV2   =                   %s / Originating science file
PROV3   =                   %s / Originating science file
OBSTECH = 'IMAGE,JITTER'       / Technique of observation
PRODCATG= 'science.MEFimage'   / Data product category
IMATYPE = 'VSTRIPES'           / Specific image type
ISAMP   =                    T / TRUE if image represents partially sampled sky
FLUXCAL = 'ABSOLUTE'           / Certifies the validity of PHOTZP
PROCSOFT=                   %s / Data reduction software/system with version no.
REFERENC=                   %s / Bibliographic reference
ASSON1  =                   %s / Name of associated file
ASSOC1  =                   %s / Category of associated file
ASSON2  =                   %s / Name of associated file
ASSOC2  =                   %s / Category of associated file
TL_RA   =                   %f / Tile RA [HHMMSS.TTT]
TL_DEC  =                   %f / Tile Declination [DDMMSS.TTT]
TL_OFFAN=                   %f / Tile rotator offset angle [deg]
EPS_REG =                   %s / ESO public survey region name
NJITTER =                   %d / Number of jitter positions
NOFFSETS=                   %d / Number of offset positions
NUSTEP  =                   %d / Number of microstep positions
DIT     =                   %f / Integration Time
NDIT    =                   %d / Number of sub-Integrations
COMMENT
END
```

Comprehensive list of header keywords for the VISTA stripes image in the image extensions

```
XTENSION= 'IMAGE   '           / FITS Extension first keyword
BITPIX  =                   %d / Number of bits per data pixel
NAXIS   =                    2 / Number of data axes
NAXIS1  =                   %d / Length of data axis 1
NAXIS2  =                   %d / Length of data axis 2
PCOUNT  =                    0 / Parameter count
GCOUNT  =                    1 / Group count
EXTNAME =                   %s / FITS Extension name
INHERIT =                    T / Primary header keywords are inherited
BZERO   =                   %f / real = fits-value*BSCALE+BZERO
BSCALE  =                   %f / real = fits-value*BSCALE+BZERO
BUNIT   =                   %s / Physical unit of array values
BLANK   =                   %d / Value used for NULL pixels
DATAMAX =                   %f / Maximum pixel value
DATAMIN =                   %f / Minimal pixel value
CRVAL1  =                   %f / Coordinate value at ref pixel
CRVAL2  =                   %f / Coordinate value at ref pixel
CRPIX1  =                   %f / Ref pixel in X
CRPIX2  =                   %f / Ref pixel in Y
CTYPE1  =                   %s / pixel coordinate system
CTYPE2  =                   %s / pixel coordinate system
CUNIT1  =                   %s / Unit of coordinate transformation
CUNIT2  =                   %s / Unit of coordinate transformation
CD1_1   =                   %f / Transformation matrix element
```

```
CD1_2    =                    %f / Transformation matrix element
CD2_1    =                    %f / Transformation matrix element
CD2_2    =                    %f / Transformation matrix element
CSYER1   =                    %f / Systematic error
CSYER2   =                    %f / Systematic error
CRDER1   =                    %f / Random error
CRDER2   =                    %f / Random error
PHOTZP   =                    %f / Photometric zeropoint MAG=-2.5*log(data)+PHOTZP
PHOTZPER=                     %f / Uncertainty on PHOTZP
PHOTSYS  =                    %s / Photometric system VEGA or AB
GAIN     =                    %f / Number of electrons per data unit
ABMAGLIM=                     %f / 5-sigma limiting AB magnitude for point sources
ABMAGSAT=                     %f / Saturation limit for point sources (AB mags)
PSF_FWHM=                     %f / Spatial resolution (arcsec)
ELLIPTIC=                     %f / Average ellipticity of point sources
DATASUM =                     %s / Data unit checksum
END
```

Notes regarding keyword definitions

- MJD-OBS should be set to MJD-OBS of the first exposure contributing to this data product.
- MJD-END—the end of observations can be obtained in an approximate fashion using MJD-OBS of the last exposure contributing to this data product and adding the total exposure time of this exposure, i.e. MJD-END = MJD-OBS+(DIT*NDIT)/86400 in which MJD-OBS, DIT and NDIT refer to the last exposure.
- EXPTIME—for a VISTA deep stripes image resulting from the co-addition of 3 deep pawprint images offset by ca. 1/3 of the detector size, having total exposure time T_{exp} each, EXPTIME should be set to $2*T_{exp}$.
- TEXPTIME—for the example given above TEXPTIME should be set to $3*T_{exp}$.
- ASSON1 and ASSOC1 are compulsory for VISTA pawprint to associate the respective weight image, also known as confidence map (see Sect. 3.3.1.1). Further instances of the indexed keywords ASSON*i* and ASSON*i* may be used to associate more data products if needed.

3.8.5 VISTA source list

The VISTA source list provides the file format for the tabular data of sources extracted from VISTA imaging data products. Typically the VISTA source list is pipeline-produced, using the nightly calibrations and is delivered on an image-by-image basis.

The single-band source catalogue extracted from one VISTA tile is the prototypical example but a VISTA source list may origin from other images types like the VISTA pawprint as well. Any VISTA source list is necessarily associated to its originating image due to its processing provenance.

The VISTA source list is based on the FITS binary table format. Each data array of the originating image gives rise to one binary table extension in the FITS file. Thus, the source list of a VISTA tile contains one single binary table extension while the source list of VISTA pawprint contains 16 binary table extensions. The primary HDU does not contain data.

The VISTA source list adopts a number of keywords that characterize the originating imaging observation to facilitate direct archive queries.

List of header keywords specific to the VISTA source list

```
TELESCOP= 'ESO-VISTA'            / ESO Telescope designation
INSTRUME= 'VIRCAM  '             / Instrument name
OBSTECH = 'IMAGE,JITTER'         / Technique of observation
PRODCATG= 'science.srctbl'       / Data product category
IMATYPE =                     %s / Specific image type
ISAMP   =                     %c / TRUE if image represents partially sampled sky
```

Comprehensive list of header keywords for the VISTA source list in the primary HDU

```
SIMPLE  =                    T / Standard FITS format (NOST-100-2.0)
BITPIX  =                    8 / Number of bits per data pixel
NAXIS   =                    0 / Number of data axes
EXTEND  =                    T / Extensions may be present
ORIGIN  = 'ESO-PARANAL'        / European Southern Observatory
DATE    =                   %s / Date the file was written
TELESCOP= 'ESO-VISTA'          / ESO Telescope designation
INSTRUME= 'VIRCAM  '           / Instrument name
FILTER  =                   %s / Filter name
OBJECT  =                   %s / Target designation
RA      =                   %f / Telescope Pointing (J2000.0)
DEC     =                   %f / Telescope Pointing (J2000.0)
EQUINOX =                 %.0f / Standard FK5 (years)
RADECSYS=                   %s / Coordinate reference frame
EXPTIME =                   %f / Total integration time per pixel (s)
TEXPTIME=                   %f / Total integration time of all exposures (s)
MJD-OBS =                 %.8f / Start of observations (days)
MJD-END =                 %.8f / End of observations (days)
DATE-OBS=                   %s / Date the observation was started (UTC)
TIMESYS = 'UTC     '           / Time system used
PROG_ID =                 %20s / ESO programme identification
OBID1   =                   %d / Observation block ID
OBID2   =                   %d / Observation block ID
OBIDn   =                   %d / Observation block ID
M_EPOCH =                   %c / TRUE if resulting from multiple epochs
SINGLEXP=                   %c / TRUE if resulting from single exposure
PROV1   =                   %s / Originating science file
PROV2   =                   %s / Originating science file
PROV3   =                   %s / Originating science file
OBSTECH = 'IMAGE,JITTER'       / Technique of observation
PRODCATG= 'science.srctbl'     / Data product category
IMATYPE =                   %s / Specific image type
ISAMP   =                   %c / TRUE if image represents partially sampled sky
PROCSOFT=                   %s / Data reduction software/system with version no.
REFERENC=                   %s / Bibliographic reference
ASSON1  =                   %s / Name of associated file
ASSOC1  =                   %s / Category of associated file
TL_RA   =                   %f / Tile RA [HHMMSS.TTT]
TL_DEC  =                   %f / Tile Declination [DDMMSS.TTT]
TL_OFFAN=                   %f / Tile rotator offset angle [deg]
EPS_REG =                   %s / ESO public survey region name
DATASUM =                   %s / Data unit checksum
END
```

Comprehensive list of header keywords for the VISTA source list in the binary table extensions

```
XTENSION= 'BINTABLE'           / FITS Extension first keyword
BITPIX  =                    8 / Number of bits per data pixel
NAXIS   =                    2 / Number of data axes
NAXIS1  =                   %d / Length of data axis 1
NAXIS2  =                   %d / Length of data axis 2
PCOUNT  =                    0 / Parameter count
GCOUNT  =                    1 / Group count
TFIELDS =                   %d / Number of fields in each row
TTYPEi  =                   %s / Label for field i
TFORMi  =                   %s / Data format of field i
TUNITi  =                   %s / Physical unit of field i
EXTNAME =                   %s / FITS Extension name
INHERIT =                    T / Primary header keywords are inherited
NXOUT   =                   %d / Length of image data axis 1
NYOUT   =                   %d / Length of image data axis 2
TCRVL3  =                   %f / Coordinate value at ref pixel
TCRVL5  =                   %f / Coordinate value at ref pixel
TCRPX3  =                   %f / Ref pixel in X
TCRPX5  =                   %f / Ref pixel in Y
TCTYP3  =                   %s / Pixel coordinate system
TCTYP5  =                   %s / Pixel coordinate system
TC3_3   =                   %f / Transformation matrix element
TC3_5   =                   %f / Transformation matrix element
TC5_3   =                   %f / Transformation matrix element
TC5_5   =                   %f / Transformation matrix element
ABMAGLIM=                   %f / 5-sigma limiting AB magnitude for point sources
```

```
ABMAGSAT=                    %f / Saturation limit for point sources (AB mags)
PSF_FWHM=                    %f / Spatial resolution (arcsec)
ELLIPTIC=                    %f / Average ellipticity of point sources
DATASUM =                    %s / Data unit checksum
END
```

Notes regarding keyword definitions

- IMATYPE and ISAMP characterize the VISTA image type from which sources have been extracted as specified in Table 15. ISAMP must be set to 'T' (true) if IMATYPE is 'PAWPRINT' or 'VSTRIPES'.
- The keywords that characterize the observation at large, namely ORIGIN, TELESCOP, INSTRUME, FILTER, OBJECT, EQUINOX, RADECSYS, EXPTIME, TEXPTIME, MJD-OBS, MJD-END, PROG_ID, OBID*i*, M_EPOCH, SINGLEXP, OBSTECH, IMATYPE, ISAMP, REFERENC, TL_RA, TL_DEC, TL_OFFAN, EPS_REG, should be adopted from the original image from which the sources were extracted.
- PROV1—for a single-band source list the reference to the image data product from which this source list was extracted. If image and source list are being submitted at the same time, PROV1 has to be set to the filename of the image under which it is submitted. If the image has been submitted to and archived by ESO at an earlier time, PROV1 has to be set to the ESO archive identifier, which has been assigned to the respective file at the time of archiving. The ESO archive identifier can be obtained from the special file named "CONTENT.ESO" in the release directory on the phase 3 ftp area.
- PROV*i*—for a band-merged source list the indexed provenance keyword should be used to record the list of precursor products based on which this source list has been generated. Note that PROV*i* cannot be validated if it points to a file that is not included in the ESO archive system. Therefore, it is necessary that the PROV*i* refer to product files being already archived in the ESO archive or to files being submitted simultaneously with the referencing product.

3.9 Data release description

The data release description provides an account of the release content, the originating observations, the calibration and data reduction procedures, the data quality, the data format, and, possibly, the scientific context of the programme. The release description forms an integral part of any ESO data release. It is essential for ESO/EDP to review and validate any release. Furthermore, the information given therein is vital for users who want to employ the data for their own scientific research. Combined with links to access the data products, the release description will be published on the ESO web to present the data and to provide a persistent URL for the data release.

ESO/EDP recommends the following structure for the data release description:

Abstract

A short, broad overview, text-only, referring to ESO programme, instrument, observational setup, filters/bands used, total coverage, resolution etc. when applicable. Possibly touching on the scientific context.

Overview/layout of observations

For imaging data products: A brief listing of the positions of the various fields/objects with an indication of the set of bands used for each, preferably with a finding chart or display of the covered fields/objects.

For spectroscopic data products: If possible, a finding chart, or another illustration that gives an idea of from where on the sky the spectra were taken.

Release content

For imaging data products: An extended listing for each field/object of sky position, filter, exposure time, seeing, observing date etc.

For spectroscopic data products: An extended characterisation of the spectra.

Release notes

Short descriptions of the reduction methods used, the calibration procedures (astrometric, photometric, wavelength etc.), characterization of the data quality, and a comparison with previous releases where applicable. It is recommend that the reference catalogue being used to establish the astrometric calibration is specified, e.g. GSC1, GSC2, USNO, 2MASS.

Data format

A description of the types of files in this release, associated files, and naming conventions used.

Acknowledgements

The acknowledgments to be included when using this data. Usually, a reference to the scientific publication associated with the data is given.

The principal investigator is responsible for the content of the data release description and for its delivery to ESO along with the data submission. The release description consists of formatted text typically supplemented by images and tabular information as needed. The following file formats are accepted: plain text (ASCII), HTML, Microsoft Word (*.doc), for images: JPEG, TIFF, GIF, and PNG. Multiple files belonging to one release description should be bundled into a single file using the *tar* or *zip* utilities. To ease identification, the name of the release description file should involve the full name of the data release including the collection name.

The filename of the release description has to be `release-description.tar` in the main directory of the phase 3 ftp area.

4 User guide for the phase 3 data submission process

4.1 Enter the Phase 3 Release Manager

Navigate your web browser to

`http://www.eso.org/sci/observing/phase3/rm`

to access the ESO Phase 3 Release Manager – a web application to manage the process of data submission and release through the ESO science archive facility. The Release Manager allows ESO users to manage their ESO phase 3 programmes, to create new data collections and releases, to manage the work-flow of data releases, and to view the contents of archived data releases.

4.2 Log in to the ESO User Portal

Unless you already have logged in to the ESO User Portal with your web browser, you will be asked by the system to identify yourself with your personal ESO User Portal credentials (Figure 1). As a principal investigator of an ESO programme you are familiar with the ESO User Portal from the proposal submission and observing preparation procedures.

If the submission of data has been delegated to you by the principal investigator of an ESO programme and you are not a registered user of the ESO User Portal, first, you will need to register yourself before proceeding. To this end please click on the link named "I would like to create a new account" near the bottom of the ESO User Portal welcome page, which carries you to the registration dialogue. After having created a new User Portal account, you can log in and proceed with the following step of the phase 3 submission process.

4.3 Choosing your programme

The first administrative step of the data submission process is the identification of the ESO programme for which you are going to submit data products. The entry point of the Phase 3 Release Manager application has two tabs, listing the phase 3 programmes that you own, and the list of programmes delegated to you, like shown in Figure 3.

4.3.1 Principal investigator of ESO public survey or large programme

If you are the principal investigator of an ESO public survey or large programme, your programme is already registered and listed in the phase 3 release manager. If you own multiple programmes all of them are listed. In order to choose the programme to submit data for, just click on its name (cf. Fig. Figure 3), which navigates you to the overview of data collections for this programme.

If, by mistake, your programme is missing from the list, please contact usd-help@eso.org, Subject: EDP-ADP Submission, via email.

4.3.2 Co-Investigator

If you act as a phase 3 delegate on behalf of the principal investigator of an ESO public survey or large programme, typically being Co-Investigator of the programme, you can pick the programme to submit data for from the list of delegated programmes, by clicking on the respective name. If the programme is missing from the list, please contact the respective principal investigator to request phase 3 delegation for this programme. ESO user support is not able to effect phase 3 delegation because authorization by the programme's principal investigator is strictly required. To setup phase 3 delegation as principal investigator, see Sect. 4.4, page 33.

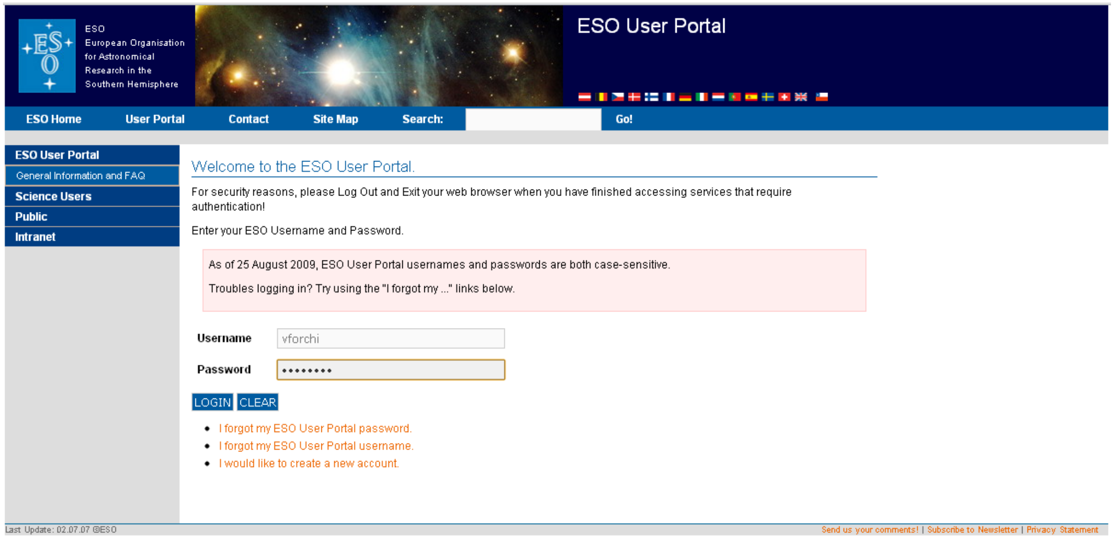

Figure 1: The ESO User Portal login page

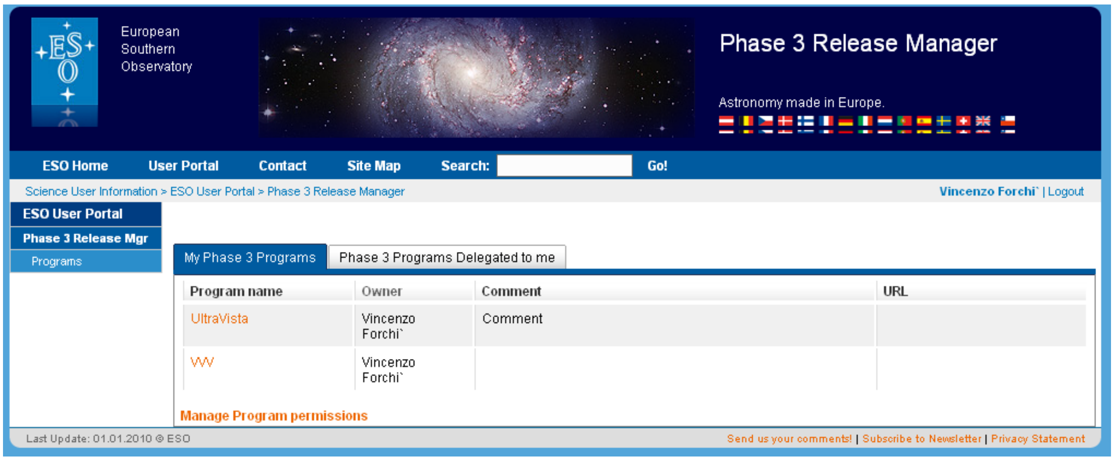

Figure 3: Entry page of the Release Manager

Principal investigator of normal ESO programme

If you are the principal investigators of a normal ESO programme, i.e. neither ESO public survey nor large programme, and you intend to submit data resulting from this programme for the first time, you need to request the registration of your progamme for phase 3 submission by sending an email message to usd-help@eso.org, subject: REQUEST FOR PHASE 3 PROGRAMME <*PPP.C-NNNN*>, where <*PPP.C-NNNN*> denotes your ESO programme identifier. The body of the message should be empty. Thereafter, usually within one working day, you will receive by email the confirmation that the programme has been registered and you can proceed by picking the respective programme from your list of programmes being displayed by the Phase 3 Release Manager.

4.3.3 Data products resulting from archival research

If you have carried out research being primarily based on ESO archival data rather than on ESO data that has been obtained in the course of your own ESO observing programme, you are encouraged to submit the resulting data products to ESO for public release through the ESO science archive facility. To this end you need to request the registration of a dedicated phase 3 programme by sending an email message to usd-help@eso.org, Subject: EDP-ADP Submission, indicating the name of your research project and the type of data products to be submitted. Thereafter, usually within one working day, you will receive by email the confirmation that the programme has been registered and you can proceed by picking the respective programme from your list of programmes being displayed by the Phase 3 Release Manager.

4.4 Delegating the phase 3 process

As the principal investigator of an ESO programme you can delegate the phase 3 process to one or more persons of your choice to distribute the effort of data submission and release preparation. The principal investigator can delegate the phase 3 per programme to any ESO user, i.e. a person being registered with the ESO User Portal. A delegate can create new collections and data releases and can submit data products in the same way as the principal investigator can do. The principal investigator can revoke at any time any delegation rights he might have granted. Multiple delegates can, in principle, work on the same data release but it is in the sole responsibility of the principal investigator to ensure the overall consistency.

From the top-level page of the Phase 3 Release Manager showing the overview of programmes, choose the link "Manage programme permissions" below the table of your programmes near to the bottom of the screen to view and administrate delegation settings (Figure 3). This brings you to the page for managing programme permission from where the following actions can be taken (Figure 5):

- Delegate a programme to another user registered in the ESO user portal (by entering his/her e-mail address and clicking delegate)
- Revoke the permissions from an existing delegated program (by clicking on revoke)

To return to the Release Manager, click Phase 3 Programs in the navigation bar on the left.

The final action of *closing a data release* cannot be delegated but the principal investigator in person has to take this action to approve the completeness and quality of the data and the accuracy of the associated description.
Closing a data release represents a crucial step in the course of the phase 3 process because the operations following thereafter and leading to the public release of the data through the ESO Archive are being executed by the system in a largely automatic fashion.

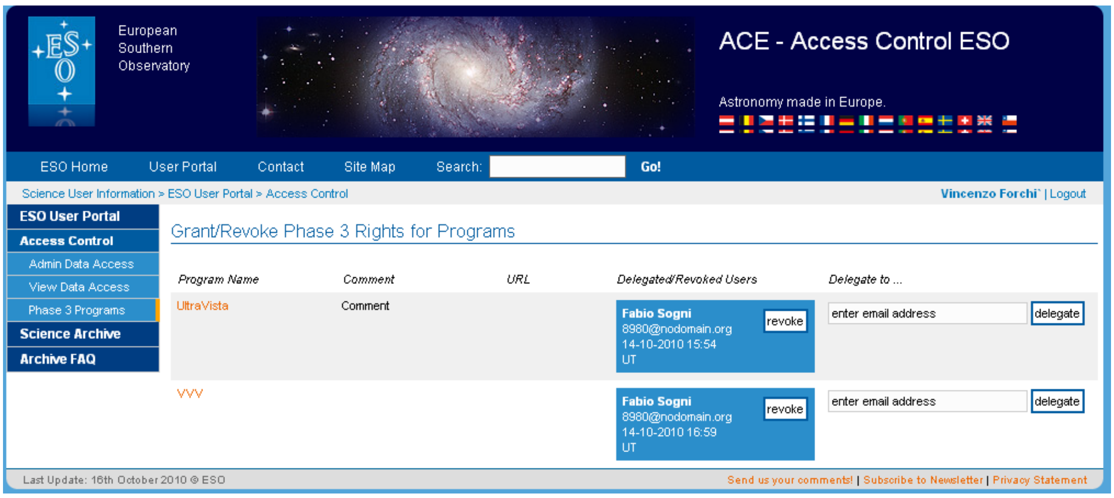

Figure 5: Page for managing permissions for phase 3 delegation

Figure 7: List of data collections resulting from the selected programme

4.5 Defining the ESO data release

After programme selection the Release Manager takes you to the page displaying the list of data collections for this programme (Figure 7). In the last preparatory step before you can actually start to submit data products, the ESO data collection and data release have to be defined.

4.5.1 Data collection and data release

Data collection and data release provide the framework that supports the data submission process and facilitates data access through the ESO archive. The data collection allows organising the data products from a given programme according to the principal investigator's high-level criteria into self-consistent groups, which, subsequently, the archive user can browse and access. The data release is primarily a container for the data products to be submitted and released together.

The concepts of data collection and data release are closely related to each other. The two form a simple hierarchical structure where data collection is at the top and any data release must be associated to one and only one data collection. The other way around, any data collection must have at least one data release to be functional.

The data collection consists of a series of data releases tagged by incremental numbers starting from one. All the data releases belonging to a given data collection inherit the data collection's name. The individual data release may be considered a version of the data collection.

Initially, any collection consists of the first data release ("Data Release 1"). Subsequent data releases for the same collection may follow to add more data according to the observing programme's progress. It is also possible to submit a revised version of a previously released data product.

4.5.2 Guidelines

Each data collection is defined by its name and by the set of data products being members of the associated data releases. The collection name has to be defined at the time of starting the data submission and cannot be revised later by the user. Each data release has to be accompanied by a description of its content, data properties and format to enable the archive user to employ the data for their own scientific research (the release description, see below).

For ESO large programmes, it is common practice to organize the data products according to the scientific publications that have been generated thereof. One data collection may correspond to one target object. Otherwise, for programmes that consist of independent observations with multiple instruments, data collections might be defined by instrument. The type or number of data products are not useful criteria for the definition of data collections. In practice, one ESO programme may result in a single data collection, like, e.g., the zCOSMOS galaxy redshift survey.

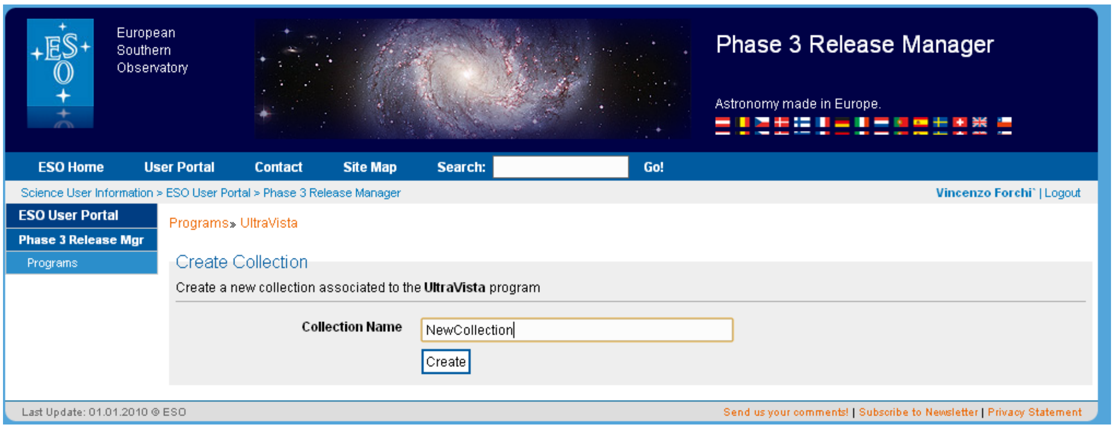

Figure 8: Creating a new collection

Figure 9: Newly created data collection without releases

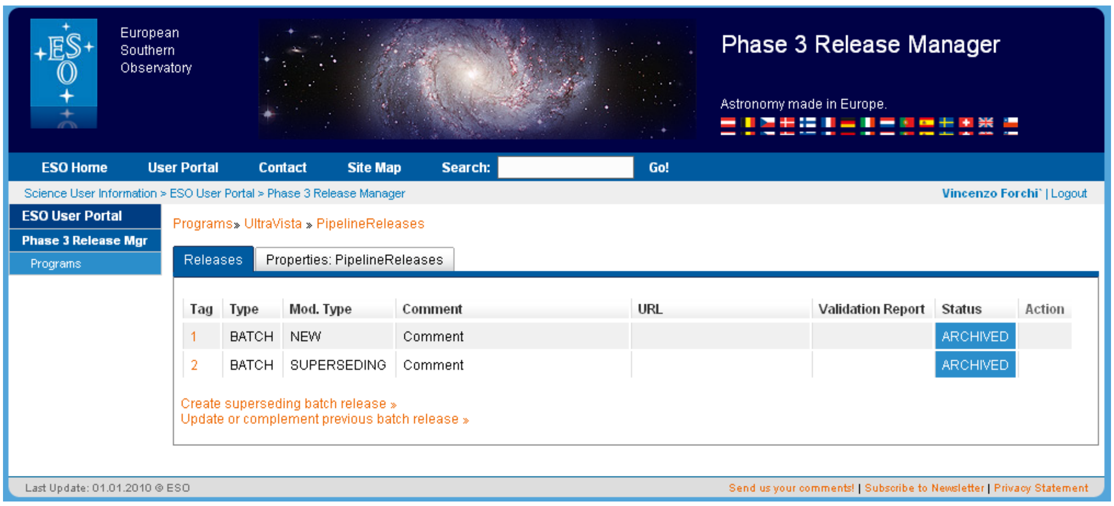

Figure 10: List of releases belonging to a data collection

4.5.3 Initial data release

If you are submitting data products for your programme for the first time, the list of data collections is empty and the name of the data release under which the data submission takes place must be defined in the Phase 3 Release Manager by clicking the menu item "Add collection" (see Figure 7). This system prompts you for the name of the data collection (Figure 8). Note that the collection name should not contain any number indicating the version or alike because the data releases will be automatically assigned an integer numbers incrementing with each release. To proceed, click on the name of the newly created data collection, which brings you to the empty list of releases for this collection (Figure 9).

That followed, the initial data release for this data collection must be created be clicking the menu item "Create a new batch release". The system automatically assigns the data release number 1 to the newly created initial data release. Your are now allowed to enter a comment in the respective field and a list of email recipients to be notified about the progress of the phase 3 process for this release (Figure 11). Click the Save button to create the new data release.

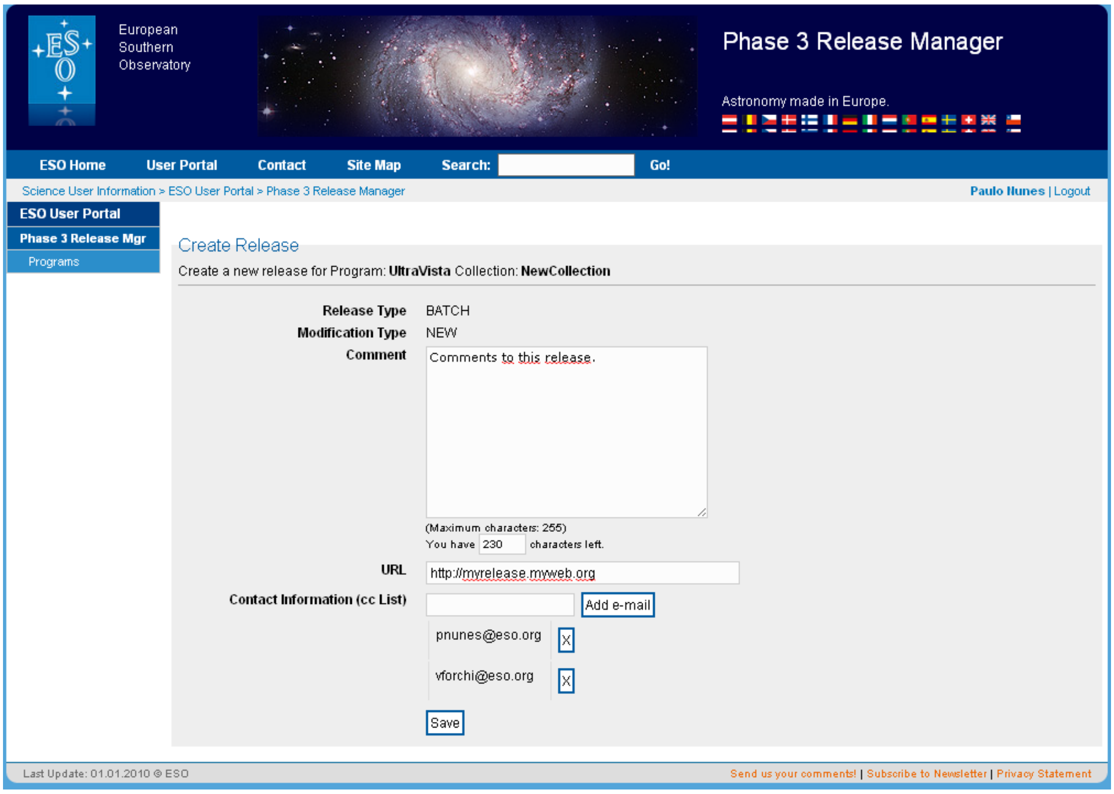

Figure 11: Creating a new data release

4.5.4 Subsequent data release

If you are submitting data products for your programme for which you have a previous data release, there are the following options.

1. If the new data extend or revise the existing data collection, first, choose the collection by clicking the collection name, then, choose the menu item "Update or complement previous batch release" (Figure 10). The system automatically increments and assigns the data release number to the newly created data release.
2. If the new data should replace previously published data, first, choose the collection by clicking the collection name, then, choose the menu item "Create superseding batch release" (Figure 10). The system automatically increments and assigns the data release number to the newly created data release.

3. Alternatively, if the new data does not logically belong to the existing data collection, you should create a new data collection by clicking the menu item “Add collection” in the Phase 3 Release Manager’s data collection page (Figure 7). Please take into account that the name of the data collection must be unique within the programme and that the collection name does not contain any number indicating the version or alike.

4.6 Adding data products to the release

Having defined the data release, you are ready to transmit your data products to ESO for which a dedicated FTP server has been installed. You may use any FTP client of your choice that supports secure authentication (TSL), see below for a list of compatible clients. You may consider the powerful and free *FileZilla* (http://filezilla-project.org/) as FTP client, which provides a graphical user interface and supports abort/resume functionality among other useful features, or the command-line client *lftp* (http://lftp.yar.ru/), which comes with many Linux distributions by default.

First, connect to the FTP server at

phase3ftp.eso.org

and login with your ESO User Portal credentials.

Then, change to the directory

/*<Phase 3 programme>*/*<Data collection name>*/batch_*<Data release number>*

For example, for the VISTA Hemisphere Survey with

Programme:	VHS
Collection:	VHS imaging
Release:	DR1

the complete URL would read

ftp://phase3ftp.eso.org/VHS/VHS imaging/batch_1

Thereafter, you can start transferring your set of products.

The directory and the data deposited therein are visible and accessible just for you as the programme owner and for your delegates. In the course of preparing the data release you can modify files on the FTP server as needed, including file removal.

As a data provider you also control the data flow in time. You may transfer the files for a data release in one go or you may accumulate them on the FTP server over a period of time before you close the release. This flexibility allows adapting the submission process to the particular needs due to data processing and verification activities of each programme.

If no more data is being added, the data will be kept on the FTP server for a period of three months unless the release is closed before.

4.7 Submitting the data release description

The principal investigator is responsible for the content of the data release description and for its delivery to ESO along with the data submission. The release description consists of formatted text typically supplemented by images and tabular information as needed. The following file formats are accepted: plain text (ASCII), HTML, Microsoft Word (*.doc), for images: JPEG, TIFF, GIF, and PNG. Multiple files belonging to one release description should be bundled into a single file using the *tar* utility. To ease identification, the name of the release description file should involve the full name of the data release including the collection name.

The release description with the filename `release-description.tar` has to be placed into the release directory of the ftp area.

ESO/EDP is in charge of editing and formatting the release description and of publishing the information on the ESO web site including appropriate links to the archived data products.

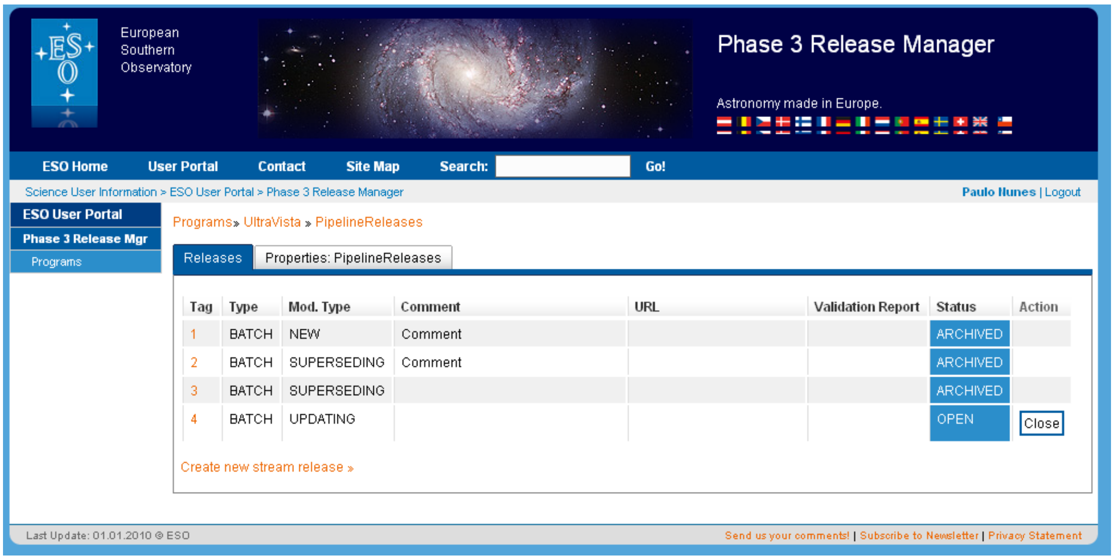

Figure 13: Closing a data release

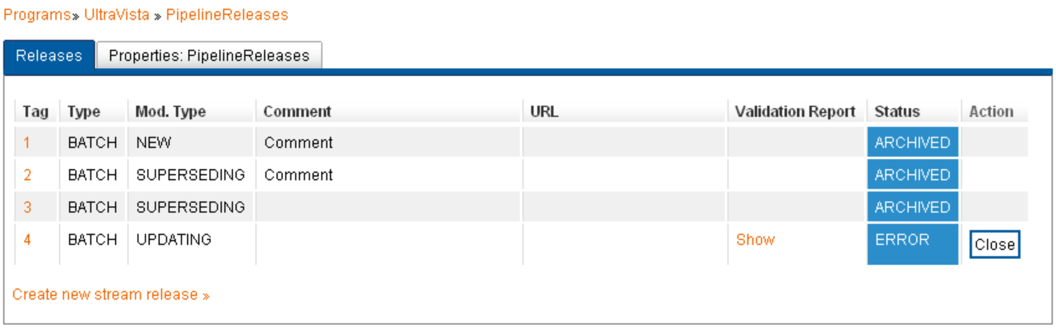

Figure 14: Failed data release validation results in ERROR status

4.8 Closing the data release

The PI concludes the data submission by closing the data release, an action that cannot be delegated but has to be taken by the principal investigator in person. Normally, thereafter, the release and its content cannot be changed anymore.
By closing the release the principal investigator approves the completeness and correctness of the submitted data and its description. Furthermore, the principal investigator agrees to the publication of the data being currently stored in the release directory of the staging area and to the publication of the associated data release description.

Before of closing a data release, its completeness should be carefully checked because the automatic validation procedures cannot detect if data is missing. The PI can close the data release with the Phase 3 Release Manager by clicking the CLOSE button on data release page (Figure 13).

Closing the data release turns the data on the FTP area into read-only state, i.e. you cannot modify existing files or add new data anymore. The operations following thereafter and leading to the public release of the data through the ESO Archive are being executed by the system in a largely automatic fashion without further interacting with the user assuming that the submitted data pass the validation process.

4.9 Data release validation

The validation process carried out at ESO consists of two stages. First, there is a fully automatic procedure checking the internal consistency and metadata content of the submitted data products, which is basically identical to the user-side validation. If this validation fails, the release state will change from CLOSED to ERROR, you will receive a notification by e-mail which prompts you to correct the problems and to CLOSE the release again (Figure 14). You can avoid this type of error by validating all products on your side before of submission. If the release hasn't passed the automatic validation you can click the respective link to "Show the Validation Report".
The second level of validation is performed by the ESO phase 3 support scientist and consists of reviewing the release content and description at large in order to spot possible issues. The problems typically found in the course of this process lie in the following areas: adequacy and consistency of the data release description, data quality issues, and metadata content.
In case of a problem the PI and the contacts given in the CC list will be contacted by email to discuss the issue and to agree on corrective actions. Depending on the nature of the problem, the release state may have to be reverted to "OPEN" to allow the PI to modify the submitted data.

4.10 Data release becomes public

The data release will be archive and becomes public after the validation process has been concluded (Figure 14). Each data release is announced using the appropriate ESO channels, e.g. through the ESO science news and the ESO archive news feed. The PI and the contacts given in the CC list will be notified about the actual date of public release.

4.11 Update of an existing release

To be added - see the release modification type (option "–m") in the Release Validator user manual, Sect. 5.2.

5 Appendices

5.1 List of compatible FTP clients

The ESO phase 3 infrastructure uses Pure-FTPd, which was reported to be fully compatible with the following clients with the SSL/TLS encryption layer turned on (taken from the documentation of Pure-FTPd):

- CoreFTP Lite (Windows)
  URL: http://www.coreftp.com/
  SSL/TLS perfectly works when "AUTH TLS" is enabled. CoreFTP Lite has some neat features like IPv6 support, remote file searching, .htaccess editing, queueing, bandwidth control, etc.

- CoreFTP Lite is free both for personnal and business use, but people who want to register in order to get the enhanced (non-"lite") version and commercial support can get a special discount for Pure-FTPd users, through this secret link:
  http://www.2checkout.com/cgi-bin/ccbuyers/purchase.2c?sid=62821&product_id=9&quantity=1

- SmartFTP (Windows)
  URL: http://www.smartftp.com/
  An excellent client with IPv6 support, port range limitation and other useful features (!= bloat). And it's free for personal, educational and non-commercial use. And it detects Pure-FTPd :)
  SSL/TLS perfectly works when the "FTP over SSL (explicit)" protocol is selected and when the data connection mode (Tools->Settings->SSL) is set to "clear data connection" while the AUTH mode (also in Tools->Settings->SSL) is set to "TLS".

- IglooFTP Pro (Windows, Linux)
  URL: http://www.iglooftp.com/
  SSL/TLS is automatically detected and works when Preferences->Security->Encrypt is set to "Commands [if possible], Transfers [if possible]".

- FlashFXP (Windows)
  URL: http://www.flashfxp.com/
  SSL/TLS works. In the "Quick connect" dialog box, pick the "SSL" tab and:
  - enable Auth TLS
  - disable Secure File Listing
  - disable Secure File Transfers

- SDI FTP (Windows)
  URL: http://www.sdisw.com/
  SSL/TLS works. In the "Connection" tab, just pick "SSL Support: TLSv1".

- LFTP (Unix, MacOS X)
  URL: http://lftp.yar.ru/
  SSL/TLS is automatically detected and works out of the box.

- RBrowser (MacOS X)
  URL: http://www.rbrowser.com/
  A cute graphical client for MacOS that was reported to work by Jason Rust and Robert Vasvari.

- Glub Tech Secure FTP Client (at least Unix, MacOS X and Windows)
  URL: http://secureftp.glub.com/

SSL/TLS is automatically detected and works out of the box.

- FileZilla (Windows, OSX, Linux)
  URL: http://filezilla-project.org/
  SSL/TLS works. In the "Site details" dialog box, pick "FTP over TLS (explicit encryption)" as the "Servertype". Reported by Philip Hallstrom.

- Cyberduck (OSX)
  http://cyberduck.ch/
  SSL/TLS works out of the box.

5.2 Phase 3 Release Validator User Manual

PHASE 3 RELEASE VALIDATOR

NAME

validator.jar - validates a phase3 data release before uploading to ESO.

SYNOPSIS

java -jar validator.jar [-h]

to get help on the available options.

OR

java -jar validator.jar -v

print the version and exit.

OR

java -jar validator.jar -r release_dir -m modification_type [-f fitsverify_utility]

to run a validation of the data contained in release_dir for a release of type modification_type [using fitsverify_utility to check the compliance of fits files to the standard].

OPTIONS

--conf

-c filename

Default value: none.

Specify a configuration file from where to read the command line options. The file is parsed as a properties file, i.e. each line is either a comment, starting with a hash character (#), or in the format:

<option-name>=<option-value>

- If <option-name> is a valid command line option, then its value is set to <option-value>

- If <option-name> is not a valid command line option then the line is ignored.

- If <option-name> is specified both in the configuration file and on command line, the value on command line overrides the value in the configuration file.

- <option-name> can be either the long name or (when it exists) the short name of a command line option, always without the leading dash(es).

The following two examples specify the same configuration:

Example1) Configuration value from command line:

--fitsverify/home/user/bin/fitsverify

Example2) Configuration value from configuration file:

fitsverify=/home/user/bin/fitsverify

--fitsverify

-f fitsverify_utility

Default value: fitsverify

Specifies which command line utility to use for fits format validation. If this option is not given, the default value "fitsverify" (quotes for clarity) for the fits verification utility will be used. The validator tries to locate an executable called <fitsverify_utility> first as pathname, then on the same directory where validator.jar is located and then on any directory of the executable path. If <fitsverify_utility> is not found an error is reported but the validation continues (due to the missing utility the result will be in any case an error, but in this way other potential errors are reported as well).

--modification-type

-m modification_type

This option is mandatory and does not have a default value. Specify the modification type of the release. The modification type can be either CREATE or UPDATE (both case insensitive). In case of an UPDATE release, a file named

"CONTENT.ESO" (quote for clarity) must be present in the release's directory. This file contains in an internal format the information currently stored at ESO for the release being updated. This file must be downloaded from ESO and must not be edited thereafter. A file "CHANGES.USER" (quote for clarity) can optionally be present as well. This file is in text format, it is written by the user, and it contains the required update actions for the release. It is composed by lines in the format:

{DELETE|REPLACE} filename

--help
-h

Print usage help and exit.

--reldir
-r releasedir

This option is mandatory and does not have a default value.
Specifies the base directory of the release to validate. This directory and all its sub-directories must be readable and accessible.

--version
-v

Print the version and exit.

--verbose
-V

Run in verbose mode. This increases only the number of messages in the log file, it does not effect the validator output on terminal.

DESCRIPTION

The validator is a command line tool used to check if a phase 3 data release is compliant with the ESO constraints and requirements before the release is uploaded to ESO. The validator provides a pass/fail result, in case of failure the list of detected errors is written on file.

There are 3 main steps in the validation process:

1. Validation of the release structure.
   The release structure is extracted from the metadata available in the headers of the release's fits files. The fits header keywords parsed to reconstruct the release structure are:
   PRODCATG - category of the fits file.
   ASSONn - name of the n-th component of the dataset.
   ASSOCn - category of the n-th component of the dataset.
   PROVn - name or ID (in the ESO archive) of the n-th component of the provenance.
   Invalid categories, duplications and inconsistencies in the definition of datasets or provenance informations are reported as errors.
2. Fits validation.
   For this step an external utility (by default the NASA HEASARC fitsverify) is used. The external utility must be present as executable on the system where the validation is performed. If the utility is not present and an alternate option is not specified the release will be considered in error.
3. Metadata validation.
   This step checks the consistency of the metadata against the rules specified by ESO. The rules for this check are dynamically updated before each check, therefore an HTTP connection with ESO is required during the validation.

In case of an update release (instead of a newly created release) the release structure quoted in step 1. is given by the merging of these three elements:
(1) The metadata available in the headers of the local fits files.

(2) The structure stored remotely at ESO (contained in the file CONTENT.ESO).
(3) The changes to the existing structure specified by the user (file CHANGES.USER).
To be precise: (1) is merged with the result of [(2) + (3)] but only if (1) is valid: in case of errors on the release structure parsed from the local files the remote content and its updates are ignored by the validation process as long as the local errors are not fixed. On the other hands if the files CHANGES.USER or CONTENT.ESO are not in the correct format the overall parsed release structure will be incomplete or anyway invalid and therefore the validator might report errors on the local files even if they would be considered valid when validated as part of a newly created release.

At startup the validator checks if the input directory exists and is readable, if the fitsverify utility (or the equivalent specified on command line) exists and is executable, and if an HTTP connection to ESO to download the metadata validation rules can be opened.
- If the checks on the directory fail, the validator exits immediately with an error.
- If the configured ESO URL is invalid the validator exits immediately with an error.
- If fitsverify is not available, the validation goes on but will end with an error.
- If a rule file cannot be downloaded, the validation of the files with the corresponding category will be considered in error.

OUTPUT

The output of the validator (on standard output) is a summary of the validation, which is also reported on file, and a status message (release valid / release in error) which is either of the following messages (quotes for clarity):

"OK - RELEASE CAN BE UPLOADED TO ESO."
"ERROR - PLEASE FIX THE ERRORS BEFORE UPLOADING THE RELEASE."

Summary example:

FILES		<number>
	Science	<number>
	Calib	<number>
	Ancillary	<number>
	Other	<number>
ASSOCIATIONS		
	Dataset	<number>
	Provenance	<number>
ERRORS		<number>
	Invalid category	<number>
	Fits validation	<number>
	Meta-data	<number>
	Outlier	<number>
	Missing	<number>
	Invalid provenance	<number>
	Duplication	<number>
	Inconsistency	<number>
	Other	<number>

Summary Explanation:

FILES: Existing files belonging to the release (i.e. declared in the fits headers and at the same time available, either on disk or remotely). Note: this means that the number FILES might be different from the number of files present locally in the release's directory.

Science
Calib
Ancillary
Other

Breakdown of FILES per category.

ASSOCIATIONS: Associations declared in the headers of the fits files.

Dataset

Datasets declared in the headers.

Provenance

Provenance information declared in the headers.

ERRORS: Total number of errors arisen while validating the release.

Invalid category

Files with a category not declared in the ESO list of valid categories.

Fits validation

Fits files for which the used fitsverify utility reported an error.

Meta-data

Fits files which did not pass the metadata validation.

Outlier

Files found in the directory structure of the release but not declared in the fits headers.

Missing

Files declared in the fits headers but not found in the directory structure of the release.

Invalid provenance

Provenance information with missing elements or where a circular definition were detected.

Duplication

Duplicated definitions in the release structure.

Inconsistency

Inconsistencies in creating the release structure. This can happen while merging remote and local contents in an update release: the contents themselves might be valid but they do not fit together. Other possible inconsistencies are:
- An empty new release or an update release with no updates.
- Any fits file that cannot be parsed by the release parser will add 1 to the number of inconsistency erros (NOTE: on top of the potential errors given by metadata rules and fitsverify).

Other

Errors which do not fit in any of the above entries.
Example: if fitsverify utility cannot be run, the error will be added to this entry.

EXAMPLES:

$> java -jar validator.jar

Prints a short usage message.

$> java -jar validator.jar -r /data/HARPS -m create

Validate the release's directory /data/HARPS using as fitsverify either the one in the current directory or any found on the executable path. The files validator.error, validator.log, validator.toc are written in the current working directory.

$> cd /tmp; java -jar /data/utilities/validator.jar -r /data/HARPS -m create

Validate the release's directory /data/HARPS using as fitsverify the executable /data/utilities/fitsverify if exists, otherwise the first one called fitsverify and found on the executable path. The files validator.error, validator.log, validator.toc are written in the current working directory (/tmp).

$> java -jar validator.jar -r /data/HARPS -m create -f /data/utilities/alternate_util

Validate the release's directory /data/HARPS using as fitsverify the executable /data/utilities/alternate_util

$> java -jar validator.jar -r /data/HARPS-TAKE2 -m update

Validate the release's directory /data/HARPS-TAKE2 and merge its content with the content declared in /data/HARPS-TAKE2/CONTENT.ESO and modified according to the instruction in /data/HARPS-TAKE2/CHANGES.USER. The resulting release is described in the file validator.toc

FILES

Files generated in output.

The validator produces 3 files in the current working directory:

1. validator.error: list of short error messages describing the errors found in validating the release. This file is empty if no errors are found.
2. validator.toc: it contains the status (release ok/in error), a summary of the release (number and type of validate files, number and type of found errors, number of parsed datasets and provenance information) and a dump of the parsed metadata for datasets, provenance, and categories.
3. validator.log: a more detailed list of messages generated during the validation.

If the validator cannot create the validator.error and validator.toc files, their content is printed on standard output instead.

External fitsverify utility:

fitsverify is a command line utility which verifies the compliance of a fits file with the fits standards. It is produced and distributed by NASA HEASARC and can be downloaded from:
http://heasarc.gsfc.nasa.gov/docs/software/ftools/fitsverify/
The binary version for Linux is provided together with the validator.jar file.
Any alternate utility can be used as long as:

- The alternate utility can run from command line.
- The alternate utility takes as single input parameter the name of the fits file to check.
- The alternate utility returns as exit code 0 if the input is a valid fits file, and a code != 0 otherwise.
- If the exit code is not 0, details on the error(s) are sent to the standard output (so that they can be reported in the validator.log file).