1 Title: The VST ATLAS

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1.1 Abstract

We describe two alternative survey observing strategies for the VST ATLAS; which one is preferred depends principally on the OmegaCam readout time for 2×2 on-chip binned exposures and on the VST target acquisition time which are currently unknown. These strategies may also change if the VST-ISW Chilean Survey and the VISTA Hemisphere Survey proposals are also supported as Public Survey Proposals. The survey scheduling, observational and data calibration requirements are described. Data reduction will be carried out using the VISTA Data Flow System (VDFS) with CASU (Cambridge) providing pipeline processing and WFAU (Edinburgh) providing basic science archiving facilities. The manpower and hardware that will deliver the various pipeline data products to the ESO Science Archive and the WFAU Science Archive are described. Finally the survey timeline includes two major public data releases at two and three years, plus releases of core data products to the ESO Archive at more frequent intervals.

2 Survey Observing Strategy

The minimum observations required for this survey are the *ugriz* bands with 60s exposures each. The seeing is required to be in the range 1-1.4 arcsec. These parameters will allow the VST ATLAS to reach deeper than the SDSS survey in the N Hemisphere, with better average image quality. Two developments which may affect the above strategy are the proposals for the VST-ISW Chilean Survey (PI: L. Infante, PUC) and the VISTA Hemisphere Survey (VHS, PI: R.G. McMahon, Cambridge). At the time of writing, it is not known whether these surveys are going to be accepted as Public Survey programmes. The VST-ISW survey is aiming to cover 6000 deg^2 with single 600s r band exposures in sub-0.8 arcsec seeing and include the VST ATLAS as a sub-area. This survey will use Chilean VST time. The VHS is a survey which proposes to cover the whole S sky in the ZYJK bands and to include the VST ATLAS areas as high priority sub-areas for its first 3 years. The Z band is of interest for ATLAS because it goes 0.9mag deeper than VST because of a 3× longer exposure in VISTA's larger aperture with slightly better assumed seeing. There are a variety of routes in which time could be traded between these projects which we shall investigate to see if we can effectively end up with at least a factor of 2 increase in exposure time in the *ugi* bands, as well as the 10× longer r and 3× longer z band exposures. These avenues will be pursued when the status of the other proposals is clarified and also when the actual capabilities of VST and VISTA are empirically known. Meanwhile, for the purposes of this document, we shall simply assume that the proposed exposure times in the original VST ATLAS proposal still apply.

Therefore our basic observing strategy for each VST ATLAS field is to obtain 60s exposures in each of the *ugr* bands in dark time sequentially and then to obtain 60s exposures in each of the *iz* bands in grey/bright time sequentially. Obtaining the full set of exposures within just two sequences would minimise the impact that point-source time variability might otherwise have on derived colours. This strategy will also increase the likelihood of equivalent image quality (in terms of PSF, photometric conditions) in each field, simplifying final flux calibration of the data.

However, as we describe below, there would be the possibility of improved observing efficiency if 2 × 2 on-chip binning for OmegaCam produced significantly lower readout times. Assuming that the reduced readout time still dominated VST target acquisition time, then the reduced overhead would argue in favour of observing many fields without changing filter. The advantage in terms of survey speed would then outweigh the advantages of contemporaneous observations of a single field.

Period	Time (h)	Mean RA	Moon	Seeing	Transparency
P79	95(d)+60(g/b)	10–15h30, 21h30–04h00	dark+grey/bright	$< 1.''4$	clear(+ some phot.)
P80	95(d)+60(g/b)	10–15h30, 21h30–04h00	dark+grey/bright	$< 1.''4$	clear(+ some phot.)
P81	95(d)+60(g/b)	10–15h30, 21h30–04h00	dark+grey/bright	$< 1.''4$	clear(+ some phot.)
P82	95(d)+60(g/b)	10–15h30, 21h30–04h00	dark+grey/bright	$< 1.''4$	clear(+ some phot.)
P83	95(d)+60(g/b)	21h30–04h00	dark+grey/bright	$< 1.''4$	clear(+ some phot.)
P84	95(d)+60(g/b)	21h30–04h00	dark+grey/bright	$< 1.''4$	clear(+ some phot.)

Table 1: VST time requirements including overheads by observing period for the basic observing strategy.

2.1 Scheduling requirements

VST ATLAS aims to survey 1500deg^2 in *ugriz* per year in the first 3 years of VST operation. Here we assume that VST is commissioned at end of 2006 and that VST is available from Period 79. One of the many aims of VST ATLAS is to provide the imaging base for the AAOmega Luminous Red Galaxy (LRG) Redshift Survey and for this to remain competitive, we need VST to supply our imaging as soon as physically feasible. Nevertheless there is still 1-2 years of SDSS data on the equator that can be used while VST ramps up. The status of the AAOmega LRG survey is that we have had a highly successful pilot run where AAOmega performed to specification with $3-4\times$ improved throughput over the previous 2dF spectrographs. A proposal to observe up to 450000 LRGs from 1/8/06 has now been submitted.

VST ATLAS will need about 30 nights a year, split 18 dark and 12 bright/grey. Our basic targets are in the RA range between RA: 10h00-15h30 at Dec: $-20 < \delta < -2.5$ deg to give $\approx$ 1500deg^2 in the Northern Galactic Cap and RA: 21h30-04h at Dec: $-50 < \delta < -15$ deg to give $\approx$ 3000deg^2 in the Southern Galactic Cap for the full 4500deg^2 survey. The third year of the survey would therefore focus mainly on the Southern Galactic Cap. The Large Programme proposed for Periods 79-82, would therefore produce a survey of 3000deg^2 split evenly between the Northern equatorial and SGC areas; time to complete the final 1500deg^2 would be requested in Periods 83, 84. This timescale has slipped by a year from that stated in out Large Programmme proposal because of the delay to VST commissioning.

Choice of fields to observe on any given night need only be governed by seeing (< 1.4 arcsec), air mass (<1.4) requirements and moonlight restrictions in bright time ($> |5|$ days from full moon).

2.2 Observing requirements

In the first instance, we assume that the dominant overhead is target acquisition and/or guide star acquisition which takes of order 60s. We assume that filter movement can be done in parallel with read-out. In this case then there may be more to be gained in terms of contemporaneous observations by observing 3 filters (*ugr*) sequentially during dark time and 2 filters sequentially (*iz*) during grey/bright time. We also assume that guide-star acquisition (if necessary) can be done simultaneously during the first exposure after an offset; also that in a 60s exposure the CR density may be low enough that CR-split observations may not be necessary, although this will leave gaps of up to 80 arcsec between the CCD chips. The filter change time is assumed to be dominant at about 50s. Again this will be tested during commissioning observations. Therefore the overhead per observation in this mode is assumed to be 100% and since the on-sky exposure time is 5 mins, the total sequence of 5 filters will take 10 min. We shall then be offsetting by about 54arcmin between each pointing in a strip to allow 10% overlap in the RA direction. We shall also arrange to have 10% overlap in the Dec direction to allow cross-calibration. To cover 4500 deg^2 we would then need $\approx$ 925h VST time including overheads (see Table 1).

Under the above assumptions, a complete ATLAS observation for a given field then comprises: target acquistion; guide star aquisition; a sequence of exposures in 3 (or 2) filters. This sequence takes 6 (or 4) mins and is therefore repeated on 10 (or 15) more field centres to define a single OB. Here, taking these data contemporaneously will

			Limiting	Mag.
band	λ	$\Delta\lambda$	AB	Vega
u	3550	570	22.0	21.0
g	4750	1390	22.8	22.9
r	6230	1370	22.3	22.1
i	7620	1530	21.8	21.4
z	9130	950	20.7	20.2

Table 2: VST ATLAS limiting magnitudes, defined as the 10σ limit (converted from Rifatto VOCET table).

minimise data matching problems caused by stellar and QSO variability. However, interchip gaps will remain. Variations on the above strategy are possible to address this issue. For instance, if the rotation angle is such that the longer CCD side is parallel to RA direction, then smaller 43 arcmin offsets in the RA direction while maintaining 10% overlap in the Dec direction would at least eliminate the two larger 80 arcsec interchip gaps. This would increase the survey time from $\approx$ 925h to $\approx$ 1165h.

If it is possible to do 2×2 on-chip binning with OmegaCam, then it may be that the read-out time may drop by a factor of $\approx$ 4 from 38s to $\approx$10s. Given that we are requesting 1-1.4arcsec seeing, a pixel size of 0.42arcsec would more than adequately sample the PSF while also matching the SDSS pixel size of 0.40arcsec. In this case it would be more efficient to observe a strip of fields sequentially using a single filter, assuming that the minimum filter change time is $\approx$ 47s. We are also assuming that 60s exposures do not require guide star acquisition. In this case we should split the exposure time into half (30s) and make two pointings per field, the second pointing offset by 4arcmin in RA and 7arcmin in Dec direction to help remove CRs, CCD defects and CCD gaps. Assuming that target acquisition/offset time is also $\approx$ 10s the overhead is only 33%. To cover 4500deg^2 we then need $\approx$500h VST time including overheads. In this case we could afford to increase our total exposure time in all bands to 2×60s and our 2×10s (15%) overhead would then imply a survey time of $\approx$ 875h.

A complete ATLAS observation for a given field would then comprise: target acquisition; an exposure of 60s in a given filter; an offset of several arcminutes; a second exposure of 60s. This sequence takes 140s and is therefore repeated on 25 more field centres to define a single OB.

In either of the above cases, we request that the same strip is observed in consecutive dark and grey/bright time periods to minimise the effects of QSO and stellar variability as much as possible.

Clearly if the 600s VST ISW survey r exposure is included in our exposures then our net observing efficiency will rise. This will be the case even if the different seeing requirements for the 600s r frame make the observations non-sequential in the 5 filters.

2.2.1 Exposure times and filter choice

Here, and in the rest of the ATLAS SMP except where stated, we shall assume 60s exposures in each of the *ugriz* bands. Because of the higher efficiency of VST+OmegaCam this will easily reach the Sloan magnitude limits already used in the current SDSS-2dF LRG survey. Grey and even bright time could be used for the i and z bands, although care would have to be taken to ensure survey uniformity. Seeing of 1-1.4arcsec FWHM could be used, since this is an improvement over the 1.4arcsec FWHM median seeing for the SDSS imaging data used as the base for the current equatorial SDSS-2dF LRG survey. The estimated limiting magnitudes for the VST ATLAS are listed in Table 2.

The SDSS telescope has a 2.5-m aperture and uses a 55s exposure in the *ugriz* bands. The limiting magnitudes for VST ATLAS are intended to reach at least as deep as SDSS limits in the same bands. But since OmegaCam throughput is $\approx$ 10% higher at all wavelengths and also taking into account average seeing of $1.''2$ FWHM, an exposure of 60s will make the corresponding VST ATLAS limit $\approx$ 0.3mag fainter in all bands, although the use of grey/bright time to observe i/z may reduce the VST ATLAS advantage there.

We have chosen to work in seeing between 1-1.4 arcsec as the maximum acceptable seeing to ensure that, on the average, the VST ATLAS will have imaging better than that of SDSS. We note that, at Paranal, such seeing occurs about 30% of the time (see http://www.eso.org/gen-fac/pubs/astclim/paranal/seeing/seewind/).

2.2.2 Survey coverage

We shall use a simple tiling pattern for the 2 ATLAS sub-areas where ATLAS fields will have essentially constant offsets in the RA direction. In the case where on-chip binning is not being used, these field centre offsets will be 54 arcmin, reducing to 43 arcmin in RA if the variation to remove the two 80 arcsec gaps is used; in the case where on-chip binning is available, offsets between field centres in the RA and Dec directions will be 1 degree.

In the case where we have 2×2 on-chip binning, a second set of overlapping pointings is proposed, in order to establish a common calibration across the survey, to address problems caused by chip blemishes, cosmic rays and to correct for loss of sky coverage due to gaps between the CCDs and filter mount vignetting. This requirement is most efficiently met with an immediate set of repeat exposures obtained at a small offset from each field centre. We propose offsetting 4 arcmin in RA and 7 arcmin in Dec (i.e. 0.5 of a CCD in each direction).

3 Survey data calibration needs

3.1 Detector characteristics

Standard sequences of bias frames, darks and twilight (or dome) flatfields will be used to remove the gross instrumental signatures. These should be made with or without on-chip binning as appropriate. Fringe frames constructed from deeper observations in the i- and z-bands will also be needed: we foresee no requirement to carry out special observations to construct these as we have confirmed that the required stacked frames will be available from e.g. the KIDS survey programme (K. Kuijken, priv.comm). Illumination corrections are also needed to ensure uniform photometric calibration across the array - these are in addition to flatfields and correct for effects such as scattered light. These can be characterised using dense large area photometric standard fields or from suitable sub-sampling of photometric fields across the array. We expect that unbinned fringe frames will also be useful for the 2×2 binned case but this will be checked during commissioning.

3.2 Astrometry

Astrometric calibration will be via the numerous unsaturated 2MASS point sources available in each field. Previous experience for a wide range of telescope systems indicates that a standard ZPN projection with a radially symmetric correction of the form

$$r_{true} = k_1 \times r + k_3 \times r^3 + k_5 \times r^5 + ... \quad (1)$$

where r_{true} is an idealised angular distance from the optical axis, r is the measured distance, and k_1 is the scale at the centre of the field; this will provide a good description of the field distortion. Coupled with a linear "plate" constant solution for each detector of the form

$$\xi = a * x + b * y + c \qquad \eta = d * x + e * y + f \quad (2)$$

we find that this gives astrometric residuals over the whole field of better than 100mas. The global systematics in 2MASS (on the ICRS system) are also below the 100mas level.

3.3 Photometry

For external photometric calibration VST ATLAS pointings need to be supplemented by standard (e.g. Landolt or Sloan) field observations through all five filters every two to three hours through each night. Regular observations of standards also help determine how photometric a given night is which is of later help when cross-calibrating contiguous survey observations. At this stage it is not yet clear how far the standard observatory calibration plan will meet these needs. We can supply standard-field OBs as needed.

It is assumed that ESO will provide basic sky quality measures such as photometric quality and extinction measures at zenith.

Internal calibration of observations uses the flatfield and dark sky characteristics of the detectors to place them all on a common gain system.

For the purposes of quality control (eg. sky transparency and system performance) a photometric zeropoint will be determined for each set of observations by direct comparison of the i- or z-band instrumental magnitudes with appropriately colour-corrected magnitudes of 2MASS stars. A more accurate nightly photometric calibration will be applied retrospectively given the standard star observations.

The internal gain-correction, applied at the flatfielding stage, should place all the detectors on a common zeropoint system (to ≈1-2%): hence given a stable instrumental setup, the apparent variation of zeropoint then directly measures the change in "extinction" without the need to rely solely on extensive standard field coverage over a range in airmass.

Therefore for any given observation of a star in a particular passband

$$m^{cal} = m^{inst} + ZP - k(\kappa - 1) = m^{std} + ce^{std} + \epsilon \tag{3}$$

where ZP is the zeropoint in that passband, κ is the airmass of the observation, ce^{std} is the colour term to convert to the instrumental system and ϵ is an error term. This assumes that the second-order extinction term and colour-dependency of κ are both negligible. By robustly averaging the zeropoints for all the matching stars on the frame an overall zeropoint for the observation can be obtained.

On photometric nights the extinction coefficient κ should be constant in each passband. The extinction κ can be monitored through each night either by assuming the true instrumental zeropoint only varies slowly as a function of time or by making measurements over a range of airmass. Goals for photometric accuracy of individual pointings are <5% in all passbands. Later downstream cross-calibration using the overlaps between fields will be used to improve this by about a factor of 2.

3.4 Artefacts

Saturated stars are automatically flagged in the processing system and most scattered light or ghosts are dealt with automatically by the catalogue background tracking software. In the case where no offset frame pairs are available, strategies to remove CRs and other blemishes will depend on their numbers and characteristics and various methods will be explored during commissioning. Otherwise dual pairs of images will be used to remove both CRs and satellite trails.

4 Data reduction process

We will use a version of the VISTA Data Flow System (VDFS; Emerson et al. 2004, Irwin et al. 2004) for all aspects of data processing and management. The Cambridge Astronomy Survey Unit (CASU) will be responsible for the VDFS pipeline processing component and first pass calibration. The Wide Field Astronomy Unit at Edinburgh will provide a basic Science Archive for VST data which may nevertheless offer some functionality over and above what may be available from the ESO Science Archive.

The optical pipeline processing component of the VDFS has been scientifically verified by processing wide field mosaic imaging data using a range of existing CCD mosaic camera e.g. ESO WFI, CFHT 12K and MegaCam, CTIO Mosaic, KPNO Mosaic AAO WFI, INT WFC and WHT PFC. The WFAU Science Archive is already being used to archive UKIDSS survey data from UKIRT WFCAM.

4.1 Pipeline processing

The VDFS pipeline is a modular design allowing straightforward addition or removal of processing stages and has been tested on a range of input datasets. The standard processing (see figure) assumes availability of the calibration data discussed in section 3. and includes:

- instrumental signature removal – bias, non-linearity, dark, flat, fringe, cross-talk
- consistent internal photometric calibration to put observations on an approximately uniform system
- catalogue generation including astrometric, photometric, and morphological shape descriptors and derived Quality Control(QC) information
- accurate astrometric calibration from the catalogue with an appropriate and World Coordinate System (WCS) in all FITS headers
- nightly photometric calibration using suitable pre-selected standard areas covering the entire field-of-view to monitor and control systematics
- each frame and catalogue supplied with provisional calibration information and overall morphological classification embedded in FITS files
- propagation of error arrays eg. weight maps, bad pixels, relative exposure via the use of confidence maps
- realistic errors on selected derived parameters
- nightly average extinction measurements in all relevant passbands
- merging of bands within each pointing to form muticolour catalogues
- pipeline software version control – version used recorded in FITS header
- processing history including calibration files used recorded in FITS header

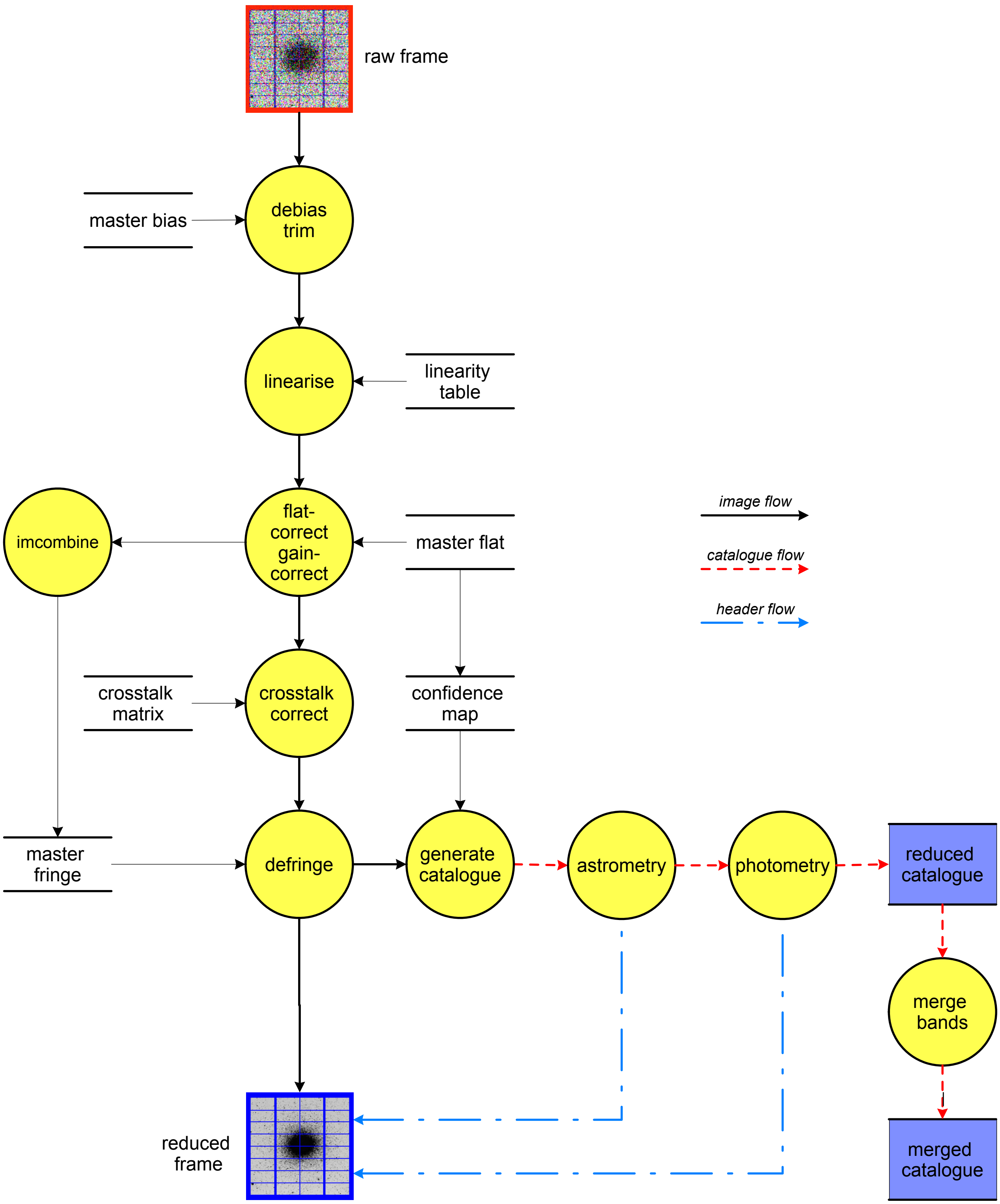
We note that some initial quality control processing may be carried out within the context of the ESO DFS group's processing. The required calibration data were identified in section 3.

The intermediate ATLAS products will be (i) instrumentally-corrected image frames in all five filters, (ii) homogeneous band-merged object catalogues (*ugriz* from single pointings).

4.2 Archiving

The WFAU VST Science Archive (VSA) ingests the products of pipeline processing (instrumentally corrected images, derived source catalogues, and all associated metadata) into a database. At minimum, the WFAU archive will then present a static database for both calibrated images and extracted object catalogues. In principle, the science archive system then can go on to curate them to produce enhanced database-driven products. In the VDFS science archive, the curation process can include the following: individual passband frame association; source association to provide multi-colour, multi-epoch source lists; global photometric calibration; enhanced astrometry including derivation of stellar proper motions; consistent list-driven photometry across sets of frames in the same area; cross-association with external catalogues; and generation of new image products, e.g. stacks, mosaics and difference images etc., all according to prescriptions set up for a given survey programme. In practice, the number of these higher functionalities that will be available by the end of the survey will depend on future applications for PPARC support for WFAU.

The VDFS supplies static file products plus catalogue database releases to the community. WFAU cannot undertake to provide data products over and above those currently supplied by VDFS, so the following static flat file products are currently not available to be delivered to ESO although they will be available as a queryable resource in the form of catalogue database tables prepared within the VST Science Archive:



raw frame
master bias
debias trim
linearise
linearity table
imcombine
flat-correct gain-correct
master flat
image flow
catalogue flow
header flow
crosstalk matrix
crosstalk correct
confidence map
master fringe
defringe
generate catalogue
astrometry
photometry
reduced catalogue
merge bands
reduced frame
merged catalogue

- static file source catalogues linking the parameters of individual objects across all filter bands
- more enhanced static file products such as PSF-matched images and/or matched aperture photometry across all observed filters, photo-Zs, etc.

We re-emphasise that these will be available as a queryable resource from the WFAU Science Archive for users to create their science data subsets on-the-fly. Also filter matched source catalogues will be available directly from the CASU pipeline. If it is essential to have the more enhanced static file products delivered to the ESO archive facility automatically from the WFAU archive, then WFAU will need extra staff resources to implement their production.

Metadata and data formats conform to the evolving VO standards: self-describing FITS and also XML-VOTable formats, the latter annotated with Unified Content Descriptors, are available from VDFS as detailed in the referenced documents (see below). We note that the Science Archive concept itself is inherently VO-enabled; we use data format standards and implement Astrogrid (the UK VO project) data access infrastructure as these becomes available. WFAU has several datasets available through the prototype Astrogrid infrastructure library DSA (Data Set Access software, formerly known as PAL, or the Publisher's Astronomy Library)

5 Manpower and hardware capabilities devoted to data reduction and quality assessment

5.1 Team members with functional tasks:

Name	Function	Affiliation	Country	% FTE
T. Shanks	PI	Durham Univ.	UK	40
N. Metcalfe	Qual. Ass.+CASU-WFAU Liaison	Durham Univ.	UK	20
PDRA (TBD)	Data Quality Control	Durham Univ.	UK	60
M. Irwin	Pipeline development	IoA, Cambridge	UK	20
R. McMahon	Data Quality Control Manager	IoA, Cambridge	UK	10
N. Walton	Pipeline + VO compatibility	IoA, Cambridge	UK	20
E. Gonzalez-Solares	Pipeline processing	IoA, Cambridge	UK	50
D. Evans	Astrometric Calibration	IoA, Cambridge	UK	10
S. Hodgkin	Photometric Calibration	IoA, Cambridge	UK	20
N. Hambly	Science archive architect	Univ. of Edinburgh	UK	10
M. Read	Archive operations	Univ. of Edinburgh	UK	10
J. Bryant	Archive operations	Univ. of Edinburgh	UK	10
G. Busarello	Data Release Oversight	OAC Naples	I	10
A.Edge	Data Release Oversight	Durham Univ.	UK	10
S. Maddox	Data Release Oversight	Nottingham Univ.	UK	10
R. Nichol	Data Release Oversight	Portsmouth Univ.	UK	10
W. Sutherland	Data Release Oversight	IoA, Cambridge	UK	10

Note: The full list of CoIs incorporates a longer list of individuals who have interests in the early exploitation of the survey and who are invited to attend Consortium meetings held at least twice a year. The full list will soon be available from the VST ATLAS page (http://astro.dur.ac.uk/Cosmology/vstatlas).

5.2 Detailed responsibilities of the team:

The PI, T Shanks, was the UK PI of the 2dF QSO Survey. He is also the PI of the 2SLAQ QSO survey and a co-I of the 2SLAQ LRG survey. He is also coordinator of the SISCO EU RTN network. Shanks is also the PI of the AAOmega LRG Baryon Acoustic Oscillation proposal. Shanks has applied to PPARC for a 3 year teaching buyout on the basis of being PI of the VST ATLAS and he is also applying for a specific PDRA position (3 year) at Durham to support ATLAS. He shall also be applying for further support from PDRAs on the Durham Extraglactic Astronomy and Cosmology PPARC Rolling Grant for science exploitation. Most of Shanks' research effort is now focused on the VST ATLAS and the related AAOmega LRG project.

The PI will liaise closely with the management of the CASU data pipeline and the WFAU archive, monitoring quality, and will communicate with the wider team to identify needed manpower and co-ordinate science exploitation. The PI's institution hosts a public website for VST ATLAS (http://astro.dur.ac.uk/Cosmology/vstatlas).

The Durham effort will be augmented by input from Dr. N. Metcalfe (Computer Officer) and the ATLAS PDRA (TBD). These two will provide a vital link between the CASU data reduction pipeline and the WFAU archive in terms of helping to ensure that the data reduction and archiving chain works as coherently for VST optical imaging data as it does for NIR imaging data. Metcalfe, in particular, is highly experienced in all aspects of optical galaxy photometry. He will also play a role in data quality control, assessing the quality of the CASU pipeline output as archived at ESO and WFAU.

At CASU, Irwin and Walton will lead the management and delivery of the initial reduced data products from the survey. The VST/OmegaCam data will be processed using a version of the VISTA Data Flow System (VDFS), which although being further developed (see http://www.ast.cam.ac.uk/vdfs/) is a proven working system. The Cambridge Astronomy Survey Unit (CASU) will lead the Pipeline Processing activity. Funding and personnel for processing of UK-led VST public surveys are now in place and the hardware infrastructure for this has been designed as a modest extension of the existing VDFS pipeline processing setup. The pipeline processing components have been scientifically verified by processing wide field mosaic imaging data for a range of existing optical CCD mosaic cameras e.g. Suprime-CAM, ESO WFI, CFHT 12K and MegaCam, CTIO Mosaic, KPNO Mosaic, AAO WFI, INT WFC and WHT PFC. It has also been used to process data from the NIR mosaic camera WFCAM on UKIRT at a rate of up to 250GB/night.

Note 1: The VISTA pipeline is being developed through the VEGA programme, PI Gilmore in Cambridge. Emerson (QMUL) is responsible for the Vista elements of that programme, with Irwin being the lead co-I with responsibility for the processing pipeline elements in Cambridge.

Note 2: Walton is project Scientist of the AstroGrid Virtual Observatory project in the UK, and now additionally Project Scientist of the Euro-VO's VO Technology Centre (http://www.eurovotech.org). This centre is defining many of the VO standards that the ESO SAF will conform to and in turn demand compliance with. Walton works closely with staff in ESO, and in particular with Padovani, Head of the ESO VOSystems Group responsible for the SAF. He is thus well placed to ensure the smooth ingression of VST ATLAS survey products into the ESO SAF.

Irwin and Walton, together with Shanks, will have responsibility to ensure that the required level of survey products are provided to the ESO Science Archive Facility (SAF), conforming to the agreed ESO SAF and Virtual Observatory standards. McMahon at Cambridge, helped by Metcalfe at Durham, will provide important support for data quality control.

In addition, the PI, with a sub-panel of CoIs (identified above), will oversee the science requirements for the cataloguing and base-level exploitation of VST ATLAS data products. S.J. Maddox will bring to the panel his extensive previous experience from the APM galaxy survey. Beyond this, the sub-panel team members' own science interests span most of the broad range of extragalactic astronomy served by VST ATLAS. This panel would remain in place until a final calibration of ATLAS data is achieved. It will be most active, meeting by telecon in between consortium meetings, during the first two years of the survey's execution.

WFAU has currently one science archive operator for VDFS (WSA operations). Furthermore, an existing VDFS developer moves to operations at the end of Q3 2007. The intention is that (around 10%) of these 2.0FTE, i.e.

0.2 FTE, will be available to work with the VST public survey teams, including ATLAS, to support science archive operations. In addition, overall management of science archive operations is currently fully funded to Q1 2008; around 0.1FTE will be available to manage VST public survey related science archiving up to that point; this resource level (or more if necessary) will be rebid for in Q4 2007. In the meantime, N. Metcalfe and the Durham PDRA will be working with the VDFS team to help adapt the WFAU Science Archive for optical images during this period.

5.3 Hardware

Our ATLAS team will accept raw SM data as delivered by ESO. There are no specific time requirements on when we would require the data after acquisition at the telescope (e.g. we are not wishing to detect SN, GRBs etc in near real time). Therefore we would anticipate that ESO would provide the data via ftp download from their raw data repository in Munich. Alternatively we could accept data shipped on NGAS disks or on LTO tapes.

In terms of data volumes, ATLAS will generate ≈15TB of raw science and calibration data (each unbinned exposure of the 32 CCD camera produces 0.5Gbyte). As this will be obtained over several semesters, it will not lead to significant extra data volume pressure on our processing system, which currently deals with ≈25–30 Tbytes of raw data per year.

Once the data has been accepted in Cambridge, it will be fed into the VDFS data flow system pipeline running at CASU. The process is described elsewhere in this document (see also Irwin et al, 2004).

Spare disk capacity will be made available by the ATLAS team in Cambridge to provide staging storage for the reduced data products as they are produced from the pipeline. It is anticipated that of order 8 TB of disk will be acquired initally for this purpose.

As noted in section 8 below, processed data will be released to ESO on a set timescale. Transfer will be to the ESO SAF, preferably via 'ftp' of the image and catalogue files. It is anticipated that ALL UK processed VST public survey data will be transferred to ESO in an identical fashion, in order to minimse the number of interfaces (to external data product providers) to be managed by ESO.

In terms of the WFAU VST Science Archive, since we wish to retain both pixel data and catalogue data at the VSA (as is the case in VDFS) then the hardware requirements have been estimated as 30TB (pix) and 3TB (cats), relative to the (funded) requirements for WFCAM/VISTA. We shall be bidding for this resource from PPARC at an estimated cost of 60k pounds. This figure allows for a Moore's law decrease in the cost of equipment over the period (5yr).

6 Data quality assessment process

After pipeline processing, the data will be tagged with seeing measurements and other DQC information (see below). Cambridge and Durham staff as outlined above will check seeing, limiting magnitudes and sky background level for consistency with survey data quality requirements. OBs failing these checks at a significant level will be reinserted into the observing programme, and noted for report in the 6-monthly progress reviews.

The quantitative criteria applied are liable to be revised in the light of experience with this new facility. In advance of data-taking we would anticipate the following limits:

Seeing: Reported mean seeing across all exposures in an OB required to be in range $1 - 1.2$ arcsec. No single exposure within an OB should be >1.4 arcsec.

Magnitude Limit: Within an OB we would require limiting magnitudes in ugriz to be at least as good as the 10σ limits reported in Table 1.

Sky background: For *ugr* we require dark time with no Moon. For *iz* we will use grey time as long as the observations are made $> |5|$ days from full Moon.

Additional quality flags: A number of secondary quality indicators will be tracked. These will include the estimate of ellipticity of unresolved images. High ellipticity would indicate problems with the optics or the observing system. Sky noise and aperture correction factors will also be measured, logged and examined as flags of potential problems.

An overview of the status of the processing of the ATLAS data will be maintained - giving access to the quality control data, and recording date of arrival of the raw data and date of transfer to the ESO SAF. This overview will be modelled on that currently routinely running for the WFCAM data pipeline - see e.g. `http://apm15.ast.cam.ac.uk/wfcam/report_night_reduction_status?semester=05B&SUBMIT=Submit+Query`

7 Data products and VO compliance:

ATLAS data will be calibrated to ESO agreed standards for the survey, thus the data will be photometrically and astrometrically calibrated to better than 0.05 magnitudes and to 0.1 arcsec rms precision, respectively. Full object catalogues will be generated for each image. These will conform to the standards developed for the VDFS. It is anticipated that these catalogues will be hosted eventually at the ESO SAF, and additionally in Edinburgh. Full global access will be available by ensuring that all products conform to VO standards - as an example see the WFS SIAP service
`http://esavo.esa.int/registry/result.jsp?searchMethod=GetResource&identifier=ivo://org.astrogrid/INT-WFS.SIAP)`
which is callable through AstroGrid and the emerging Euro-VO portals.

The following data products will be available:

- instrumentally corrected frames along with header descriptors propagated from the instrument and processing steps (science frames and calibration frames)
- stacked and/or mosaiced data for dithered observations of single targets
- statistical confidence maps for all image products
- derived object catalogues based on a standard VDFS set of object descriptors including astrometric and photometric measures, and morphological classification
- Data Quality Control database including measurements of seeing, average stellar shape, aperture corrections, sky background noise levels and limiting magnitudes
- homogeneous band-merged catalogues (*ugriz* from single pointing).

8 Timeline delivery of data products

Our team anticipate two main product releases resulting from the survey, timed at survey start plus 2yr and survey start plus 3yr. These will be the DR1 and DR2 catalogue releases and will, finally, incorporate *ugriz* photometry on all catalogued sources. DR1 would only be flux-calibrated at the individual pointing level, whereas the aim for DR2 would be to place the entire survey on a uniform photometric scale.

In addition to the DR1 and DR2 catalogue release indicated above, the ATLAS team will ensure delivery of the following core data products to the ESO SAF:

- astrometrically and photometrically calibrated, re-gridded images, along with their respective weight maps, in all of the project-relevant filters will be provided on a per pointing basis.
- source catalogues based on individual bands. Associated source catalogues linking the parameters of individual objects across all of the observed filter bands will be provided on a pointing by pointing basis.

- these survey products will be supported and characterized by additional 'meta' information providing a full description sufficient for their full scientific exploitation.

These 'core' products will be delivered within 2 months of receipt of the raw data from ESO.

As mentioned above, full status of all data processing and products, together with quality control info - will be provided by the ATLAS project. Thus ATLAS will be providing sufficient information to ESO to enable it to carry out its regular six-monthly reviews.

9 References

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