PUBLIC SURVEY STATUS REPORT
(91st OPC MEETING)

This report should be returned to the Observing Programmes Office of the European Southern Observatory (opo@eso.org).

PROPOSAL ESO No.: 177.A-3011
TITLE: : The VST ATLAS
PRINCIPAL INVESTIGATOR: Prof. T. Shanks

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1. **Scientific Aims (brief description)** The main aim of the VST ATLAS is to make a survey of >4000deg^2 in the Southern Hemisphere in the ugriz bands to the depth of SDSS. The ATLAS will comprise ~2000deg^2 in the North Galactic Cap between 10h<RA<15h30 and ~2000deg^2 in the South Galactic Cap between 21h30<RA<04h00. The main motivation for the survey is for cosmology. For example, there is the possibility of using the VST ATLAS UV coverage as the base for spectroscopic QSO redshift surveys out to z=2.2 in order to investigate non-Gaussianity and the power-spectrum turnover via QSO clustering. Such a QSO survey could also deliver competitive Baryon Acoustic Oscillation measurements of the Dark Energy equation of state at z~1.5. Pilot survey observations based on ATLAS data have already been carried out on the AAT 2-degree Field (2dF) facility. ATLAS data can also be combined with the VISTA Hemisphere Survey to produce *ugrizYJHK* photo-z for galaxies out to z~1. Then cross-correlation of Luminous Red Galaxies with the Cosmic Microwave Background fluctuations will test the evidence for an accelerating Universe via the Integrated Sachs Wolfe effect. Many other non-cosmological projects are clearly also feasible including the search for high redshift z~7 QSOs via optical dropout, the search for stellar streams and the search for local large scale structure including the Great Attractor. Indeed, our aim is that ATLAS becomes the equivalent of a Southern Sloan with similar scientific impact.

2. **Detailed progress report with respect to initial estimate from the Survey Management Plan (including preliminary results, whether published or not).** The VST ATLAS now has covered the equivalent of ~1700 deg^2 in *ugriz* so far between mid-August, 2011 and October, 2012 in Periods 87,88,89 and 90 (see status maps at http://astro.dur.ac.uk/Cosmology/vstatlas/). Over these ~13 months, this rate therefore corresponds to ~800deg^2 per 6-month Period. Since we are aiming to cover >4000deg^2, this means that we may need to extend the project into ESO Periods 92-93. CASU are pretty much up-to-date in their reduction (v1.0) of the ATLAS data as described below.

The total number of tiles to cover the targeted ATLAS area is 5078 (x5 bands). Table 1 shows how many of these have been completed by passband. It can be seen that *i* and *z* which are done in gray time have the highest completeness followed by *r* then *g* then *u*. Most of the scheduled areas in *ugriz* are complete in the SGC. In the NGC *i* and *z* is more complete in the scheduled areas than *u* and *g*.

Band	Complete	Failed	Scheduled	Unscheduled
u	1284	244	1607	1943
g	1531	94	1510	1943
r	1759	114	1262	1943
i	2015	136	968	1959
z	2057	196	866	1959

Table 1. Total number of VST ATLAS pointings so far completed up to October 2012. Scheduled means OB submitted and Unscheduled means OB to be submitted.

Table 2 shows that all OBs from P87 have been completed. 80% of *i* and *z* tiles have been completed for P88 with only 60% of *u* and *g* tiles completed. In P89 about 50% of *i* and *z* have been completed whereas only 25% of *g* and 10% of *u* have been completed. Thus it seems that there has been a slowing down of the rate at which *u* and *g* tiles are being observed. This is unwelcome given the emphasis of the science case for ATLAS on the bluer bands.

Band	P87			P88			P89			P90		
	√	X	?	√	X	?	√	X	?	√	X	?
u	425	17	0	752	147	534	107	80	970	0	0	73
g	425	17	0	781	47	518	235	30	892	0	0	73
r	425	17	0	974	97	365	360	0	797	0	0	73
i	425	0	0	1096	102	238	494	34	629	0	0	73
z	425	0	0	1119	96	221	513	100	544	0	0	73

Table 2. VST ATLAS pointings by Period and bandpass. √ means completed, X means failed/rescheduled and ? means OB submitted but not completed.

In terms of estimating the time taken to complete the survey, *i* and *z* are going at a rate of about 160 tiles in each band a month and so should take 32 months to complete or another 19 months. The full ~4500deg^2 (of which 4200deg^2 has been approved by the PSP) *iz* survey should therefore be completed by the end of Period 92. The *ugr* survey is going at a rate of ~120 per band per month and so will take 42 months in total or another 29 months at the current rate. At that rate the survey will be completed by P94. One possibility to speed up the *ugr* survey is to allow more *r*-band tiles to be done in gray time once the *iz* survey is completed in which case the survey might still be completed by the end of P93.

We note that in P90 we were advised to only submit OBs covering 73 tiles since ESO wanted to clear the backlog that had built up at VST for ATLAS and for the other public surveys. This inevitably means that the survey will extend beyond P91 and that more data will be required in P91 than envisaged in the revised SMP (see below).

Progress report on VST activities from Cambridge Surveys Unit (CASU)

Pipeline processing

Internet transfers of VST data from the ESO Archive in Garching to Cambridge have generally been very reliable with only the occasional night requiring manual intervention. After local data checks and ingest the the VST web pages at CASU track the progress of the data through the processing system (http://casu.ast.cam.ac.uk/vst/data-processing/) through to release and access (http://casu.ast.cam.ac.uk/vstsp/) for the survey PIs and their teams. CASU now also routinely transfer the OB grades and completion status from ESO and add these to the data product files and the survey progress database.

As noted in the previous report, the image processing part of the pipeline is stable and the only significant changes relate to the implementation of a robust system for correcting for the effect of scattered light in the flatfields (illumination correction). All VST catalogue data at CASU has been updated to fix the illumination correction problems which otherwise amount to a 0.25 mag systematic variation over the 1 sq deg field. These products have been released as Version 1.0 and external tests indicate systematics in calibration have been reduced to the 1% level over the entire field.

After much trial and error we concluded that ab-initio detection on U-band data was not good enough for the ATLAS requirements and so we have complemented the normal U-band catalogues with list-driven catalogues based on the g-band source lists. These additional catalogues are generated at the band-merging stage and yield a significant improvement in the depth probed by the U-band data.

The next pipeline upgrade will include a photometric recalibration of the survey using a combination of the standard fields observed nightly and the APASS all-sky photometric catalogue. ZP variations per pointing are already within 5-10%, but with illumination-corrected catalogues and by additionally taking advantage of the all-sky APASS catalogues, achieving a uniform global calibration at the 2% level is feasible.

Quality Control

In addition to the usual VDFS QC monitoring of average stellar seeing, ellipticity, and sky surface brightness and noise properties at the individual CCD level, CASU have initiated a more detailed analysis of the image properties based on comparisons between detectors. The well-aligned coplanar OmegaCam detector array coupled with the curved focal surface is extremely sensitive to imperfections in focus or tracking which are relatively easy to detect using the 32 detector-level QC parameters.

Calibration issues

After various tests, and external verification, CASU have adopted the APASS all-sky photometric g,r,i catalogues (http://www.aavso.org/apass) to monitor both overall throughput and provide a working solution to the severe illumination correction problem inherent in VST data. Scattered light corrupts the flatfields, both dome and twilight, with the detail varying with external conditions. In turn this leads to spatially-dependent magnitude offsets made up of several inter-related components with different spatial scales and symmetries. The fix is sufficiently complicated that all the internal flux values per detected object have to be corrected. After recalibrating, these form the basis for the standard user end products and yield an internal per field calibration at the level of +/-1% for the broadband u,g,r,i,z filters.

A further issue has been the gain variation occurring randomly in some detectors. These have been most noticeable in detector #82 which shows random changes of up to 0.5 mag. As noted in the previous report a possible solution to this is to attempt a fix at the catalogue band-merging stage. Recent video board changes from June 2012 seem to have solved this particular issue but extant data taken prior to this still requires a practical fix.

2.1. Scientific Progress and Outlook

The next step in terms of calibration at Durham is to make the global calibration of the survey in each band. We are doing this in two ways, one is using the 2arcmin overlap regions in RA and Dec on each tile. This will be done using the least squares matrix method of Glazebrook et al (1994), extended using Bayesian priors to include anchor areas with photometric sequences. This will also be checked against the alternative CASU calibration method using the APASS optical survey and the final global calibration will be a mix of these two. A global calibration will first be made for the KIDS S area which encompasses a GAMA galaxy redshift survey area and where the science returns are also therefore very high.

2.2. Publications (accepted or in press)

The problems with the unexpectedly large illumination correction for VST images have held up the photometry calibration paper based on the William Herschel Deep Field, Chandra Deep Field South and SDSS overlap data but this is being prepared now that the recalibrated data is available from CASU.

3. Quality Control and Phase 3. The Phase 3 submission plan should be described here.

3.1 The PI should comment on the quality control and the science validation of the acquired data.

Quality control is ongoing at Durham. Generally data quality looks excellent. The most important way to validate the data is by using it for science projects and we have now carried out some pilot observations for a proposed AAT 2dF survey called the 2dF QSO Dark Energy Survey (2QDES). VST ATLAS provided the imaging data base for these pilot observations on a director's night on 20 December 2011 and then another 3 nights between 28-30 April 2012. We prepared about 50 sq deg of ATLAS imaging data using u-g:g-r and g-r:r-i colour-colour diagrams to select QSO candidates which were then observed ~330 at a time using 2dF. The observations realized about 3000 QSO redshifts. 2dF fibre observations are clearly quite demanding, even more so since we were pushing to a limit of g~22 for QSO identifications. The success of the observations confirm that the positions for faint stellar objects are good enough for them to be observed in 2.1 arcsecond diameter fibres over a 3 sq deg field simultaneously. It also confirms that the CASU photometry reaches the equivalent of g~22 in the u-band. The best rates we have achieved from ATLAS are QSO sky densities of $60deg^{-2}$ or about 180 per 2dF field. This is even before the inclusion of the ongoing Chilean u band extension (PI L. Infante) which will double the u band exposure to 240s. A further week of AAT 2dF time has been allocated in November 2012 and January 2013.

We have also been investigating the effect of using ATLAS data with and without the illumination correction for galaxy clustering projects. For the most demanding angular correlation function projects, the required rms in magnitudes is about 0.03mag. Without the illumination correction there would be a difference of ~0.25mag in zeropoint from the centre to the edge of the field. With the illumination correction, that reduces to ~0.01mag. Therefore the implementation of the illumination correction is seen to be vital in allowing us to achieve our science goals in terms of studies of faint galaxy clustering.

3.2 The PI should describe the current status of the Phase 3 submission. Any feedback or requested modifications of data products or timeline for survey releases should be described here. PIs should also include any relevant information for the scientific validation of the data products.

The Phase 3 submission plan remains the one described in Section 5 of the Revised ATLAS SMP. In detail: Our team anticipate two main product releases resulting from the survey, timed at survey start plus 1.5 yr and survey start plus 2.5 yr. These will be the DR1 and DR2 catalogue releases and will, finally, incorporate globally calibrated *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 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.

We are expecting ESO to request the first ATLAS data release DR1 for March 2013 on the basis of ATLAS data observed between August 2011 and September 2012.

4. Are any changes proposed with respect to the Survey Management Plan in P91 (e.g., in strategy, field coordinates, exposure time and/or other settings)? If yes, please provide a clear and detailed justification.

The ATLAS survey was supposed to finish in P91 with the Apr-Jun observations in Table 3 below. As described above, we will need to extend the observations till P92 to finish the survey in *i* and *z* and to P93 in *u, g, r* if we make more use of gray time for r when the *i* and *z* survey is finished in P92. Remembering that the PSP recommended that ATLAS be accelerated and completed by the end of P91 because of competition from DES, we therefore urge the OPC to make a full allocation for time requested for ATLAS in P91.

5. Observing Plan for Period 91.
Specify which part of the Survey Management Plan (SMP) the survey will focus on in P91 in the 1st column and provide the corresponding details in the table below. In particular please highlight any changes with respect to the SMP for P91, and provide a full justification for these changes in Section 4 above.

SMP Period	Field name/ mean RA	Filter	Time (h)	Seeing	Moon	Transparency	Comments / strategy (e.g., no. of epochs)
P91 Apr-Jun	NGC RA~14h	ugr	90	<1.4	dark	clear + some phot.	As in revised SMP
P91 Apr-Jun	NGC RA~14h	iz	54	<1.4	gray/ bright	clear +some phot.	As in revised SMP
P91 Jul-Sept	SGC RA~23h	ugr	115	<1.4	dark	clear + some phot.	Extra to revised SMP because of VST backlog/delay
P91 Jul-Sept	SGC RA~23h	iz	72	<1.4	gray/ bright	clear +some phot.	Extra to revised SMP because of VST backlog/delay

Table 3. Observing Plan for Period 91.