PUBLIC SURVEY STATUS REPORT
(95th 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: VST ATLAS
PRINCIPAL INVESTIGATOR: 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 cover ~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 use QSO clustering to investigate primordial non-Gaussianity, the power-spectrum turnover and BAO measurements of the Dark Energy equation of state at z~1.5. 17 nights of pilot survey observations based on ATLAS data have already been carried out on the AAT 2-degree Field (2dF) facility and future AGN surveys from e-BOSS and e-Rosita will greatly benefit from these data. This quasar redshift survey has further demonstrated the power of combining ATLAS with WISE satellite data in the L(3.4micron) and M(4.6 micron) bands to increase the quasar selection density. ATLAS data can also be further combined with the VISTA Hemisphere Survey to produce *ugrizYJHKLM* 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. ATLAS Data Release 1 (DR1) covering the period from 1/8/2011 - 30/9/2012 is available from the ESO archive and DR2 (1/8/2011 -30/9/2013) is currently being prepared for release by the end of the year.

All OBs have been submitted in P87 through P94 for *ugriz* coverage of the ~4000 deg^2 of ATLAS that were originally approved by the PSP. However, it was always envisaged that ATLAS would cover ~4700deg^2 by including the area at b>29deg and Dec<-20 in the NGC and the science case in the revised Survey Management Plan assumed this increased area. At its April 2014 meeting, the PSP gave approval to observe this extra area in the *iz* bands to take ATLAS to its full 4700deg^2 area. A Chilean VST proposal (PI L Infante) has been submitted to the ESO TAC for P95 to survey this extended area in the *ugr* bands.

2. Detailed progress report with respect to initial estimate from the Survey Management Plan (including preliminary results, whether published or not).

2.1. Scientific Progress and Outlook

The VST ATLAS now has covered the equivalent of ~3200 deg^2 in *ugriz* so far between mid-August 2011 and October 2014 in Periods 87 - 93 (see status maps at http://astro.dur.ac.uk/Cosmology/vstatlas/). Although all OBs for the originally approved ATLAS area of 4000deg^2 (and the additional ~700deg^2 in the NGC) are already submitted, *there is a significant backlog of OBs rolled over from previous Periods*. Currently we are expecting that the survey will take to the end of P94 to finish the original 4000deg^2 in *iz* and the end of P95 in *gr*. The hope is that the *u* survey will speed up as the *gr* bands are completed but realistically *u* completion will take to the end of P97 (30/9/16). The iz NGC survey extension will be completed by end of P96. Meanwhile CASU are up-to-date in their reduction of the ATLAS data.

The total number of tiles to cover the original ~4000deg^2 ATLAS area is 4286 (x5 bands). The extra NGC area in *iz* corresponds to 899 tiles taking the *iz* totals to 5185. 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/bright time have the highest completeness followed by *r* then *g* then *u*.

Band	Completed	Failed	Scheduled
u	2470 (208)	166	1650
g	3212 (318)	99	975
r	3316 (259)	118	852
i	3936 (272)	69	281(+899)
z	4021 (340)	119	146 (+899)

Table 1. Total number of VST ATLAS pointings so far completed up to October 2014. Scheduled means OB submitted. Number in brackets in the Completed column shows tiles completed in last 6 months. The brackets in the Scheduled column refer to the NGC iz extension.

Table 2 shows that all tiles in *i,z* have been attempted for P87 through P92 with only a few failed concatenations to be repeated alongside the few remaining scheduled from P93 and the extension in P94. In *gr* there are still 1 or 2 concatenations to be finished off in P88-P91 with the main backlog being from P93-P94. In *u* there is still a big backlog for P88-P93. Since there is less competition in *u* from other surveys, we would prefer if *gr* could be prioritized and completed in the original 4000deg^2 in P94 and P95.

Band	P87 (A,B)			P88 (C)			P89 (D)			P90 (E)		
	√	X	?	√	X	?	√	X	?	√	X	?
u	442	0	0	1285	17	134	400	34	723	12	13	148
g	442	0	0	1419	17	17	681	17	459	42	14	17
r	442	0	0	1436	0	0	715	35	407	59	14	0
i	425	0	0	1436	0	0	970	17	170	73	0	0
z	425	0	0	1426	0	0	1021	68	68	73	0	0

Band	**P91 (F,G)**			**P92 (H)**			**P93 (I,J)**			**P94 (K)**		
	√	X	?	√	X	?	√	X	?	√	X	?
u	**136**	**0**	**45**	**144**	**17**	**465**	**51**	**85**	**310**			
g	**166**	**0**	**15**	**292**	**1**	**215**	**172(2)**	**34**	**242**			
r	**181**	**0**	**0**	**320**	**35**	**169**	**171(8)**	**34**	**249**			
i	**896**	**34**	**0**				**139(3)**	**18**	**84**	**0**	**0**	**899**
z	**896**	**34**	**0**				**173(3)**	**17**	**51**	**0**	**0**	**899**

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

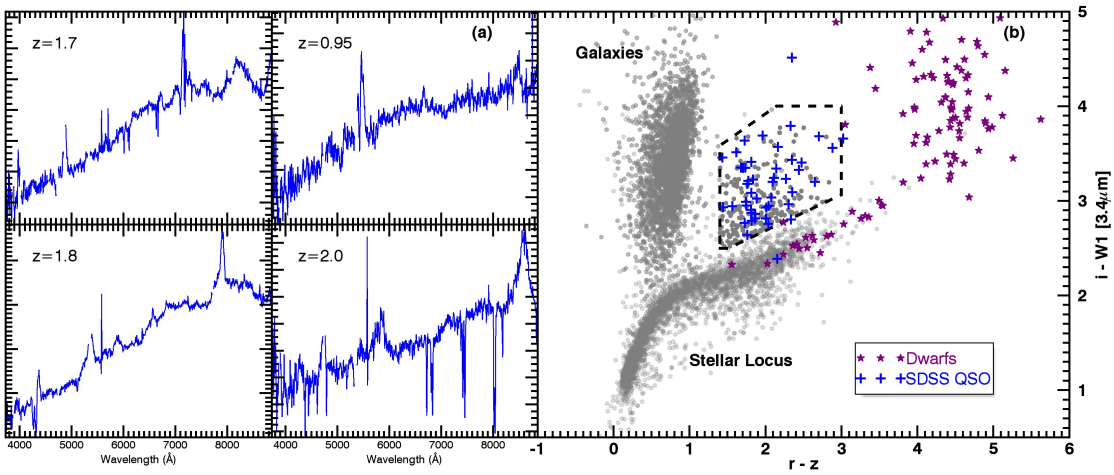

Fig. 1a. *4 examples of a new population of dust absorbed red quasars at z<2.5 selected from g-i:i-W1 by a combination of WISE and ATLAS. Spectra from AAT 2dF AAOmega (Chehade et al 2014).* **Fig. 1b.** *WISE and ATLAS r-z:i-W1 colour-colour plot shows high efficiency in isolating previously discovered SDSS 5<z<6 quasars (Findlay et al 2014).*

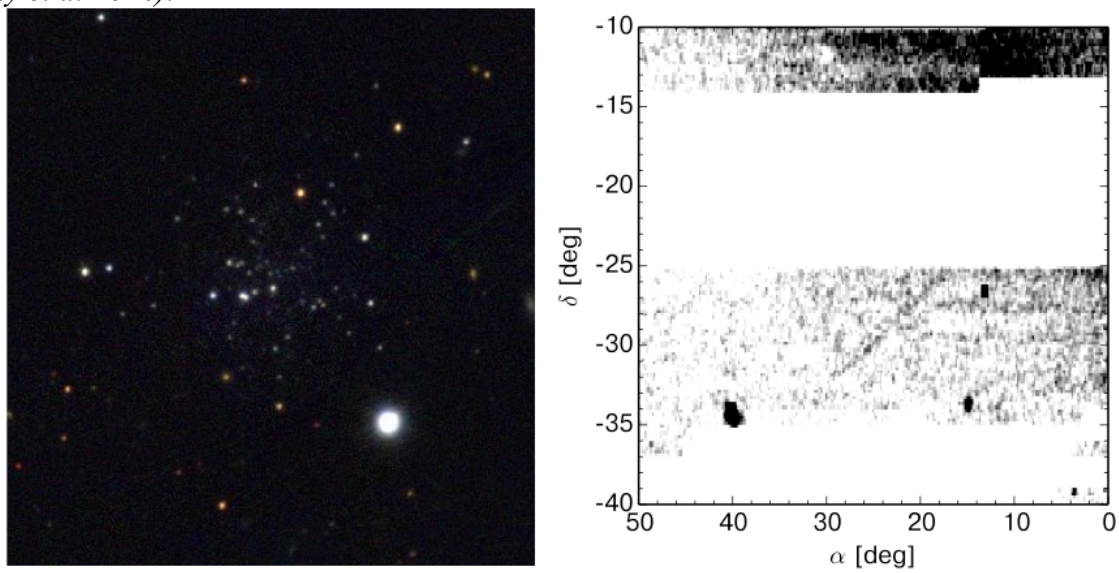

Fig. 2a *Discovery of the Crater Milky Way satellite in VST ATLAS survey data as shown here in a ~3x3arcmin true colour gri image (Belokurov et al, 2014, arXiV:1403:3406).* **Fig. 2b** *The spatial density variation of stellar sources in the g- and r-bands which track the stellar locus of the stream colour magnitude diagram (Koposov et al, 2014 arXiV:1403.3409).*

As examples of science highlights, in Fig 1a we show results from the 2QDES pilot survey where 10000 0.5<z<3.5 quasar redshifts were observed using the combination of ATLAS and WISE photometry. A population of obscured dusty quasars were found, some examples of whose very red spectra are shown here. In Fig 1b a redder combination of ATLAS and WISE bands are used to select higher redshift 5<z<6 quasars and follow-up of these candidates is now ongoing.

Another science highlight is that ATLAS is also proving ideal for searching for Milky Way satellites and stellar streams as shown by the discovery by Belokurov et al (2014) of the Crater dwarf galaxy, a new Milky Way satellite (see Fig 2a) and a new stellar stream Kposov et al (2014) (see Fig 2b).

2.2. Refereed Publications (accepted or in press)

”ATLAS lifts the Cup: Discovery of a New Milky Way satellite in Crater”, Belokurov, V.; Irwin, M. J.; Koposov, S. E.; Evans, N. W.; Gonzalez-Solares, E.; Metcalfe, N.; Shanks, T., 2014 MNRAS, 441, 2124.

“Discovery of a cold stellar stream in the ATLAS DR1 data”, Koposov, S. E.; Irwin, M. J.; Belokurov, V.; Gonzalez-Solares, E.; Kupcu Yoldas, A., Lewis, A., Metcalfe, N.; Shanks, T. 2014, MNRAS, 442, L85.

“The SAMI Galaxy Survey: instrument specification and target selection”, Bryant, J.J; Owers, M.S.; Robotham A.S.G.; Croom, S.M. et al 2014 MNRAS, accepted, arXiv1407.7335.

“The VLT Survey Telescope ATLAS”, Shanks, T., Metcalfe, N., Chehade, B., Findlay, J.R., Irwin, M.J., Gonzalez-Solares, E., Lewis, J.R., & Kupcu Yoldas, 2014, MNRAS submitted.

As indicated in the ATLAS ESO Messenger article there are many further science papers in preparation based on VST ATLAS data including the 2QDES redshift survey of 10000 quasars (Chehade et al), Survey of high-z quasars (Findlay et al), A UV bright quasar survey (Worseck et al), Luminous Red Galaxy surveys out to z~1 (Mackenzie et al), GAMA (Norberg et al), Galaxy Groups and Clusters (Murphy et al). Now that the illumination corrected and photometrically calibrated data are available most of these papers should proceed quite quickly to submission in refereed journals. However, others will require the full ATLAS area in at least some bands before they can be completed.

2.3. Other Publications (e.g. conference proceedings)

VST ATLAS First Science Results, T Shanks, V Belokurov, B Chehade, SM Croom, JR Findlay, E Gonzalez-Solares, MJ Irwin, S Koposov, RG Mann, N

Metcalfe, D Murphy, PR Norberg, MA Read, E Sutorius, G. Worseck, 2013, *ESO Messenger*, 154, 38.

We have also published online the presentations of the 3-day workshop "Exploiting the VST ATLAS… and its sister surveys" to be held at Durham University on 14-16 April, 2014. (see http://astro.dur.ac.uk/VSTWorkshop/programme.php)

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 Cambridge, Durham and Edinburgh. 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 17 nights of pilot observations for a proposed AAT 2dF quasar redshift survey called the 2dF QSO Dark Energy Survey (2QDES). VST ATLAS provided the imaging data base for these pilot observations between December 2011 and July 2013. We prepared ~200 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 ~10000 QSO redshifts. 2dF fibre observations are clearly quite demanding, even more so since we were pushing to a limit of g~22.5 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*~22.5 in the *u*-band. The best rates we have achieved from ATLAS are QSO sky densities of $95deg^{-2}$ or about 300 per 2dF field. This is even before the inclusion of the ongoing Chilean *u* band extension (PI L. Infante) which doubles the *u* band exposure to 240s.

CASU have implemented an illumination correction that reduces centre to edge photometric offsets from ~0.25mag to ~0.01mag. This is now within the range needed for projected galaxy and quasar clustering analyses.

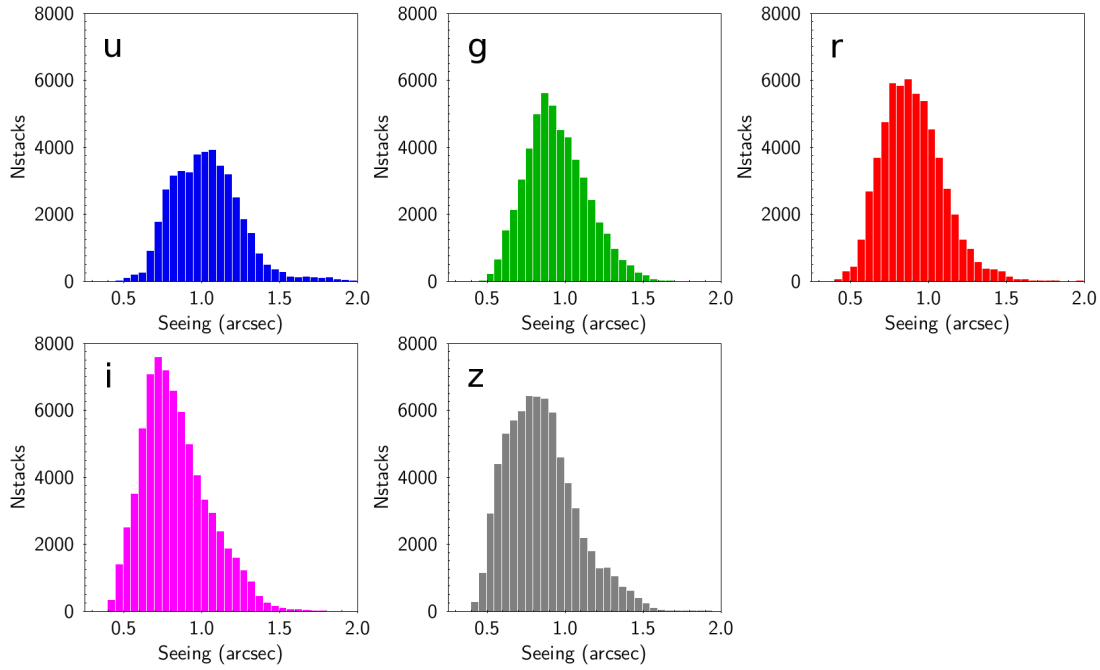

Fig. 3. Seeing (FWHM) distributions from ATLAS A, B grade stacks.

We also note that the ATLAS median seeings (see Fig. 3) in the *riz* bands are 0.90, 0.81 and 0.84 arcsec FWHM. In *u* and *g* the median seeings are 1.0 and 0.95 arcsec FWHM. These distributions are well within our <1.4arcsec specification and are significantly better than the SDSS equivalents. ATLAS median 5σ stellar AB magnitude limits are 22.0 in *u*, 23.1 in *g*, 22.67 in *r*, 22.0 in *i* and 20.87 in *z*, again well within specification. Full details of these and other survey characteristics are given in our DR1 release description that accompanies the data on the ESO SAF (or see `http://astro.dur.ac.uk/Cosmology/vstatlas`).

CASU have also implemented a global calibration in *gri* using the APASS survey stellar photometry. Meanwhile Durham are implementing an alternative global calibration based on the 2 arcmin overlaps between the ATLAS tiles.

3.2 The PI should describe here the current status of the Phase 3 submission for her/his survey project and specify how s/he wishes to structure the submission of data products during the year 2015. These plans will be reviewed and iterated with ESO to reach agreement.
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. ATLAS Data Release 1 was rolled out in October 2013 based on the first year of data taken to 1/10/12. The DR2 data release is currently being uploaded to the ESO archive and is based on all data taken between 1/8/11-1/10/13. Data releases will continue at yearly intervals till the survey ends. DR1 is only flux calibrated at the individual pointing level, whereas the aim for the final

release 6 months after the survey ends is to place the entire survey on a uniform photometric scale.

In addition to the DR1, DR2 etc catalogue release indicated above, the ATLAS team also delivers 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 are 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 are provided on a pointing by pointing basis.
- these survey products are supported and characterized by additional "meta" information providing a full description sufficient for their full scientific exploitation

Further access to the ATLAS data is available at the Cambridge Astronomical Surveys Unit database (http://casu.ast.cam.ac.uk/surveys-projects/vst) and at the Edinburgh Wide Field Astronomy Unit archive at http://surveys.roe.ac.k/osa.

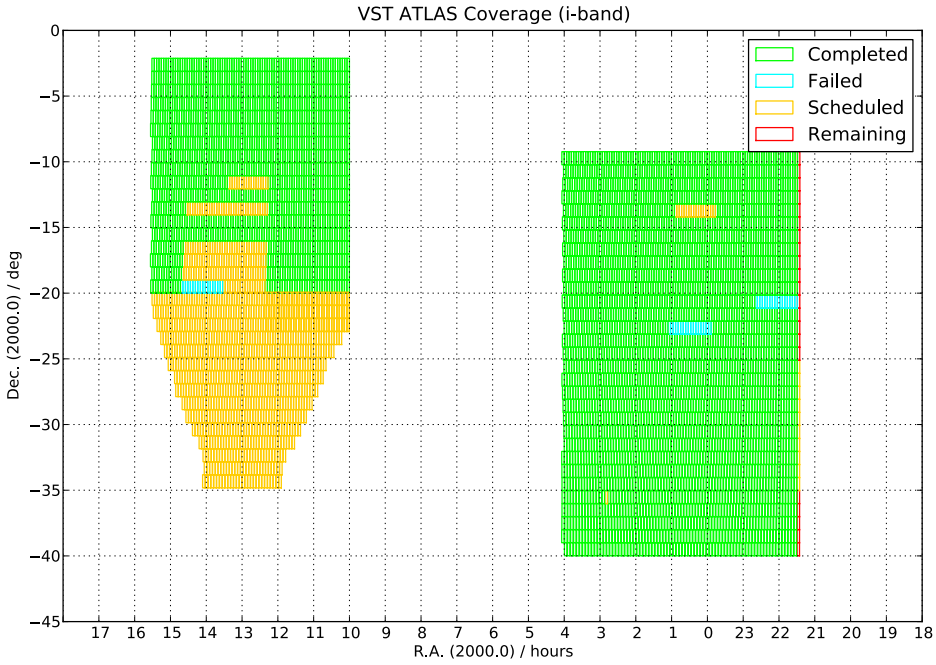

Fig. 4. ATLAS status map in i on 31/10/14. Green implies completed tiles and yellow marks tiles with OBs submitted but still to be observed. The yellow area with Dec<-20 represents the 899 tiles corresponding to the extension to ~4700 deg^2 in iz recently approved by PSP.

4. Are any changes proposed with respect to the Survey Management Plan in P95 (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. As described above, we need to roll over already submitted OBs to P94 to finish the survey in *i*, *z* and to P95-P96 in *u, g, r*.

As noted above PSP at its 28-29/4/14 meeting recommended that we be allowed to extend the survey to its originally envisaged ~4700deg^2 by allowing us to survey the NGC area above galactic latitude b>29 and Dec<-20 in *iz*. (see Fig. 4). A Chilean proposal (PI L. Infante) to complete the survey of this extended area in *ugr* has been submitted to the ESO TAC for P95 (and P96).

5. Observing Plan for Period 95 – for VISTA & VST Public Surveys *only*. Please specify which part of the Survey Management Plan (SMP) the survey will focus on in P95 in the 1st column and provide the corresponding details in the table below. In particular, highlight any changes with respect to the SMP for P95, and provide a full justification for these changes in Section 4 above.

Since all OBs for the original 4000deg^2 *ugriz* ATLAS area and the *iz* NGC extension have now been submitted in P88-P94, there is no new OB request for P95. As discussed above, the main issue now is the backlog particularly in *ugr*.

6. For Public Surveys, VHS, VIKING, VVV, ATLAS, KIDS & VPHAS+: PIs of the above surveys are requested to review the observations that were assigned a Quality Control grade "D". Please report what fraction of the D-classified OBs must be repeated to attain their scientific goals and include an assessment of the time required to repeat these OBs.

We have assessed the 69 D grade OBs observed since September 2013 and all need to be re-done to satisfy our survey's scientific goals, because the Image Quality, ellipticity or seeing was usually outside specification. We shall require a further ~4 hrs exposure on-sky to repeat these pointings. We request 8hrs in total to take into account increased overheads of observing single fields.