1 VISTA Deep Extragalactic Observations (VIDEO) Survey

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1.1 Abstract

The VISTA Deep Extragalactic Observations (VIDEO) survey is initially a 12 sq. degree, Z,Y,J,H,K_s survey (with the possibility of being extended up to and beyond 15 sq.deg.) specifically designed to enable galaxy and cluster/structure evolution to be traced as a function of both epoch and environment from the present day out to z=4, and AGN and the most massive galaxies up to and into the epoch of reionization. With its depth and area, VIDEO will be able to fully probe the *epoch of activity* in the Universe, where AGN and starburst activity were at their peak and the first galaxy clusters were beginning to virialise. VIDEO therefore offers a unique data set with which to investigate the interplay between AGN, starbursts and environment, and the role of *feedback* at a time when it is most crucial. The multi-band nature of the survey ensures many key science drivers can be tackled using the survey alone, without recourse to data from other wavebands. However, the survey fields have been carefully selected to ensure a good RA spread and mix of fields with existing multi-band data thereby enhancing the usefulness of the survey to the whole of the astronomical community, and with an eye to future use of other ESO facilities such as APEX and ALMA. The area and depth means that VIDEO fits naturally between the proposed VIKING and Ultra-VISTA surveys, maximising the legacy to the ESO community and worldwide.

2 Survey Observing Strategy

2.1 Scheduling requirements

VIDEO aims to initially survey 12 square degrees spread over three patches of sky, these are Elais-S1 ($\alpha = 00h\ 34m$, $\delta = -43d00m$), XMM-LSS ($\alpha = 02h\ 18m$, $\delta = -05d00m$), CDF-S ($\alpha = 03h32m$, $\delta = -27d00m$). The original VIDEO survey proposed in September 2006 was actually for 15 square degrees, however after the Public Survey Panel (PSP) review it was recommended that the 14 hour (VIDEO-1; $\alpha = 14h00m$, $\delta = +0500$) field should be dropped from the survey.

Obviously, all of these fields are concentrated at $00h < \alpha < 04h$, thus the scheduling for these observations is most subscribed around October to December, i.e. just after the crossover time between ESO semesters (see Fig. 1). We assume that the observations will start in earnest in Period 80 and continue for 5 years (10 semesters) as recommended by the PSP.

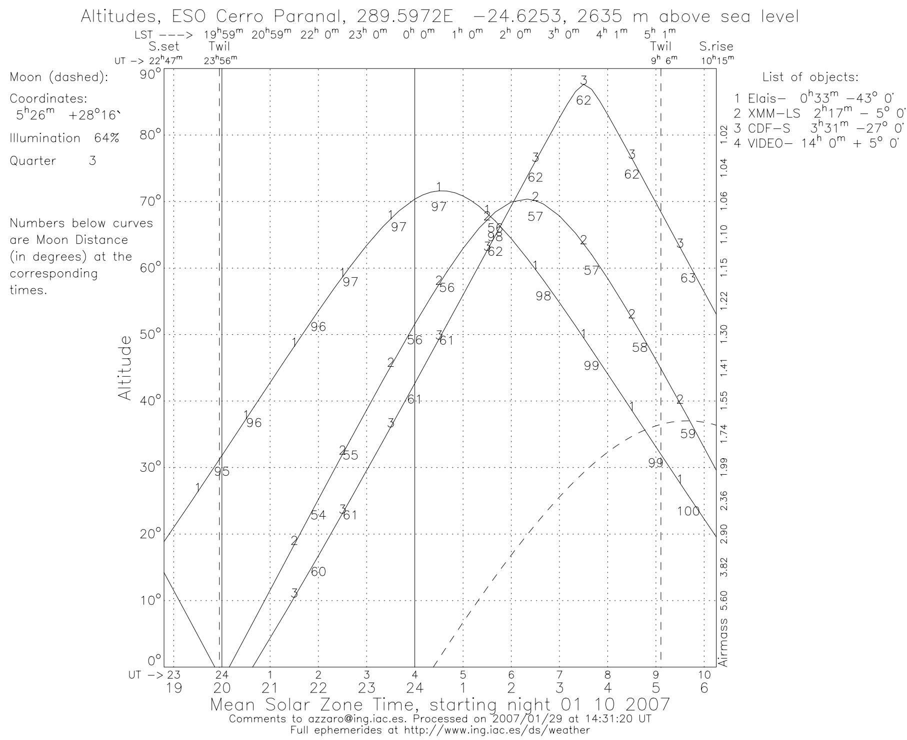

Figure 1: Visibility of each VIDEO field from Paranal on October 1st (i.e. the crossover point for Periods).

Elais-S1 ($\alpha = 00h\ 34m$, $\delta = -43d00m$)

The Elais-S1 VIDEO field is 4.5 square degrees (i.e. 3 VISTA pointings; Fig. 2). To complete the coverage of the Elais-S1 field at the required depths (see section 2.2) requires 56 nights. The highest priority will be given to $J-$ and K_s-bands initially as this strategy has the ability to produce high-impact early science when combined with the Spitzer-SWIRE data. The $Z-$, $Y-$ and $H-$bands will be completed ~ 1 year later, although we emphasise that useful $Z-$band data will be available on the same timescale as the $J-$ and K_s-band data. The Elais-S1 field can be seen between August and December at airmass < 1.2 for at least 2 hours from Paranal. Thus it can easily be observed in both ESO semesters for roughly the same amount of time. However, given that our other high-priority fields, namely XMM-LSS and CDF-S are predominantly concentrated in the even-numbered Period then we observe the Elais-S1 field principally in the odd-numbered periods.

The breakdown of observations for the 10 periods is shown in Table 1 for Elais-S1. One can see that the first tile is envisaged to be completed in $J-$ and K_s-bands by the end of Period 81, with 28 hours of $Z-$band data also available. The full tile should be complete in all five bands by the end of Period 83, the second tile should be complete in all five bands by Period 87 and the 4.5 square degrees of Elais-S1 should be completed in Period 89. The number of hours to be used in Period 89 is lower than in other odd-numbered Periods to allow for unforeseen delays in the survey the field.

XMM-LSS ($\alpha = 02h18m$, $\delta = -05d00m$)

XMM-LSS is the second VIDEO field which will cover 4.5 square degrees. We weight the first tile in the XMM-LSS field highly due to the wealth of complementary data in and around this field (see e.g. Fig. 3). Thus the central XMM-LSS field is scheduled to be completed in $Z-$, $J-$ and $K-$ by the end of Period 81 (see Table 2), followed closely by the completion of $Y-$ and $H-$bands early in Period 82. The next two tiles to the north and

	Elais-S1					
Period	Time (h)	Mean RA	Moon	Seeing	Transparency	Band (time)
P80(Oct'07-Mar'08)	9	00hr 34m	Dark	< 0.8	THN,CLR	Z(9)
P80(Oct'07-Mar'08)	8	00hr 34m	Grey	< 0.8	THN,CLR	Y(0) J(8)
P80(Oct'07-Mar'08)	10	00hr 34m	Bright	< 0.8	THN,CLR	H(0) K_s(10)
P81(Apr'08-Sep'08)	28	00hr 34m	Dark	< 0.8	THN,CLR	Z(28)
P81(Apr'08-Sep'08)	28	00hr 34m	Grey	< 0.8	THN,CLR	Y(2) **J(26)**
P81(Apr'08-Sep'08)	32	00hr 34m	Bright	< 0.8	THN,CLR	H(4) **K_s(28)**
P82(Oct'08-Mar'09)	10	00hr 34m	Dark	< 0.8	THN,CLR	Z(10)
P82(Oct'08-Mar'09)	9	00hr 34m	Grey	< 0.8	THN,CLR	Y(9) J(0)
P82(Oct'08-Mar'09)	10	00hr 34m	Bright	< 0.8	THN,CLR	H(10) K_s(0)
P83(Apr'09-Sep'09)	28	00hr 34m	Dark	< 0.8	THN,CLR	**Z(28)**
P83(Apr'09-Sep'09)	28	00hr 34m	Grey	< 0.8	THN,CLR	**Y(17)** J(11)
P83(Apr'09-Sep'09)	32	00hr 34m	Bright	< 0.8	THN,CLR	**H(28)** K_s(4)
P84(Oct'09-Mar'10)	10	00hr 34m	Dark	< 0.8	THN,CLR	Z(10)
P84(Oct'09-Mar'10)	8	00hr 34m	Grey	< 0.8	THN,CLR	Y(0) J(8)
P84(Oct'09-Mar'10)	10	00hr 34m	Bright	< 0.8	THN,CLR	H(0) K_s(10)
P85(Apr'10-Sep'10)	25	00hr 34m	Dark	< 0.8	THN,CLR	Z(25)
P85(Apr'10-Sep'10)	28	00hr 34m	Grey	< 0.8	THN,CLR	Y(14) **J(14)**
P85(Apr'10-Sep'10)	32	00hr 34m	Bright	< 0.8	THN,CLR	H(7) **K_s(25)**
P86(Oct'10-Mar'11)	9	00hr 34m	Dark	< 0.8	THN,CLR	**Z(9)**
P86(Oct'10-Mar'11)	9	00hr 34m	Grey	< 0.8	THN,CLR	Y(9) J(0)
P86(Oct'10-Mar'11)	10	00hr 34m	Bright	< 0.8	THN,CLR	H(10) K_s(0)
P87(Apr'11-Sep'11)	26	00hr 34m	Dark	< 0.8	THN,CLR	Z(26)
P87(Apr'11-Sep'11)	28	00hr 34m	Grey	< 0.8	THN,CLR	**Y(2)** J(26)
P87(Apr'11-Sep'11)	32	00hr 34m	Bright	< 0.8	THN,CLR	**H(20)** K_s(12)
P88(Oct'11-Mar'12)	9	00hr 34m	Dark	< 0.8	THN,CLR	Z(9)
P88(Oct'11-Mar'12)	9	00hr 34m	Grey	< 0.8	THN,CLR	Y(2) **J(7)**
P88(Oct'11-Mar'12)	10	00hr 34m	Bright	< 0.8	THN,CLR	H(0) K_s(10)
P89(Apr'12-Sep'12)	22	00hr 34m	Dark	< 0.8	THN,CLR	**Z(22)**
P89(Apr'12-Sep'12)	24	00hr 34m	Grey	< 0.8	THN,CLR	**Y(24)** J(0)
P89(Apr'12-Sep'12)	31	00hr 34m	Bright	< 0.8	THN,CLR	**H(21) K_s(10)**

Table 1: The envisaged observing strategy for the Elais-S1 field. The band and time (hours) shown in the final column are the planned exposures (including overheads) in the specified Period, the bold font denotes when a tile is completed in that particular band.. The seeing is the value at the focal plane.

south would then be completed in Periods 84/86 (JK_s/ZYH) and 88/89 (JK_s/ZYH) respectively.

CDF-S ($\alpha = 03h32m$, $\delta = -27d00m$)

The Chandra Deep Field South is our third high-priority field, with the current plan to survey 3 square degree (i.e. two VISTA tiles). These will be positioned toward the centre of the Spitzer-SWIRE area (see Fig. 4). The first priority will be the northern tile which contains the GOODS and UDF fields and also COMBO-17. This will ensure a quick return on high-profile science. As shown in Table 3, we only plan to observe CDF-S every other semester, thus leaving time in the odd-numbered semesters to concentrate on Elais-S1 and XMM-LSS, and also providing the opportunity to begin observations of the VIDEO-1 field during the 5-year survey timescale if deemed appropriate. With this strategy the first tile will be completed in Period 82 and the second tile would be completed in Period 88. For this survey area we adopt a slightly different strategy to the others, which will broaden the scientific opportunities with VIDEO, as we aim to complete the tile in all five filters within the same Period.

2.2 Observing requirements

Our strategy for observing the VIDEO fields is as follows. We will ensure, where possible, each full 1.5 sq.deg tile will be completed to the required VIDEO-specific depth in all five near-infrared colours once observations on a given tile have been started.

Tiles will be started from the centre of each field and working outwards to fill the whole survey field. This will ensure that there is always a VIDEO field available throughout the year over the five years of the survey.

Our strategy is such that we prioritise the XMM-LSS central field to ensure high-impact early science as it can be combined with UKIDSS-UDS, Spitzer and Subaru optical imaging. The survey strategy is detailed in Table 7.

	P80	P81	P82	P83	P84	P85	P86	P87	P88	P89
ELAIS-S1										
Z	9	28	10	28	10	25	9	26	9	22
Y		2	9	17		14	9	2	2	24
J	8	26		11	8	14		26	7	
H		4	10	28		7	10	20		21
Ks	10	28		4	10	25		12	10	10
XMM-LSS										
Z	28	28	20	10	22	10	21	10	21	10
Y		2	25			13	14	5	6	14
J	21	12		12	22		8	8	16	
H		3	30		1	16	20	8	4	18
Ks	21	15		16	23		5	8	21	
CDF-S										
Z	24		24		24		24		21	
Y	1		25		12		6		9	
J	24		24		14		17		12	
H			29		15		15		14	
Ks	28		1		15		15		14	

Table 6. Summary of the completion dates for the various VIDEO fields. Green represents the first tile, red the second and bluethe third. The numbers represent the number of hours spent on that field in the given filter in the given Period.

2.2.1 Exposure times

We base our exposure times on the typical elliptical galaxy colours at $z > 2$, where we are sensitive to the bulk of the luminosity density arising from galaxies. Therefore, for our limit of $K_S = 21.7$, this corresponds to $H = 22.7$, $J = 23.7$, and $Z = 25.2$. We also include observations in Y to enable us to perform high-redshift

	XMM-LSS					
Period	Time (h)	Mean RA	Moon	Seeing	Transparency	Band (time)
P80(Oct'07-Mar'08)	28	02hr	Dark	< 0.8	THN,CLR	Z(28)
P80(Oct'07-Mar'08)	21	02hr	Grey	< 0.8	THN,CLR	Y(0) J(21)
P80(Oct'07-Mar'08)	21	02hr	Bright	< 0.8	THN,CLR	H(0) K_s(21)
P81(Apr'08-Sep'08)	28	02hr	Dark	< 0.8	THN,CLR	**Z(28)**
P81(Apr'08-Sep'08)	14	02hr	Grey	< 0.8	THN,CLR	Y(2) **J(12)**
P81(Apr'08-Sep'08)	18	02hr	Bright	< 0.8	THN,CLR	H(3) **K_s(15)**
P82(Oct'08-Mar'09)	20	02hr	Dark	< 0.8	THN,CLR	Z(20)
P82(Oct'08-Mar'09)	25	02hr	Grey	< 0.8	THN,CLR	**Y(25)** J(0)
P82(Oct'08-Mar'09)	30	02hr	Bright	< 0.8	THN,CLR	**H(30)** and K_s(0)
P83(Apr'09-Sep'09)	10	02hr	Dark	< 0.8	THN,CLR	Z(10)
P83(Apr'09-Sep'09)	13	02hr	Grey	< 0.8	THN,CLR	Y(0) J(13)
P83(Apr'09-Sep'09)	16	02hr	Bright	< 0.8	THN,CLR	H(0) K_s(16)
P84(Oct'09-Mar'10)	22	02hr	Dark	< 0.8	THN,CLR	Z(22)
P84(Oct'09-Mar'10)	22	02hr	Grey	< 0.8	THN,CLR	Y(0) **J(22)**
P84(Oct'09-Mar'10)	24	02hr	Bright	< 0.8	THN,CLR	H(1) **K_s(23)**
P85(Apr'10-Sep'11)	10	02hr	Dark	< 0.8	THN,CLR	**Z(10)**
P85(Apr'10-Sep'11)	13	02hr	Grey	< 0.8	THN,CLR	Y(13) J(0)
P85(Apr'10-Sep'11)	16	02hr	Bright	< 0.8	THN,CLR	H(16) K_s(0)
P86(Oct'11-Mar'12)	21	02hr	Dark	< 0.8	THN,CLR	Z(21)
P86(Oct'11-Mar'12)	22	02hr	Grey	< 0.8	THN,CLR	**Y(14)** J(8)
P86(Oct'11-Mar'12)	25	02hr	Bright	< 0.8	THN,CLR	**H(20)** and K_s(5)
P87(Apr'10-Sep'11)	10	02hr	Dark	< 0.8	THN,CLR	Z(10)
P87(Apr'10-Sep'11)	13	02hr	Grey	< 0.8	THN,CLR	Y(5) J(8)
P87(Apr'10-Sep'11)	16	02hr	Bright	< 0.8	THN,CLR	H(8) K_s(8)
P88(Oct'11-Mar'12)	21	02hr	Dark	< 0.8	THN,CLR	Z(21)
P88(Oct'11-Mar'12)	22	02hr	Grey	< 0.8	THN,CLR	Y(6) **J(16)**
P88(Oct'11-Mar'12)	25	02hr	Bright	< 0.8	THN,CLR	H(4) **K_s(21)**
P89(Apr'12-Sep'12)	10	02hr	Dark	< 0.8	THN,CLR	**Z(10)**
P89(Apr'12-Sep'12)	14	02hr	Grey	< 0.8	THN,CLR	**Y(14)** J(0)
P89(Apr'12-Sep'12)	18	02hr	Bright	< 0.8	THN,CLR	**H(18)** K_s(0)

Table 2: The envisaged observing strategy for the XMM-LSS field. The band and time (hours) shown in the final column are the planned exposures (including overheads) in the specified Period, the bold font denotes when a tile is completed in that particular band. The seeing is the value at the focal plane.

	CDF-S					
Period	Time (h)	Mean RA	Moon	Seeing	Transparency	Band (time)
P80(Oct'07-Mar'08)	24	03hr 30m	Dark	< 0.8	THN,CLR	Z(24)
P80(Oct'07-Mar'08)	25	03hr 30m	Grey	< 0.8	THN,CLR	Y(1) J(24)
P80(Oct'07-Mar'08)	28	03hr 30m	Bright	< 0.8	THN,CLR	H(0) K_s(28)
P82(Oct'08-Mar'09)	24	03hr 30m	Dark	< 0.8	THN,CLR	Z(24)
P82(Oct'08-Mar'09)	25	03hr 30m	Grey	< 0.8	THN,CLR	Y(25) J(24)
P82(Oct'08-Mar'09)	30	03hr 30m	Bright	< 0.8	THN,CLR	H(29) K_s(1)
P84(Oct'09-Mar'10)	24	03hr 30m	Dark	< 0.8	THN,CLR	**Z(24)**
P84(Oct'09-Mar'10)	26	03hr 30m	Grey	< 0.8	THN,CLR	**Y(12) J(14)**
P84(Oct'09-Mar'10)	30	03hr 30m	Bright	< 0.8	THN,CLR	**H(15) K_s(15)**
P86(Oct'10-Mar'11)	24	03hr 30m	Dark	< 0.8	THN,CLR	Z(24)
P86(Oct'10-Mar'11)	23	03hr 30m	Grey	< 0.8	THN,CLR	Y(6) J(17)
P86(Oct'10-Mar'11)	30	03hr 30m	Bright	< 0.8	THN,CLR	H(15) K_s(15)
P88(Oct'11-Mar'12)	21	03hr 30m	Dark	< 0.8	THN,CLR	**Z(21)**
P88(Oct'11-Mar'12)	21	03hr 30m	Grey	< 0.8	THN,CLR	**Y(9) J(12)**
P88(Oct'11-Mar'12)	28	03hr 30m	Bright	< 0.8	THN,CLR	**H(14) K_s(14)**

Table 3: The envisaged observing strategy for the CDF-S field.The band and time (hours) shown in the final column are the planned exposures (including overheads) in the specified Period, the bold font denotes when a tile is completed in that particular band. The seeing is the value at the focal plane.

QSO – dwarf star separation. To distinguish these we require $Z - Y > 1.5$ and $Y - J < 0.8$, therefore we wish to probe to a depth of $Y = 24$.

Our aim is to be able to detect a galaxy at the break of the elliptical galaxy luminosity function over 90% of the Universe, which corresponds to $0 < z < 4$. This ensures that we are sensitive to one of the most important epochs in the Universe, where star-formation and accretion activity were at a maximum.

We use the $K-$band luminosity function from 2MASS (Kochanek et al. 2001) where $M^{\star} = -24.3$. Assuming a passively evolving stellar population with a high formation redshift, in agreement with extremely red objects in the GOODS data set (e.g. Caputi et al. 2005), then we expect a $z \sim 4$ elliptical galaxy to have a total magnitude of $K = 21.2$. Under the assumption that 40% of a $z > 2$ elliptical galaxy's light is lost if a 2 arcsec aperture is used (see e.g. Jarvis et al. 2001) then the measured magnitude within this aperture would be $K \sim 21.7$, which defines our 5σ K_s-band limit. The exposure times are summarised in Table 7.

K$_s$-band

For the K_s-band observations we relax our seeing constraint in accord with the recommendation from the PSP and consequently we no longer require any micro-stepping. We use the VISTA exposure time calculator to calculate all of our time requests. For the K_s band we use DIT=10 s with NDIT=6 with a 5-point jitter pattern. To complete a tile with this strategy requires 1800 s (2207s including overheads), which gives a 5σ point source sensitivity of $K_s = 19.5$ mag. Therefore to reach the full depth with this strategy requires 59 OBs. To reach the full sensitivity over one tile requires 59 OBs each of 2207 s, which equates to 36.2 hours per tile, and to cover the full 15 sq.degrees requires 361.7 hours

H-band

For the H-band observations we again use a 5-point jitter pattern with DIT=10 s and NDIT=6. Therefore to complete a single 1.6 sq.deg tile requires 2207 s (including overheads). To reach the full tile depth of $H = 22.7$ (5σ, 2 arcsec aperture) requires 54 OBs of this length (33.1 hours including overheads). For the full 15 sq.degrees this equates to 331.1 hours in total.

J-band

	Summary					
Period	Time (h)	Mean RA	Moon	Seeing	Transparency	Band
P80(Oct'07-Mar'08)	61	00hr-14hr	Dark	< 0.8	THN,CLR	Z
P80(Oct'07-Mar'08)	54	00hr-12hr	Grey	< 0.8	THN,CLR	YJ
P80(Oct'07-Mar'08)	59	00hr-12hr	Bright	< 0.8	THN,CLR	HK
P81(Apr'08-Sep'08)	56	12hr-24hr	Dark	< 0.8	THN,CLR	Z
P81(Apr'08-Sep'08)	42	12hr-24hr	Grey	< 0.8	THN,CLR	YJ
P81(Apr'08-Sep'08)	50	12hr-24hr	Bright	< 0.8	THN,CLR	HK
P82(Oct'08-Mar'09)	54	00hr-12hr	Dark	< 0.8	THN,CLR	Z
P82(Oct'08-Mar'09)	59	00hr-12hr	Grey	< 0.8	THN,CLR	YJ
P82(Oct'08-Mar'09)	70	00hr-12hr	Bright	< 0.8	THN,CLR	HK
P83(Apr'09-Sep'09)	38	12hr-24hr	Dark	< 0.8	THN,CLR	Z
P83(Apr'09-Sep'09)	41	12hr-24hr	Grey	< 0.8	THN,CLR	YJ
P83(Apr'09-Sep'09)	48	12hr-24hr	Bright	< 0.8	THN,CLR	HK
P84(Oct'09-Mar'10)	56	00hr-12hr	Dark	< 0.8	THN,CLR	Z
P84(Oct'09-Mar'10)	56	00hr-12hr	Grey	< 0.8	THN,CLR	YJ
P84(Oct'09-Mar'10)	64	00hr-12hr	Bright	< 0.8	THN,CLR	HK
P85(Apr'10-Sep'10)	35	12hr-24hr	Dark	< 0.8	THN,CLR	Z
P85(Apr'10-Sep'10)	41	12hr-24hr	Grey	< 0.8	THN,CLR	YJ
P85(Apr'10-Sep'10)	48	12hr-24hr	Bright	< 0.8	THN,CLR	HK
P86(Oct'10-Mar'11)	54	00hr-12hr	Dark	< 0.8	THN,CLR	Z
P86(Oct'10-Mar'11)	55	00hr-12hr	Grey	< 0.8	THN,CLR	YJ
P86(Oct'10-Mar'11)	65	00hr-12hr	Bright	< 0.8	THN,CLR	HK
P87(Apr'11-Sep'11)	36	12hr-24hr	Dark	< 0.8	THN,CLR	Z
P87(Apr'11-Sep'11)	41	12hr-24hr	Grey	< 0.8	THN,CLR	YJ
P87(Apr'11-Sep'11)	48	12hr-24hr	Bright	< 0.8	THN,CLR	HK
P88(Oct'11-Mar'12)	51	00hr-12hr	Dark	< 0.8	THN,CLR	Z
P88(Oct'11-Mar'12)	53	00hr-12hr	Grey	< 0.8	THN,CLR	YJ
P88(Oct'11-Mar'12)	65	00hr-12hr	Bright	< 0.8	THN,CLR	HK
P89(Apr'12-Sep'12)	32	12hr-24hr	Dark	< 0.8	THN,CLR	Z
P89(Apr'12-Sep'12)	38	12hr-24hr	Grey	< 0.8	THN,CLR	YJ
P89(Apr'12-Sep'12)	49	12hr-24hr	Bright	< 0.8	THN,CLR	HK

Table 4: Summary of the amount of time required for VIDEO per Period in the various lunar phases. In the second column we list times per lunar phase required per Period.

For the $J-$ we use 30 s DITs and NDIT=2, this equates to 2090 sec (including overheads) to complete one full 1.6 sq.deg tile down to a 5σ point source sensitivity of $J = 21.5$. Therefore to reach the full depth of $J = 23.7$ requires 57 OBs or 33.1 hours per 1.6 sq.degree tile. For the full 15 sq.degree survey area this equates to 330.9 hours.

Y-band
In Y we only aim to reach $Y = 24$ (Vega) to ensure that high-redshift quasar candidates can be distinguished from dwarf stars, whilst also providing extra photometric accuracy for Z-drop-out galaxies. This is relatively inexpensive and provides a large scientific benefit for $z < 2$ galaxies as well as the high-redshift quasar search. Using DIT=30 s and NDIT=2, with a 5-point jitter pattern means that to completely cover one tile requires 2090 s (including overheads) which reaches $Y = 21.9$ for a complete tile. Therefore to reach the full survey depth on a 1.6 sq.degree tile requires 45 seperate OBs or 26.1 hours (including overheads). Thus to cover the full 15 sq.degree requires 261.1 hours.

Z-band
The $Z-$band observations need to be deeper than in the other bands as this is the filter we will use to probe shortward of the 4000Å at $z > 1$. In $Z-$band we use DIT=45 s and NDIT=1 with a 5-point jitter pattern. Covering a full tile twice (Exposure Loops=2) with this strategy requires 3128 s (including overheads) per tile, reaching a 5σ depth of $Z = 22.9$. To reach the full survey sensitivity of $Z = 25.2$ requires 67 OBs, taking 58.2 hours per tile. Therefore, the full 15 sq.degrees requires 582.2 hours.

Therefore, the full survey requires a total of $\sim$208 nights (assuming 9 hours science time per night, with one hour per night resereved for standard calibrations required by all of the surveys). We then assume that we average 3 minute per night in pointing overheads for VIDEO as we would only slew to two fields per night maximum. This would add around 10hours, or 1 night to the survey.

2.2.2 Tiling strategy

The tiling strategy for VIDEO is relatively straightforward. We will survey each area one tile at a time, i.e. we will obtain the full depth on a single tile in a given region before moving on to the neighbouring tile. Initially we concentrate on completing the Z, J and K_s observations, again to maximise the early science. For the Elais-S1 and XMM-LSS fields, both of which require 3 tiles, we ensure that the fields surveyed with VISTA fully overlap with the other data over these fields, particularly the Spitzer data. Our observing strategy is such that we focus more on the lunar phase to dictate the observing band over the possiblity of interleaving observations in the various filters. N tiles in the Y direction cover $1.017N + 0.092(N-1)$ deg, where 1.017deg is doubly covered by pawprints and 0.092deg singly covered by pawprints (in the strips at each end $+/-Y$). The doubly covered length in the X direction is 1.475 deg. Therefore we will also survey slightly more than the nominal 12 sq.deg due to the fact that two adjacent tiles actually cover 3.14 sq.deg and three adjacent tiles cover 4.77 sq.deg. Thus the actual total area of the survey will be 12.7 sq.deg.

3 Survey data calibration needs

3.1 Detector Characteristics

Standard calibration frames taken at the start and end of the night, such as bias frames, darks and twilight flat field frames will be used to correct for detector characteristics. Using our experience with UKIRT-WFCAM observations reduction of the raw images will require the usual dark, non-linearity and flat-field corrections, but also may require additional steps. These may include reducing the level of cross talk between different areas on the detector, removal of fringing patterns and any other possible background variations which could result in imperfect reduction after the usual initial steps. As with WFCAM we expect the flat-field frames to improve over time which may lead to reprocessing of earlier raw data if it is deemed necessary by the VIDEO team.

3.2 Astrometry

Astrometry will be performed using 2MASS point sources which, as shown with the UKIDSS surveys, provides an astrometric accuracy of $\sim$ 100mas over the whole survey area. The VISTA data flow system uses a ZPN distortion model combined with a linear plate solution for each individual detector. The radial distortion term is given by $r_{\rm lin} = r + k_3 r^3 + k_5 r^5$, where $r_{\rm lin}$ is a linearised radius proportional to the tangent of the angle from the pointing axis, r is the image radius, k_3 and k_5 are the distortion coefficients.

For every data frame a catalogue of bright stars is generated and matched to the 2MASS point source catalogue. The radial distortion correction is then applied to give the linearised coordinates. Following this, a standard plate solution is performed which allows for pointing error, rotation, changes of scale across this detectors and any shear.

This is the procedure for astrometerising WFCAM data which has been shown to give residuals over the whole field to better than 0.1 arcsec. It is anticipated that VISTA data could be astrometerised to a higher degree of accuracy due to the large area of the camera providing $\sim$ 3 times as many 2MASS stars for calibration and the positioning of the corrective lenses on VISTA compared to WFCAM.

This is perfectly adequate for the VIDEO science case and ensures that excellent matching can be performed with other multi-wavelength catalogues.

3.3 Photometry

The baseline calibration strategy for the VISTA surveys is to move to standard star fields $\sim$ 5 times per night in combination with using the 2MASS point source catalogue. Such a strategy has shown to provide excellent calibration for the UKIDSS. This method is currently delivering a photometric accuracy of $\sim$ 2 per cent with the UKIDSS WFCAM data. The 2MASS-based calibration also provides a measurement of the throughput of the system, which includes the extinction over the field on any night. Thus, independent calibration can be carried out for most nights.

Each VISTA pawprint will contain in excess of 100 useful 2MASS stars with which to photometrically calibrate the VIDEO images. Colour equations transforming the 2MASS system to the VISTA system will be derived by fitting tranformation coefficients to a large number of frames.

This is perfectly adequate for the VIDEO survey. Moreover, we will also be able to perform a consistency check between the VIDEO data in XMM-LSS and that already observed in J,H and K from the UKIDSS-UDS data. Photometric measurements will be made through a number of apertures (set by the science team) following the successful method used for the UKIDSS extragalactic surveys. These will be measured in apertures with diameters stepped with a factor of $\sqrt{2}$, from 2 arcsec to 6 arcsec diameter apertures. Moreover Petrosian and PSF fitted magnitudes (and all associated errors) will also be measured.

As 2MASS does not have data in the Z- and Y-band filters a different approach is needed from using 2MASS. We therefore follow the current prescription implemented successfully to photometrically calibrate UKIDSS data (e.g. Warren et al. 2007) which has been shown to reach an overall accuracy of $\sim 2-3\%$ in regions of low extinction. This uses a restricted, extinction-corrected, colour range of $0 < J-K < 1$ from 2MASS which helps exclude unusual objects and heavily reddened stars. The initial UKIDSS data suffered from a correlation between the derived $Z=$ and $Y-$band zero points and the Galactic extinction, therefore an extinction-dependent calibration term is included in the colour equations which are:

$$Z = J + 0.95(J-H) + 0.39E(B-V)'$$

$$Y = J + 0.50(J-H) + 0.16E(B-V)',$$

where $E(B-V)'$ is the reddening computed using the prescription of Bonifacio et al. (2000), from the data of Schlegel et al. (1998). We note that for the VIDEO fields the extinction, by design, is very low, thus the corrections willbe very small for our fields.

It is envisaged that for nights where repeated observations of the same VIDEO field are carried out in the same filter, that less standard star fields will be needed.

4 Data reduction process

4.1 Pipeline processing

The Cambridge Astronomy Survey Unit (CASU) are responsible for the VDFS pipeline processing component. The VIDEO team will work closely with the VDFS team to ensure that the reduction process for VIDEO is optimised for the specific science goals of VIDEO. The VDFS has been designed for VISTA and scientifically verified by processing wide field mosaic imaging data from UKIRT's NIR mosaic camera WFCAM. Many members of the VIDEO team also have close links with the WFCAM data through the UKIDSS and have important experience of the pipeline already. Indeed the pipeline is now routinely being used to process data from the WFCAM at a rate of up to 250GB/night.

The pipeline will remove all of the instrumental effects, such as bias, non-linearity. As the various VISTA surveys progress, better and better flat fields and fringe frames will be made and it is envisaged that master flat and fringe frames will be upgraded with time. The pipeline will use these master frames to flat-field and remove fringing effects. Moreover, with time and experience of VISTA data it will be possible to develop algorithms to track and remove cross-talk and any other unforeseen low-level effects which will only become evident from the stacking of deep data.

The pipeline processing produces combined individual tiles and their associated catalogues from the CASU source finding algorithm. These products are then tranferred to the wide-field astronomy unit (WFAU) at Edinburgh via the internet.

4.2 Science archive

The second stage of the data reduction and catalogue production process is the use of the VISTA science archive (VSA) at the WFAU. The VSA will ingest the outputs from the pipeline processing, namely reduced tiles and their associated catalogues, carried out at Cambridge and curate these to produce database driven products available through the VSA web-interface.

The VSA not only acts as an archive facility but also takes the individual tiles from the pipeline processing and stacks them, generating catalogues of the stacked data. To generate deep-stacked image frames and catalogues, the VSA uses the standard CASU toolkit to stack quality-controlled subset of all available data and then runs it through the standard CASU-source extractor.

4.3 Data processing by the VIDEO team

The VIDEO team will also make their own stacked image frames and associated catalogues as a comparison data set to the VDFS generated stacks and catalogues. To ensure the most thorough investigation we will use alternative code to that used by VDFS, such as SWARP for the stacking and SExtractor for the catalogue creation. This will allow the science team to fully explore the best methods with which to generate the final deep stacks and final catalogue data. Information from this dual-method approach can then be fed back to the VDFS (if needed) to upgrade the VDFS pipeline presciption in accordance with the requirements of the VIDEO team. We will also carry out source-by-source checks on a subset of the data, again to ensure the accuracy of the photometry, particularly in the early stages of VISTA surveys. As already demonstrated by the UKIDSS-UDS process, WFAU can easily ingest deep-stacked data and generate catalogues according to the survey team requirements. Therefore, we foresee no problems in generating deep-stacked images and multi-band catalogues for VIDEO.

In the event that support from VDFS ceases to exist the PI accepts responsibilty for delivering the VIDEO survey data and catalogues. However, if this does in deed occur the PI will also ask for a longer period of time for generating the reduced data and final catalogues which would be negotitated with ESO at the time.

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

5.1 Team members:

Name	Function	Affiliation	Country
M. Jarvis	PI & OB Preparation	Herts.	UK
A. Edge	OB Preparation	Durham	UK
CASU(VDFS)	Pipeline processing	Cambridge	UK
CASU(VDFS)	Data Quality Control-I	Cambridge	UK
J. Emerson	VDFS & OB prep.	QMUL	UK
WFAU(VDFS)	Science Archive	Edinburgh	UK
WFAU(VDFS)	Data Quality Control-II	Edinburgh	UK
N. Walton	VO Standards	Cambridge	UK
	VIDEO Specific Tasks		
M. Jarvis	Data Quality Control-III	Herts	UK
I. Smail	Data Quality Control-III	Durham	UK
E. Bell, Postdoc	Data Quality Control-III	MPIA, Heid.	D
E. Gonzalez-Solares	Frame Stack	Cambridge	UK
Herts Postdoc	Frame Stack	Herts	UK
M. Jarvis, Postdoc/student	Final Catalogue Production	Herts.	UK
I. Smail, K. Coppin	Final Catalogue Production	Durham	UK
K. Meisenheimer, Postdoc	Final Catalogue Production	MPIA, Heid.	D
J. Loveday	Final Catalogue Production	Sussex	UK
	Other data products		
O. Le Fevre	VIDEO-VIMOS strategy	OAMP	F
H. Röttgering	VIDEO-LOFAR strategy	Leiden	NL
S. Rawlings	VIDEO-GMRT cat. production	Oxford	UK
R. Ivison	VIDEO-VLA/ATCA cat. production	Edinburgh	UK
S. Oliver, I . Waddington	VIDEO-SWIRE cat. production	Sussex	UK
S. Oliver	VIDEO-Herschel strategy	Sussex	UK
S. Croom & R. Sharp	VIDEO-AAOmega cat. production	AAT	Other
M. Bremer & K. Romer	VIDEO-XMM cat. production	Bristol, Sussex	UK
G. Dalton	VIDEO-FMOS cat. production	Oxford	UK
F. Walter & I. Smail	VIDEO-(sub)mm MPE/ESO Legacy	MPIA, Heid., Dur	D, UK
T. Readhead	VIDEO-SZ strategy	Caltech	USA
M. Jones	VIDEO-SZ strategy	Oxford	UK
K. Romer	VIDEO-SZ strategy	Sussex	UK
M. Moles & M. Villar-Martin	VIDEO-EMIR strategy	IAA	Spain

Matt Jarvis has recently been appointed to a 5 year fellowship and will be able to dedicate a large fraction ($\sim$ 50per cent) of his time to the running of VIDEO in general. Funding for computer hardware and a postdoc with responsibility for handling and assessing the quality of VIDEO data, and to carry out early science will also be sought from STFC in the coming months who would work 100% on VIDEO if funded, in addition to a PhD student starting Oct 2007 who will work 100% on VIDEO data as soon as the surveys start in earnest. This equates to 1.5 FTE and possibly 2.5 FTE is funding for a postdoc is approved. In addition to this, the groups in Durham (Smail, Edge & Geach) will contribute 0.4 FTE, MPIA, Heidelberg (Meisenheimer, Bell & Postdoc), Oxford (Rawlings & Mauch) 0.2FTEs, Cambridge (McMahon, Venemans and PhD student) will contribute 0.5 FTE and Oxford (Rawlings, Verma & Mauch) 0.3FTEs for data quality control and star-galaxy separation) have already committed to aiding the quality control checks over and above the VDFS quality control. The VIDEO team will also produce deep stacked data in addition to that generated with the standard tools at the VDFS, this will be carried out by the postodoc/student at Herts and Eduardo Gonzales-Solares at CASU over and above his responsibilty to VDFS at the 0.1FTE level. We will also have valuable knowledge of stacking from experience gained with the UKIDSS deep survey data, as the UDS and DXS PIs (Almaini & Edge) are coIs on VIDEO. Moreover, the University of Hertfordshire is host to three of the VISTA survey PIs and coPIs, namely Maria-Rosa Cioni, Phil Lucas and Matt Jarvis. Therefore, the pooling of resources from people within such a close proximity will help enormously when assessing the data quality arising from the various VISTA surveys.

Final catalogue production will utilise the experience of Herts, Durham, MPIA, Oxford and Cambridge after the quality control steps, along with Sussex with Jon Loveday (0.2 FTE), who brings experience from the SDSS and graduate student (0.5 FTE).

The other people listed in the bottom section of the table are the main contact points for linking the VIDEO data with other multi-wavelength data sets. Feedback from the various people listed here on the VIDEO survey data when combined with the other data sets will enable us to improve the VIDEO deliverables to ensure that all of the science possible with VIDEO can be achieved.

6 Data quality assessment process

The PI and a number of coIs are closely involved in the UKIDSS Deep Extragalactic Survey and Ultra Deep Surveys and have experience of dealing with reduced data from the VDFS and the link to WFAU. Jarvis also recently sat on the UK-VDFS review panel and as such has a good knowledge of the processes which are carried out in the data reduction procedure. The data quality control process will begin in the spring/summer 2007 with the PI working closely with the VDFS team to ensure that the data products delivered by similar surveys being undertaken with UKIDSS, such as the UDS and DXS, are of the quality that is required for VIDEO. This will ensure all of the foreseeable tasks will be in place before the VIDEO survey gets underway.

As the first data begin to arrive at CASU the reduced tiled data and single-tile based catalogues will be delivered to the Wide Field Astrommetry Unit where further checks are made (see Section 4.2).

After the second data quality control checks have taken place at the WFAU the survey PI will lead the final data quality checks. The PI will work with a VISTA postdoc in assessing the data quality, for artefacts, astrometric and photometric accuracy and distribute the reduced data for secondary checks at Durham (led by Smail) and MPIA, Heidelberg (led by Eric Bell & Klaus Meisenheimer). This will ensure that any less-than-ideal data is flagged and if needed rejected. This information will then be fed back to the VDFS with the information detailing the problems with the data products. A solution to the problem would then be sought between the VIDEO team and VDFS, if the data is essentially corrupted at the observation stage then the OB will be resubmitted to the queue.

We also emphasise that the third tier of quality control will also be using the first VIDEO data for science purposes, as carried out with the UKIDSS surveys. We have found this is the most efficient way of ensuring that the data is of the standard needed to carry out the science goals. This is reflected in the slightly longer timescale for the first release of VIDEO data in section 8.

7 Data product and VO compliance:

VIDEO data will be calibrated to the accuracy highlighted in section 3, i.e. with 0.1 arcsec astrometric accuracy and < 2 per cent photometric accuracy. Full object merged catalogues of the five VIDEO bands will be generated from each tile, as is currently carried out for the UKIDSS-DXS and UDS. This will form the basic element of the VIDEO data release. These merged catalogues will be made public through the WFAU archive in Edinburgh as well as on the ESO web site.

To summarise, the following data products will be made available:

- Fully reduced, individual tiles with complete header information detailing the processing steps and associated calibrations files used to process the data.
- Statistical confidence maps for all images.
- Quality control information, detailing the weather conditions, e.g. seeing, sky background, noise properties. Information from the reduction pipeline will also be included, such as limiting magnitudes, a variety aperture magnitudes, petrosian magnitude and PSF magnitude, along with the PSF profile information and the likelihood of objects being extended, point-like or noise. Such a scheme is currently employed in the UKIDSS data base.
- Band merged catalogues and aperture-matched photometry (Z, Y, J, H and K_s from all tiles).
- Deep stacked images from all observations up to the given date, with associated confidence maps.
- Band merged catalogues and aperture-matched photometry (Z, Y, J, H and K_s from the deep stacked data).
- We will endeavour, although not guarantee, to provide matched catalogues of the VIDEO data with Optical, Spitzer, radio and X-ray data over the VIDEO fields. In the longer term we expect Herschel to cover the same regions.

We propose that the VO-compliant image data and the various catalogues will be sent to the ESO archive via the world-wide web.

8 Timeline delivery of data products to the ESO archive:

It is envisaged that the first set of VIDEO data will be released on a timescale of 12 months after the survey begins. This timescale should allow a thorough analysis of the data for quality control purposes, and will result in the best possible science grade data. The longer timescale for the initial release is in place so as enough time is available to overcome unforeseen difficulties in handling on-sky VISTA data. This has proved very useful for the UKIDSS data and ensured that the subsequent data releases were of 'science grade'.

For subsequent semesters it is expected that this timeline will be shortened, with data to be release to the ESO archive in the semester following the observations.

T0+12months; Release of science products from first month of survey observations
T0+18month; Release of science products from first 6 months of survey observations
Thereafter we would hope that science products can be released within 6 months of raw data arriving in the UK. Optional reprocessing of data based on improved knowledge of instrument would also be considered

R	VIDEO	Z	Y	J	H	Ks	value from
	Time & depth on sky in coadded Tiles						
	Vega or AB mags?	**Vega**	**Vega**	**Vega**	**Vega**	**Vega**	
	Depth (Vega) required	25.2	24.0	23.7	22.7	21.7	Science
	Sigma required	5.0	5.0	5.0	5.0	5.0	Science
	Assumptions						
	SED assumed in using ETC	f_lambda	f_lambda	f_lambda	f_lambda	f_lambda	PI
	Aperture assumed in ETC - arcsec	2.0	2.0	2.0	2.0	2.0	PI
	In band sky brightness assumed - Vega mag/arcsec	18.2	17.2	16.0	14.1	13.0	PI
	Airmass assumed in ETC	1.2	1.2	1.2	1.2	1.2	PI
	In band on-chip image size assumed in ETC - arcsec	0.8	0.8	0.8	0.8	0.8	PI
	Extra extinction assumed in ETC	0.00	0.00	0.00	0.00	0.00	PI
3	Detector Integration Time (DIT) sec used in ETC	45	30	30	10	10	PI
	N.B. the DIT assumed will affect the number of seconds to reach a specified depth, because it affects the amount of read noise.						
1	Time (sec) required per object assuming above values						PI using ETC
	Area required sq. deg	15	15	15	15	15	Science
2	Tiles required to cover area(s)	10	10	10	10	10	PI, or PI using SADT
	effective useful sq deg/tile	1.50	1.50	1.50	1.50	1.50	R17/R18
	Priorities of different areas?	none	none	none	none	none	PI
	Single Tile Strategy						
	Parameters set						
3	DIT already assumed above	45	30	30	10	10	PI
4	Exposure coadds (Ndit) #	1	2	2	6	6	PI
5	Exposure loops (Nexp) #	2	1	1	1	1	PI
6	Microsteps (Nmicro) # of positions (steps <3 arcsec)	1	1	1	1	1	PI
7	Jitters (Njitter) # of positions (steps odd # of 0.5 pixels < 30 arcsec)	5	5	5	5	5	PI
8	Pawprints in tile (Npaw) #	6	6	6	6	6	PI
	Repeat tile in same OB how many times?	1	1	1	1	1	PI
	Multiple filters in same OB? If so which?						PI
	Mutiple tile positions in same OB? If so number?						PI
	Resulting values						
9	Total Exposure sec/tile	2700	1800	1800	1800	1800	R3*R4*R5*R6*R7*R8
10	Total Elapsed sec/tile	3128	2090	2090	2207	2207	PI using ETC
	Total Elapsed mins/tile	52.1	34.8	34.8	36.8	36.8	R10/60
	Observing efficiency %/tile	86.3	86.1	86.1	81.6	81.6	R9*100/R10
11	Time per object for s-to-n -single OB	900	600	600	600	600	R9/3
	Signal to noise (at depth required in row 3) - single OB	0.6	0.7	0.7	0.7	0.7	PI using ETC
	Depth (to sigma in row 4) - single OB	22.9	21.9	21.5	20.5	19.5	PI
	Multiple Tile Strategy						
12	# of Tiles per filter for S/N	70	45	55	53	58	R1/R11
	Time links between OBs in same filter on a Tile?						PI
	Priorities between OBs in same filter on a Tile?						PI
	Time links between OBs on a Tile in different filters?						PI
	Priorities between OBs on a Tile in different filters?						PI
	Time links between Tiles by position?						PI
	Priorities between Tiles by position?						PI
	Total Elapsed Hours per filter	608.2	261.3	319.3	324.9	355.6	R2*R10*R12/3600

Table 7. Summary of the various exposure times for the VIDEO survey.

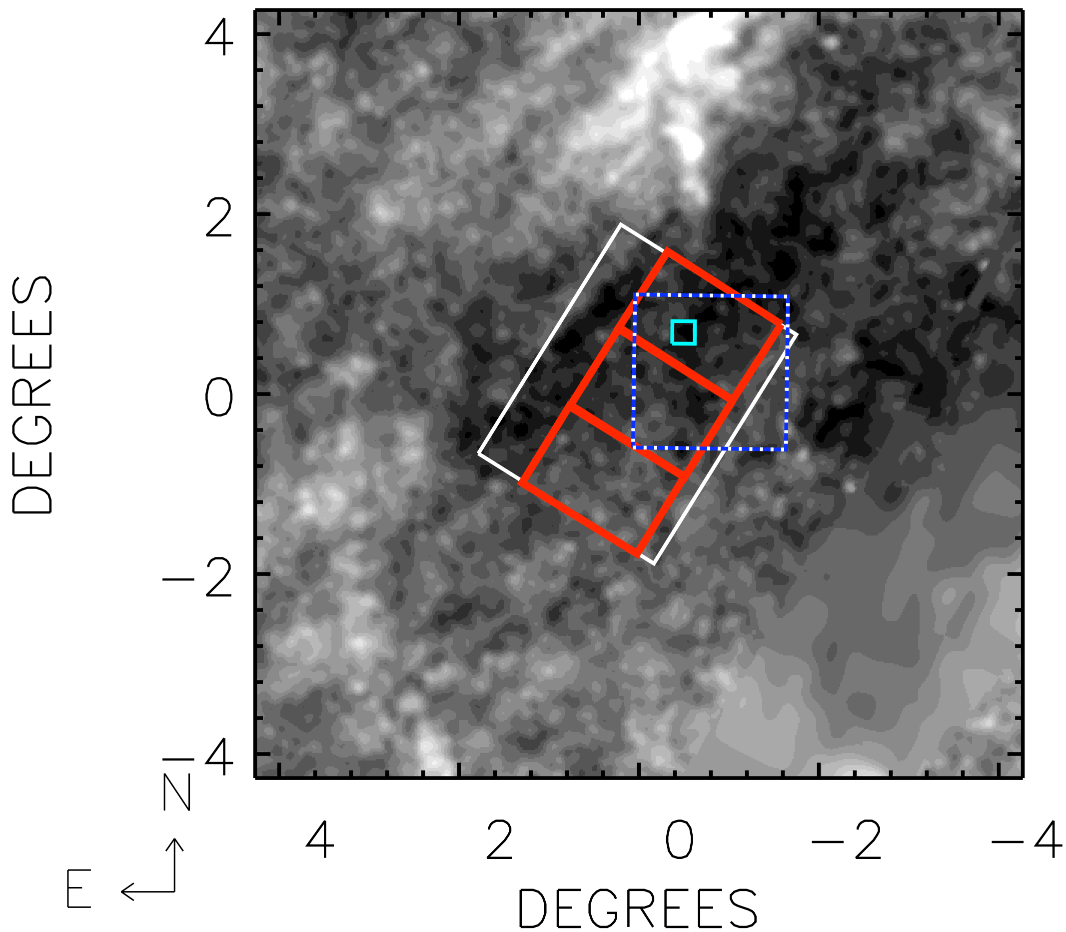

Figure 2: Tiling for Elais-S1. The three central tiles (solid red) represent the VISTA-VIDEO pointings, the large white box is the Spitzer SWIRE area, the white-blue dotted box represents the area covered by the ATCA-ATLAS radio survey. The small box in the top VIDEO pointing is the XMM pointing.

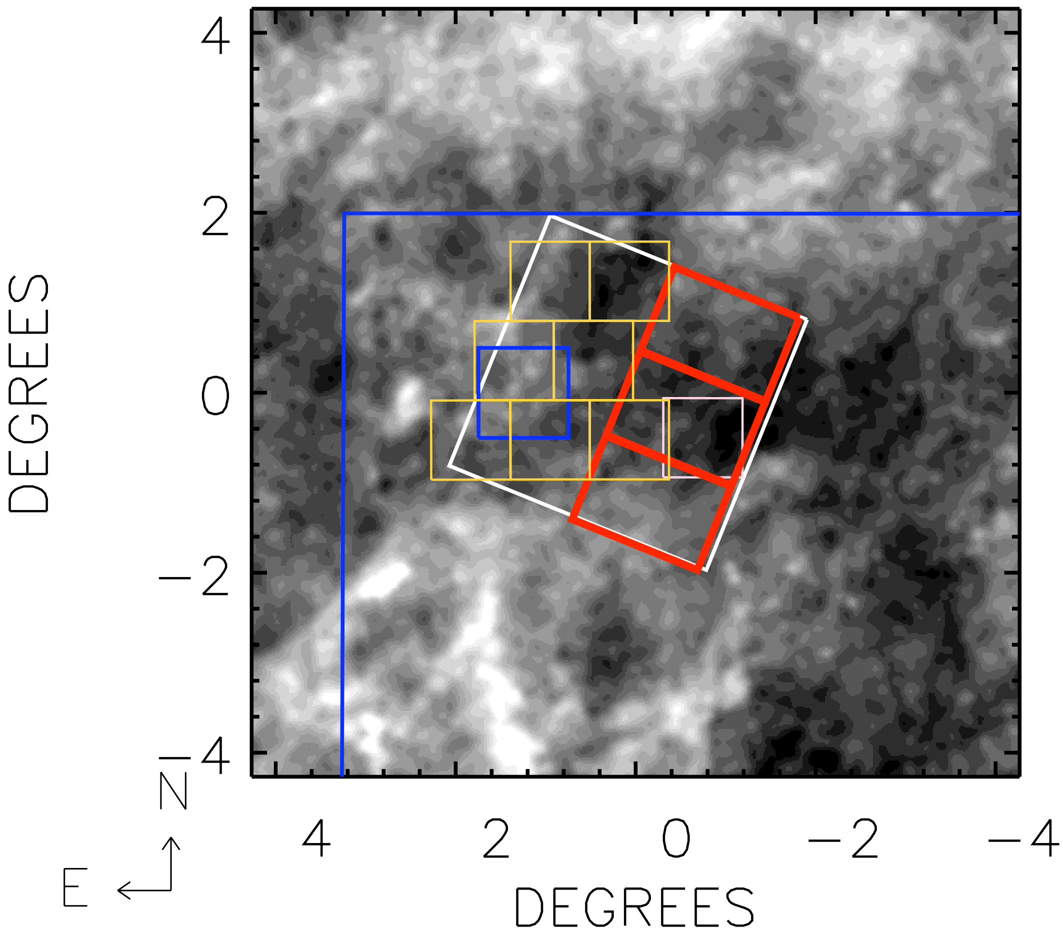

Figure 3: Tiling for XMM-LSS. Again the three solid red boxes represent the VIDEO pointings and the large white box is the Spitzer SWIRE area. Various other optical survey areas are also shown; CFHTLS-D1 area (blue square). Also shown are the UKIDSS-UDS area (grey box towards the right-hand side of the central VIDEO tile) and the area which is envisaged to be surveyed with the UKIDSS-DXS over the next 5 years. One can see that the combination of all this data is very complementary and the VIDEO-DXS survey areas have been chosen by both PIs (Jarvis and Edge) to maximise the scientific output of both surveys.

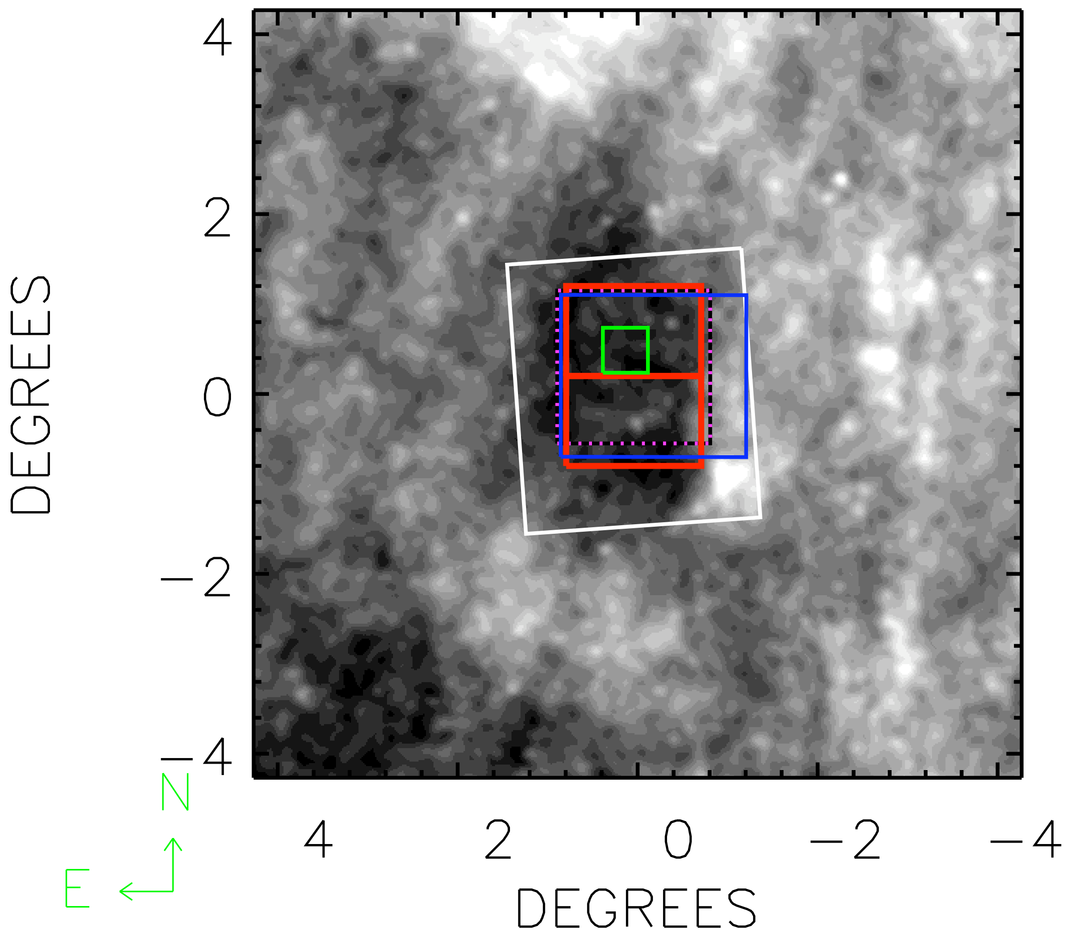

Figure 4: Tiling for CDF-S. The VIDEO pointings are represented by the two solid red boxes. Other areas shown are the Spitzer SWIRE area (large white box), the ATCA-ATLAS radio survey area (solid blue box), COMBO-17 area (small green box; which also contains the GOODS region), and the proposed SCUBA2 area (dotted box).

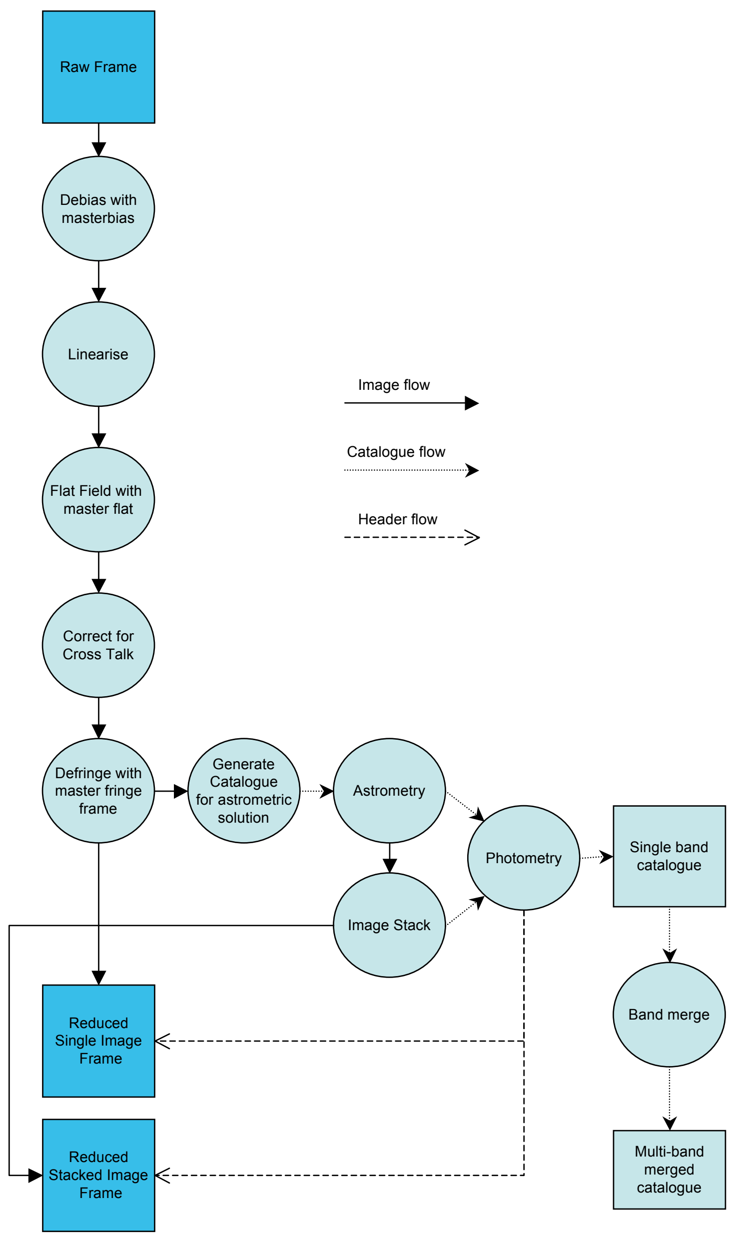

Figure 5: Block diagram of the pipeline processing steps.