VISTA IR observing strategy - Version 0.1

CASU

10th October 2003 [1]

[1]Version 0.5 prepared for IR camera FDR Design Review to be held in December 2003

Applicable Documents

Reference	Document Title	Document Number	Issue and Date
VIS-SPE-VSC-00000-0001	VISTA Science Requirements	V2.0	2000 Oct 26
VIS-SPE-VSC-00000-0002	VISTA Operational Concept Definition Document	V1.0	2001 Mar 28

Contents

1 Context **3**

2 Overview of Strategy **3**

3 The Observation Handling System **4**

4 Design of Observing Strategy **5**

4.1 OB Definition and Restrictions 5

4.2 Modes of NIR observing 6

4.3 Elements of an OB 6

1 Context

Automatic pipeline reduction of VISTA data is predicated on the assumption of a well-defined set of observing protocols that forward the relevant meta-data to the pipeline reduction system. In turn the pipeline has to not only deliver science-quality products but also provide feedback on the health of the camera and on the overall data quality. This leads to several general front- and back-end requirements:

1. all the information that the pipeline needs to process the data and to monitor the state of the system and health of the observations has to be contained within the data file header structure (FITS) and data file main body;
2. the allowed observing sequences, or OBs in ESO parlance, have to be sufficiently general to satisfy a range of user expectations, but also sufficiently well-defined and self-contained to enable automatic pipeline processing;
3. the summit pipeline must run hands-off in (almost) real-time and provide data quality control information on addition to QC0 (and QC1?);
4. the pipeline at Garching will generate astrometric and photometric calibration in addition to revisiting the quality control information derived at the summit;
5. data products from the UK-based pipelines must satisfy the overall science requirements of the VISTA science consortium and must provide the necessary input and processing options for the UK science archive. These science and archive requirements drive the design of the observing strategy.

This interim document begins by reviewing the proposed overall philosophy of data taking for VISTA IR and then proceeds via an overview of the observing strategy to see how this interacts with, and drives the design of, the Data Interface Dictionary (DID) and thence the FITS headers. In turn these constrain the required camera templates (*e.g.* aquisition template, observing template).

2 Overview of Strategy

Observing protocols and data processing strategies have to be closely linked for a successful end-to-end pipeline system. However, in developing the current framework for a data processing and observing protocol strategy we have had to make various assumptions regarding the detail of the science and data products users requirements (since they are still under development) and have, of necessity, had to allow for uncertainties in the detector properties and the (unknown) properties of the spatial and temporal variation of the sky over 1 degree scales. With this in mind we have deliberately designed the data taking (and processing) philosophy around a flexible modular system.

Data will be taken according to a flexible menu of observing protocols (discussed in the next section) to guarantee automatic pipeline processing both at the summit, in Garching, and in the UK.

The general philosophy is that all fundamental data products are FITS multiextension files (MEFs) with headers describing the data taking protocols in sufficient detail to trigger the appropriate pipeline processing components, including the generated catalogue binary tables, and that all *derived* information, data quality control (DQC), photometric and astrometric calibration and processing details, are also incorporated within the FITS headers. These headers thereby provide the basis for ingest into databases for archiving and databases for real time monitoring of survey progress and survey planning.

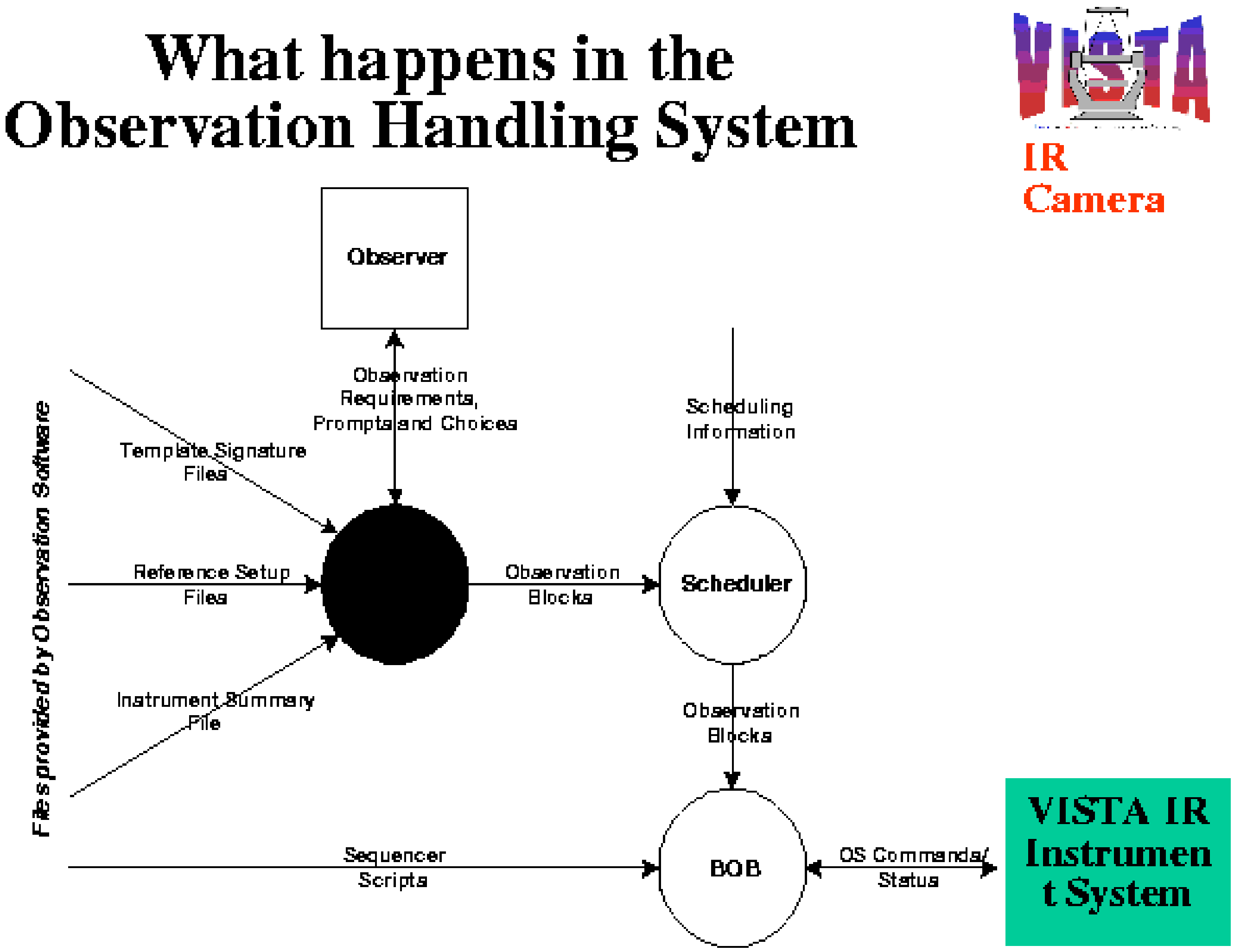

Figure 1: Overview of the OHS

3 The Observation Handling System

An overiew of the observation handling system is shown if Figure 1.

VISTA IR camera software being developed at the ATC in accordance with ESO guidelines will supply the following elements of the system:

- template signature files
  - these describe the input parameters required by a particular template
- reference setup files
  - which describe all the parameters required to make an observation in a particular instrument mode
- instrument summary file
  - describes the capabilities of the instrument eg. lists the possible observing modes, lists the installed filters etc..

- sequencer scripts
  - each template is provided with a sequencer script which performs the observation when executed

These software elements are used to help build the Observing Blocks (OBs) via the allowed observing templates, as shown schematically in figure 1.

**** Need to confirm that the OB can made up of several camera templates ****

In addition the control software provides the primary interface to the VDFS via the specification and collection of data headers item (FITS). The instrument modes of operation are identified in the FITS headers

The camera templates must cover all the options required to construct the desired structure within the OBs and also provide camera calibration modes (*e.g.* for determining the rotator centre off-line during engineering commissioning)

4 Design of Observing Strategy

To achieve the flexibility of observing protocols to satisfy different user science requirements and well-defined recipes to enable automatic pipeline processing, we propose to base the observing strategy on a nested menu system (figure 2) and cater for the possiblity that each OB may need to be self-calibrating and as self-contained as possible. The data processing pipelines will be sufficiently modular to cope with a variety of use cases providing agreed observing sequences are followed. These could typically range from quick look exposures, to producing contiguous tiled mosaics using offset skies. Each type of observing sequence component will generate FITS header keywords that identify this element of the OB to the pipeline.

4.1 OB Definition and Restrictions

An Observing Block (OB) is a selection from iterated exposures/ integrations, microsteps, dithers, tiling, and/or offset patterns taken at one or more sky positions (where position includes micro and macro offsets). Although this is an open-ended definition, in practice an OB will be limited by several factors:

- there is bound to be a 'longest acceptable observing time' for any OB due to possibly rapid seeing, sky fringing and sky brightness variations (temporal and spatial) over the VISTA 1.6 deg field-of-view (this needs to be assessed during commissioning);
- ideally each OB should be as self-calibrating as possible since there may be, for example, time-dependent flatfielding effects due to thermal emisison or sky colour and emision line variations. This implies that in general sufficient exposure time has to accumulate in each OB to ensure the data can be properly calibrated;
- offsets in dither and microstep patterns for interleaving should be $<$10 arcsec (TBC) to remain within the adjacent detector overlap boundary and to remain within the throw of the guide star movement
- tiling should be varried out on a 6 step grid with offsets of of the detector spacing, to give "uniform" coverage of the field-of-view. Constructing a tile will require non-linear resampling in all cases.

4.2 Modes of NIR observing

There are several possible modes of NIR observing which need to be covered by the Observation Handling System:

- using twilight flats to define master calibration frames to avoid the problems associated with thermal dust emission and sky fringing;
- standard interleaving/dither/tiling pattern where the flatfields, sky correction and so on are generated from stacking of all frames. Appropriate for uncrowded fields with no large extended objects;
- offset sky dither pattern – flatfield and sky estimators generated from offset sky frames. Appropriate for highly crowded regions (*e.g.* Galactic plane surveys) or fields with large extended objects (*e.g.* Magellanic Clouds galaxies).

The optional steps required to achieve these are illustrated in figure 2 and are defined more precisely in the next section

4.3 Elements of an OB

The lowest level iterator is a loop, where a loop is a combination of N exposures coadded at a given position to give an integration.

This is optionally followed by a combination of microsteps for interleaving and dithers; where a microstep is a small integral + precise sub-pixel shift for interleaving pixels to create better sampled images. These can also be stacked for flatfields and sky estimation but cannot be used to remove bad pixels. A dither is a small offset over, say, a "spiral" grid (*e.g.* 3x3). Combined dither images can be used to remove bad pixels, and other defects and stacking with rejection generates flatfields and sky estimates.

Completing the minimum contiguous region on-sky with "uniform" coverage requires six related pointings of the inner iterators to fill the gaps between detectors – a tile.

Optionally, large offsets may be required for flatfield and sky estimation in crowded regions or for large area objects. They could also be used to offset to the next science field if a single field does not meet self-calibration requirements.

Separate calibration observations, or additional targets, optionally make up the top level iterator for the OB.

All of these elements require associated FITS header keywords and keyword values for contextual evaluation and use by the pipeline.

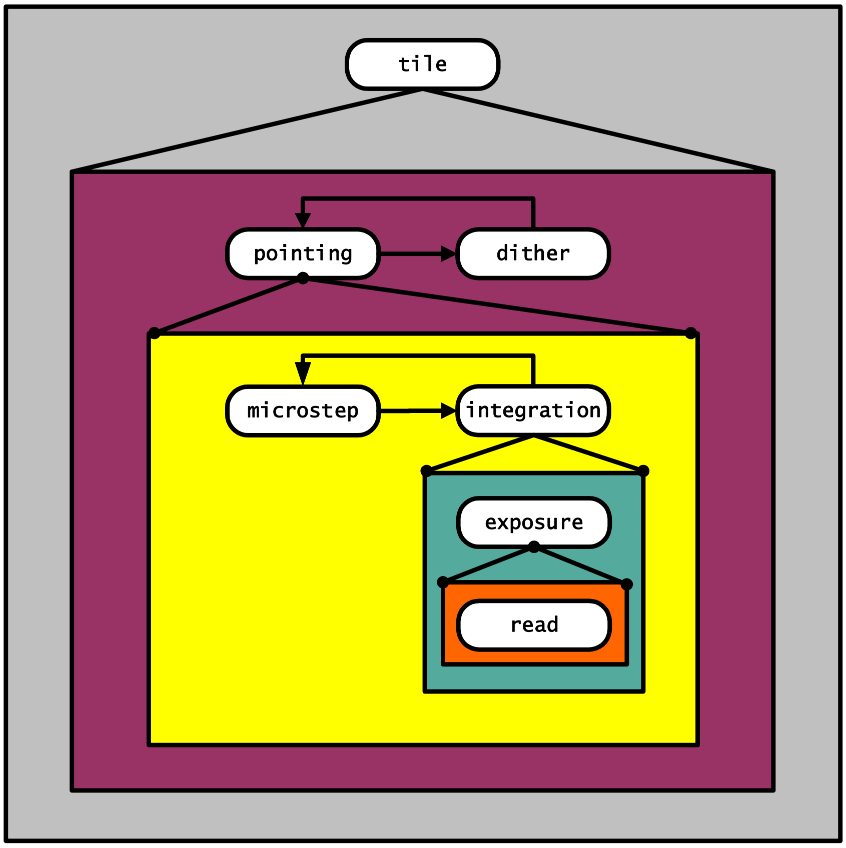

Figure 2: The elements for each target within an OB. Each component is an optional iteration of a sequence of observations. Thus at the lowest level, an exposure is made up of a sequence of reads (DCS, NDR ......). Exposures can be coadded to build up an integration. Optional microstepping interleaves frames to provide better sampling but increases the size of the data frame by 2x2. Interleaving microsteps may also include an integral pixel shift (*e.g.* step n+0.5 pixels) so the data can be combined to create local flatfields or skys. Small dithers around pointings will be used for stacking to remove bad pixels, where *small* is within the throw of the 3 guide star windows (and also subject to edge overlap constraints). Six pointings, including optional ancilliary microsteps/dithers, combined together form a tile. Offsets to other targets, or for sky estimation, are not included for clarity.