Southern African Large Telescope
SALTICAM
Preliminary Design Review

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Software

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1 Scope

This is the Software Definition Document for the preliminary design review of SALTiCAM, the verification instrument, acquisition camera, and scientific imager of the Southern African Large Telescope (SALT). It will describe the major functions and capabilities of the software in the host control PC and the instrument controller.

2 Host Computer

The host computer will be a PC running Real Time (RT) Linux. A collection of C language functions will run in the RT environment to ensure zero delays in handling time-critical data communications from the CCD controller, and to allow accurate time stamping of CCD image data. The user interface GUI will be a Labview application. Instrument setup information and CCD image data will be posted onto the network in accordance with the SALT protocols.

An in-house lab-test package will be developed compatible with development of the CCD controller software. This will be a C/xforms application and will include standard CCD test functions such as noise/gain.

The host software will have total control over sequencing of controller operations – the controller embedded software will perform single, simple tasks on command.

In the preliminary design, we treat only the basic software functions and indicators. The issues regarding hardware safety interlocks, soft and hard limits, and assignment

of responsibility between software and hardware systems will be detailed in the critical design. The one design philosophy that we can stress here is that it will be impossible for the software to harm the hardware. The safety analysis and hardware implementation will ensure that the worst result of control errors will be limited to loss of observing time.

2.1 Communication with SALT Operator/Astronomer Computers

The SALTICAM computer will display the images extracted from its detector on its display which will be located close to the SALT Operator (SO) and SALT Astronomer (SA). It will receive control signals from the SO/SA computers which will permit the SO/SA to interact with the display: place marks/boxes/windows on the display, select objects on the display, overlay catalogues on the display etc.

The SALTICAM computer will also receive setup information for the next image(s) to be obtained with the camera: exposure time, prebinning, frame transfer state, windows (if any), filter, gain, repeat count and any other information that the camera needs to define its imaging

The SALTICAM computer will also transmit compressed versions of its images (no larger than 600 x 600 pixels) over a network to either or both of these machines.

2.2 Communication with TCS server/Payload Computer

The SALTICAM computer will solicit information from the TCS server including the Right Ascension and Declination, Hour Angle and zenith distance of the pointing of the telescope.

The SALTICAM computer will also send the TCS server/Payload computer X and Y offsets which will: (i) place objects in the entrance apertures of the scientific instruments; (ii) function as guiding corrections during closed loop guiding. Small quantities of data are involved.

2.3 Communication with Data Reduction Computer

At low priority so as to avoid interference with SALTICAM's normal operations, the SALTICAM computer may be requested to transmit one or more images to the data reduction computer. SALTICAM images may be as large as 17.6 M pixels (of 2 bytes/pixel) but will usually be no larger than 4.2 M pixels. Data rates to be determined by the data reduction requirements.

2.4 Communication with Precision Time Source

The Precision Time Source will ensure that the SALTICAM computer keeps

Universal Time to 1 millisec accuracy or better at all times by providing suitably coded GPS-referenced time to the computer.

2.5 Communication with CCD Controller, Subsystem Controllers

This communication takes place between the SALTICAM computer and the CCD controller which also permits control of other subsystems:

- Bi-directional communication. Control & status, and CCD Read out data - data rate (on internal optical fibre) up to 64Mbits/sec (equates to 1M pixels/second, theoretical maximum speed). Image size up to 17.6 M pixels, but usually 4.2 M pixels.
- The SALTICAM computer will control the filter unit, the frame transfer mask, the shutter and the detector temperature via instructions to the subsystem controller (which is part of the CCD controller).

2.6 SALTICAM Man-Machine Interface (MMI)

The SALTICAM MMI will be used to set up the camera (filter, frame transfer mode, prebinning, windowing, exposure time etc.), initiate closed-loop guiding if necessary, initiate the acquisition and readout of one or more images, control data display and storage (in FITS format), and manage interaction with the displayed image. The MMI functionality shall be exportable to the SO/SA MMI computers.

2.7 SALTICAM Algorithms

The SALTICAM control program shall have at its disposal suitable algorithms for interacting with objects in any displayed image, and for closed loop guiding.

Closed-loop guiding algorithms shall include determining centroids of guide objects and deducing offsets for transmission to the guiding system in the TCS. In high time resolution mode, guide star centroiding may be achieved from the scientific images; communication with the TCS to correct the telescope pointing will be needed.

Display interaction shall include:

- Image Display: images obtained by the instrument shall be displayed with adequate resolution on a large monitor in the SALT Control Room. Control of brightness and contrast shall be part of the display algorithms. Displaying the image in any orientation of RA and Dec is required (**TBD1**).
- Image Manipulation: simple image manipulation shall be provided including:
  i. Marking the image with boxes, crosses or other suitable marker.
  ii. A read out of pixel position, RA and Dec of a mouse-type pointer.
  iii. Fitting of Gaussian functions to point sources.

iv. 2-d line plots of image brightness in any direction across the image.
v. Simple aperture photometry to estimate magnitudes of objects.
vi. Simple image processing function such as background subtraction, smoothing or median filtering.

2.8 CCD Controller and Subsystem Controller Functions

The SALTICAM computer shall send the following commands to the CCD & Subsystem controllers:

- Request for controller status
- Download CCD-specific control/executable code
- Filter selection and positioning
- Set full frame or frame transfer mode
- Frame Transfer mask in/out
- Set pre-bin factor
- Set window/s
- Set gain factor & readout speed
- Start/stop exposure
- Shutter open or close
- Shift image to store area
- Read out CCD data
- Focus control
- Various test functions such as charge pumping, noise testing etc.

3 Instrument Controller

The San Diego State University (SDSU) CCD controller is used as the instrument controller. The controller uses embedded DSP microcontrollers programmed in assembler language. Auxiliary subsystems are operated via a hardware controller that has no software capability, and is controlled via the SDSU controller.

The SDSU controller software will use the model developed at ING (La Palma) for message/data interchange protocols with the host computer. This approach is based on two “notice boards” residing in the SDSU controller memory, one write-only by the host computer, the other write-only by the controller. Parameters such as window specifications, prebin factor, exposure time etc defining the next exposure are posted on the noticeboard by the host computer. The controller posts a variety of status information such as shutter position, readout-in-progress etc.

CCD readout modes such as prebinned, windowed, prebinned and windowed will be supported. Multiple readout speeds with selectable gains will be supported, the number of options to be fixed once actual performance is measured under test.

3.1 Controller Software Functions

- Respond to commands received from the host PC
- Perform all CCD readout functions required:-

  Full frame, frame transfer, drift scan, binning, windowing, variable readout speed, variable gain
- Time CCD exposures with <10mS accuracy
- Control CCD temperature to <0.5ºC
- Communication link between host PC and SALTiCAM instrument controller

4 Test Equipment

It may be necessary to purchase test equipment to facilitate controller DSP program development. Suitable equipment is the SB56K from Domain Technologies.