SOFTWARE REQUIREMENTS

Spartan IR Camera for the SOAR Telescope

Michael Davis
Edwin D. Loh

Department of Physics & Astronomy
Michigan State University, East Lansing, MI 48824

Loh@pa.msu.edu 517 353–4869

11 October 2001	Initial release.
29 January 2002	Clarification of atomic functions
12 February 2002	Specify protocol for 6533 card

1 ArcVIEW

The software for controlling the Spartan IR Camera is an add-on to the existing package ArcVIEW, which controls the SOAR Optical Imager. ArcVIEW is written in LabView. All user controls are implemented by a graphical user interface, or GUI. These documents specify ArcVIEW:

> Sebring, T., Cecil, G., and Walker, A., January 2000, "Statement of Work, ArcVIEW Controller Suite, SOAR Telescope Project."
>
> Sebring, T., Cecil, G., and Walker, A., undated, "Statement of Work, ArcVIEW Detector Array Controller Suite, SOAR Telescope Project."
>
> Streit, S., 2000, "PCI Device Driver and controller Commands."

The major components of ArcVIEW, as modified for Spartan, (Figure 1) are the Camera Control GUI, the Engineering GUI, the Macro GUI, the Image Data Manager, and the ArcVIEW Main Module.

The ArcVIEW Main Module is the data routing manager and macro-processing module.

The Macro/script GUI (Figure 2) enables execution of single line commands or macro files. There should be no need to alter this module for the IR camera.

The IR Camera Control GUI contains all controls needed to operate the camera. This GUI will be a modification of the existing Optical Imager GUI (Figure 3).

The Engineering GUI displays engineering information that is not needed by a typical operator. This is new.

The Image Data Manager manages the incoming data. It performs three functions. (1) The incoming data stream is a merger of data from 4 quadrants for each detector and up to 4 detectors. The data manager separates the data stream so that each detector is put into a single array. (2) If selected, the data manager averages the data stream from multiple exposures. (3) The data manager writes the data to disk in FITS format.

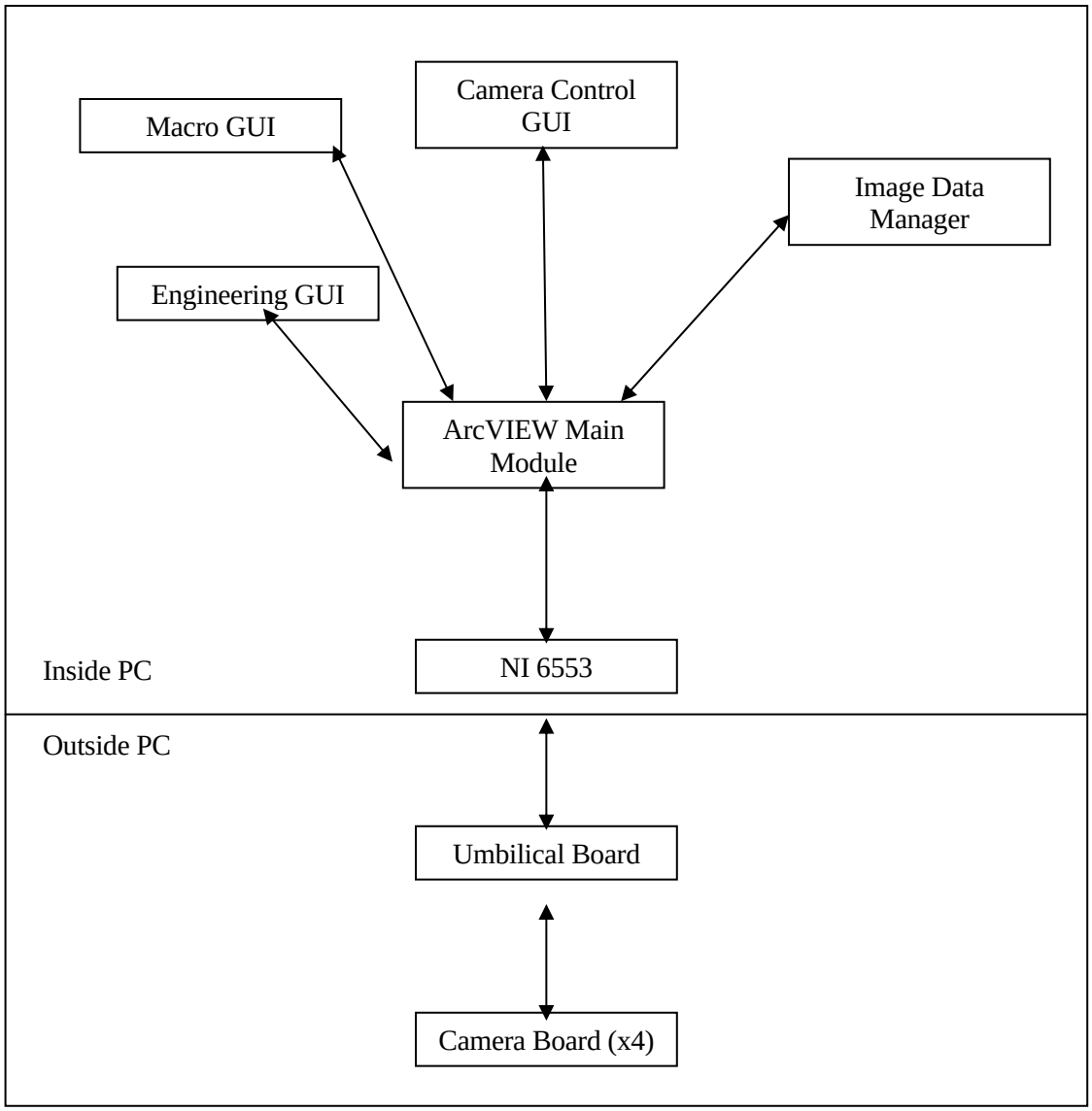


Figure 1 ArcVIEW lock diagram.

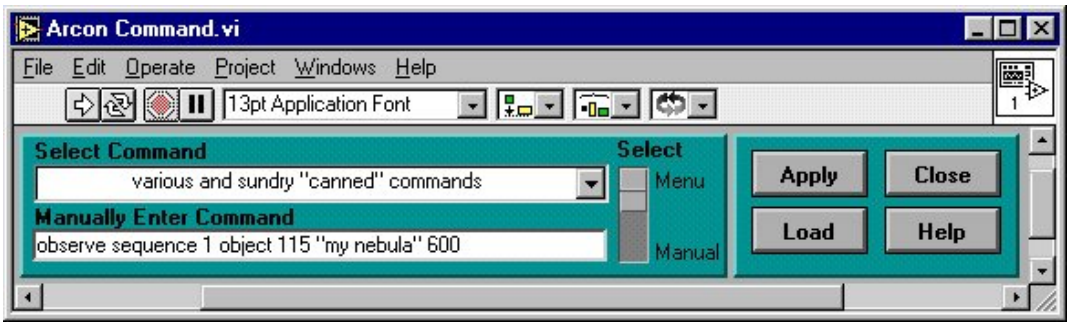


Figure 2 ArcVIEW Macro GUI from the ArcVIEW Statement of Work. Commands may either be selected from a menu or entered manually.

The detailed components of ArcVIEW are listed in Table 1. Some components will work with the IR camera with little or no modification. Other items must be written from scratch. Some components are not applicable.

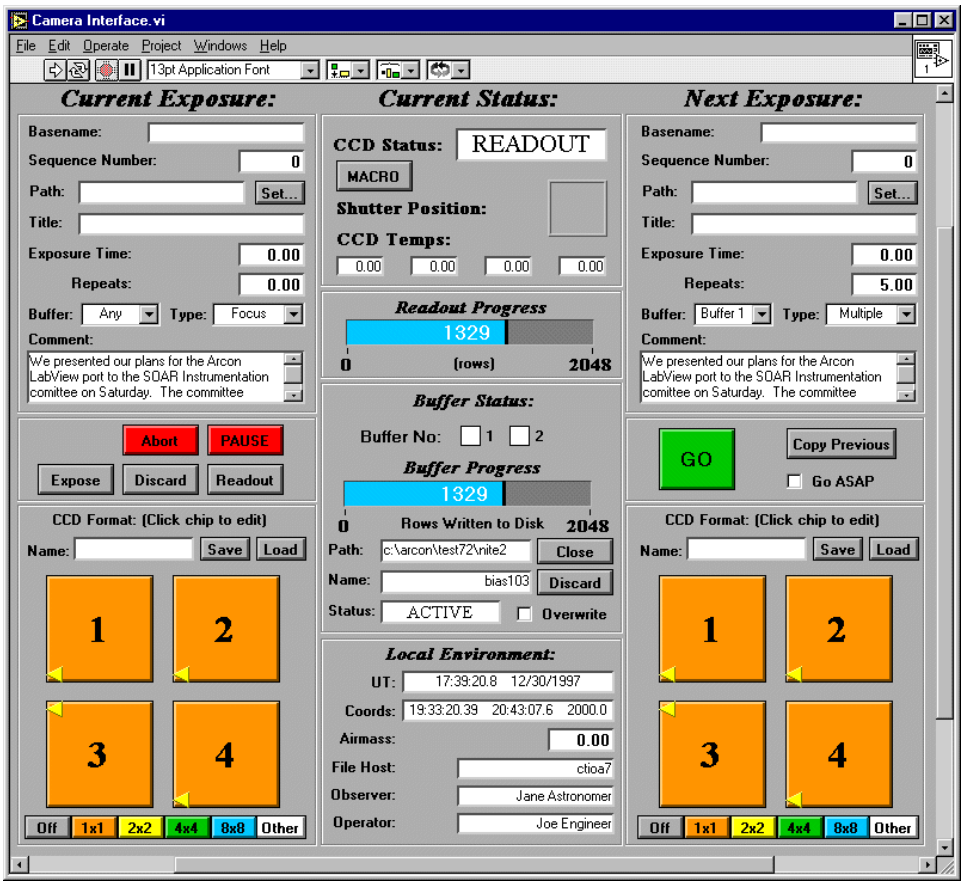


Figure 3 Prototype of Optical Imager GUI from the ArcVIEW Statement of Work

Table 1 ArcVIEW components from the Sebring et al (undated). Abreviations: NA for not applicable, NC for no change.

Software Component	**Function(s) Overview**	**Status**
Optical Camera Control GUI	Implements manual setup and control of one camera. This is an ArcVIEW plug-in. The output can be sent as commands or returned for storage as part of an observation	NA
IR Camera Control GUI	Same, except for IR camera.	Mod of above
OCS Demo GUI	Enhanced demo to show capability of storing an Observation in a Queue.	NA
Queue Manager Demo	Manages storage, editing and running of an Observation Queue as a capability demo.	NA
Queue Editor Demo GUI	Allows editing of Observations composed of the OCS demo data and Camera GUI data. Save/retrieve from file(s) and live interaction with the Queue Manager.	NC
SOAR Communications	This shall implement a TCP/IP communications handler, using the SOAR libraries when they become available.	NC
Status Panel GUI	Show variables requested from various system components via SCL calls.	?
Macro/Script Handler	Processes scripts/macros written as text files. ArcVIEW shall use G'Script.	NC
Image Data Buffer	Data buffer shall be implemented in 'C' as a simple circular buffer by CTIO as part of the driver.	?
Image Data Manager	Implements the image data buffer and access and control of the buffer.	Mod
SDSU LabVIEW Driver	LabVIEW VIs to access the routines in the "C" driver library.	NA
SDSU "C" Driver	Low level control of the SDSU hardware via calls to the PCI/CompactPCI interface card. An example is IRLabs DLL call library.	NA
Telemetry	Display of any telemetry from the camera/controller combination.	?
TCS Communications	Shall use the SOAR Communications Library (SCL) and LabVIEW code to implement message routing/response.	NC
TCS Control Module	Specific control and response handling of TCS interaction such as would normally be associated with a full DAIC system.	NA
"PicRead"	Reads the data out of the Image Buffer on the fly, unscrambles the data (if necessary) and routes to displays or other computers as desired.	?
WaveForm Editor	Creates, compiles, edits waveform files for the particular hardware array controller, such as for the SDSU-II.	NA
WaveForm Reader	Reads the waveform files for sending via the LabVIEW SDSU driver.	NA

2 IR Camera Control GUI

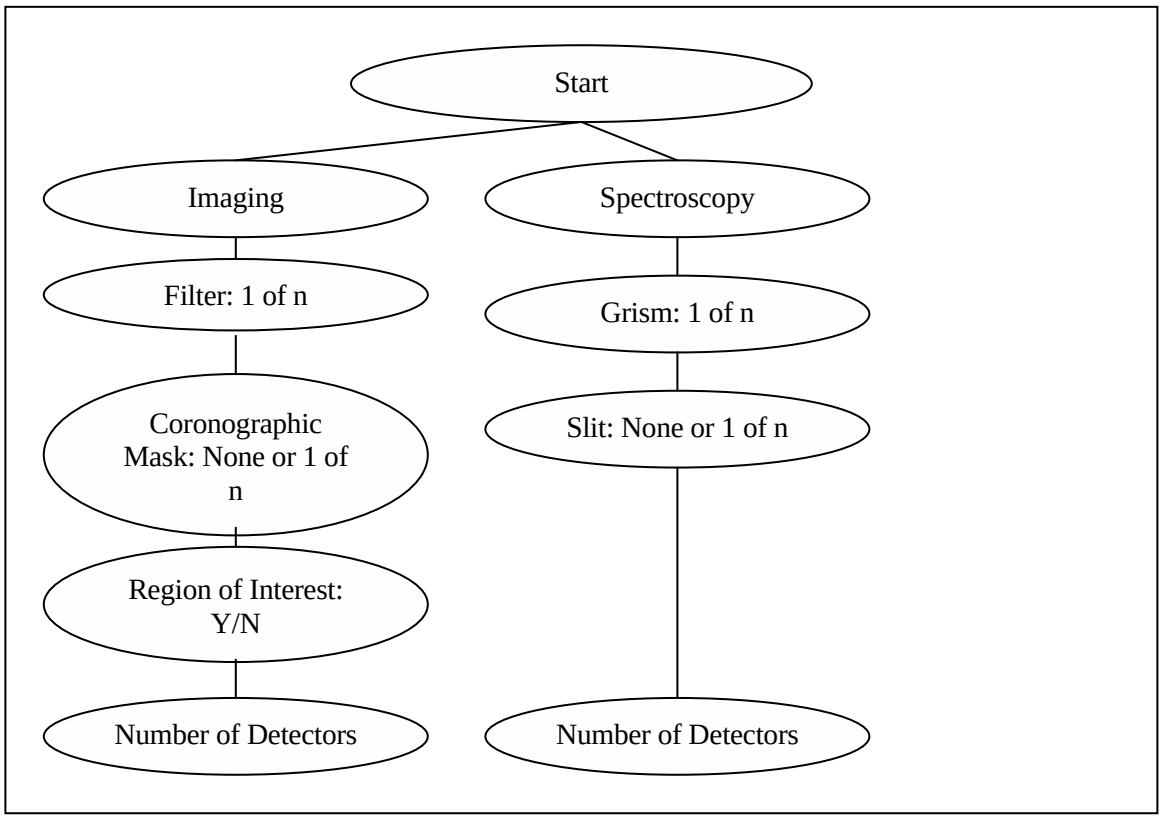
2.1 Camera States

2.1.1 Focal ratio

The camera possesses two different focal ratios, f/11 and f/21. Each focal ratio, or configuration, is a state. Changing the focal ratio requires activating the detector tilt motor, turning the two mirror motors to rotate mirrors in or out of position, and rotating a new Lyot stop into place. There should be some form of warning or question before this command is implemented. This safety measure prevents accidental or unwanted focal ratio changes. The change between configurations may only be directly implemented by the user, and cannot be activated by a command from a script.

2.1.2 Observing Mode

The camera has imaging and spectroscopy. The following tree illustrates the choices available to the observer. Each choice is a camera state.



2.1.3 Picture Parameters

The camera control GUI accepts picture parameters, such as exposure time, exposure type, and object name. These parameters must be recorded in the image header.

2.2 Camera Operations

2.2.1 Take Picture

The GUI will have a command to start an exposure.

2.2.2 Abort Picture

The GUI will have a command to abort an exposure while it is in progress.

2.3 Current Status

The IR camera control GUI displays the following information for the observer.

2.3.1 Right Ascension, Declination, Universal Time, Local Time, and Airmass

This information will come from the telescope.

2.3.2 Camera Configuration: f/12 or f/21

This information will come from the position of the motors. Therefore, the software must keep track of motor position.

2.3.3 Filter, Grism, Mask, and/or Slit In Use

This information will come from the position of the motors that turn the filter wheels. Therefore, the software must keep track of filter wheel motor position.

2.3.4 Camera Temperature

The temperature information from many sensors in the IR camera is displayed. The software must alert the observer if the camera is too warm.

2.3.5 Camera Pressure

The pressure information from two vacuum gauges inside the IR camera is displayed. The software must alert the observer if the camera pressure is too high.

2.3.6 Help Options

There are two help features on the display. The first is a context sensitive help, which allows the user to point at an area of a GUI and find a quick definition for its function. The second is a link to a web page with detailed explanations of camera functions.

2.4 Observer's Log File

The observer's log file is record of the observing session. Camera actions, such as exposures and changes of the state of the camera, are written to the log. In addition, the observer may write comments.

3 Engineering GUI

3.1 Setup File

The setup file contains the current setup information. This file includes the filter names and their positions on the filter wheel, the location of the temperature sensors, and the number and location of detectors. This file can only be changed through the Engineering GUI.

3.2 Zero Motor Position

The stepping motors maintain location by counting steps from the home position. The home position is sensed by a switch. Initially, the motor must move to locate the home position and "zero" the position. This must be done whenever the position is lost. Whether the motor controller has a command for this or whether this must be programmed is to be determined.

3.3 Engineer's Log File

The engineer's log file is record of the camera's life. Camera actions, such as exposures and changes of the state of the camera, are written to the log. In addition, the engineer may write comments.

3.4 Camera Temperature Display

The readings from all temperature sensors in the camera are displayed on the engineering GUI. They are also written to a data file at a selectable rate.

3.5 Camera Pressure Display

The readings from the vacuum gauge in the camera are displayed on the engineering GUI. They re also written to a data file at a selectable rate.

4 Image Data Manager

4.1 Image Format

The image data manager must be modified so that it can handle one to four 2048*2048 arrays.

4.2 Write Image

The images will be written to disk in standard FITS format. An option to name the files and specify the save directory must exist. These functions are already implemented by ArcVIEW

4.3 Display Image

"PicRead," an existing CTIO package, displays the images. The images will be displayed primarily using XIMTOOL, with DS9 available as a user option. Both XIMTOOL (http://iraf.noao.edu/iraf/web/projects/x11iraf/) and DS9 (http://hea-www.harvard.edu/RD/ds9/) are standard packages for viewing astronomical images in FITS format.

5 Camera Hardware Interface

5.1 NI 6553 Card

The 6553 card, a parallel data card from National Instruments, is the hardware interface to the camera. (For the Optical Imager, the data card is a Leach card, which has a special driver.)

5.2 Setup data

The setup data contains this information.

The section filterNames has the correspondence between filter position and filter name.

The section motorPosition has the motor locations of the possible states.

The section temperatureSensorName has the correspondence between sensor and sensor name.

Motor	States
Filter wheel 1	Filter 0–9
Filter wheel 2	Filter 0–9
Mask wheel	Mask 0–3
Collimator mirror	f/21 in or out
Camera mirror	f/11 in or out
Detector rotation	f/21 or f/11

5.3 Detector controller

5.3.1 Atomic functions

Atomic functions are the simplest functions performed by the detector controller. All actions performed by the detector controller may be broken up into one or more atomic functions.

Table 2 Atomic functions of the camera controller. The values of the detector selector *d* are 0–3 for specific detectors and 4 for all detectors.

Function	Command words	Comments
Null	$2000_{16}d$	No command
Flush	$1+2000_{16}d$	Flush charge
Read picture	$2+100_{16}\ m+2000_{16}d$, time, $x_0+100_{16}\ y_0$, w	Expose for a given time and read picture. For reading a region, (x_0, y_0) is the center and w is the width of the square subregion. *m* Contents 1 Repeat continuously 2 Region only
Reset	$3+2000_{16}d$	Abort current operation
Read status	None	Word Contents 0 Status 1 Time remaining 2 Temperature. Datum is coded $v+2000_{16}\ s$, where v is the value, and s is the sensor number (0–4).
Load digital pot	$3+2000_{16}d$, $v+100_{16}\ a$	The value v has 8 bits. The address a has 3 bits. *a* Contents 0 Reset 1–4 Offset for quadrant 0–3 5 Bias gate

5.3.2 Communications to the NI6533 card

The link uses "burst mode," which transfers data on the rising edge of PCLK when both REQ and ACK are true. (See Figure 4.)

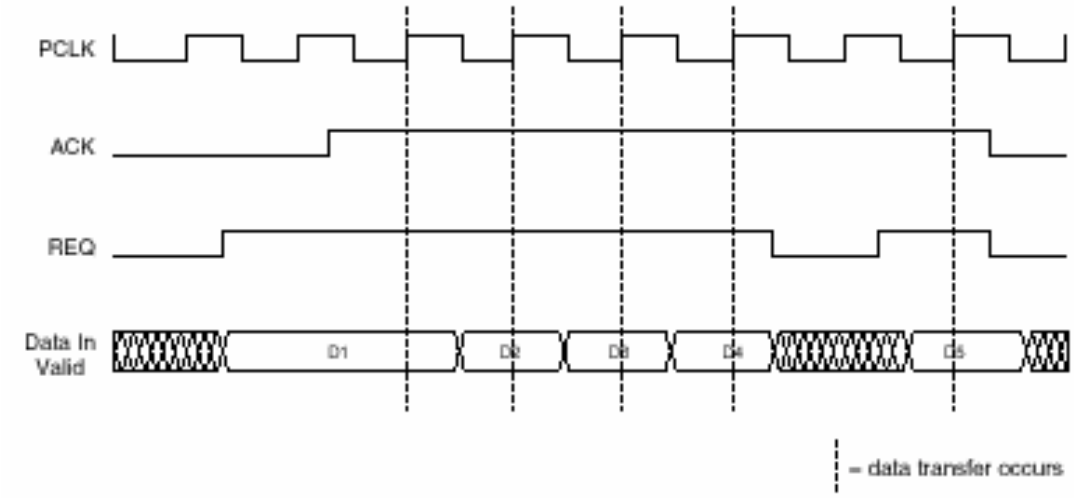


Figure 4 Timing diagram for burst mode. (653X User Manual, National Instruments, Jan 2001, p. 3-6.)

REQ and ACK are active high, which is the default.

Only group 1 signals are used. Data on ports A and B are used to form a 16-bit word.

The umbilical card drives PCLK1.

5.3.3 Timing

The two commands for the NI6533 card are read and write.

The line PCLK2, controlled by the computer, indicates the direction of data transfer.

Read status. (1) Put 0 on PCLK2 to set the direction of transfer to input. (2) Read 3 16-bit words.

Send a command. (1) Put 1 on PCLK2 to set the direction of transfer to output. (2) Write 4 16-bit words. If there are not 4 words in the command, the remaining words are zeroes.

Read a picture. (1) Send the command. (2) If the integration time is less than 5 s, read data until done. If the integration time is greater than 5 s, read the status until the integration time is less than 5 s. Then read the picture.

The base time unit of the camera board is a “tick.” All times must be sent to the umbilical board as ticks. The value of a tick has yet to be determined.

5.3.4 Data rate

The fastest rate is 5.3 Msamples/s with 4 detectors read simultaneously. Each sample has 16 bits.

The umbilical card has a 512-word buffer. The buffer can hold 0.1ms of data at the fastest rate.

5.4 Motor Controller

The motor controller drives 6 stepper motors. The controller is to be determined.

5.5 Pressure sensors

The pressure sensors are 275 Mini-convectron and 354 Micro-ion gauges from Granville-Phillips (www.granville.com). These have Device Net interfaces, which interfaces to the National Instruments PCI-DNET card.