CALIFORNIA **A**SSOCIATION FOR **R**ESEARCH IN **A**STRONOMY

Instrument Program Management

HIRES CCD Upgrade Requirements

- - - D R A F T - - -

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Revision 1.1

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1 INTRODUCTION

The purpose of this document is to indicate CARA requirements for the design and implementation of a scientific instrument for the Keck Observatory. The requirements reflect both the analysis of the science need and the proposed solution as provided by the new instrument. The requirements document is developed in the process of establishing a proposed solution to the scientific problem and is part of the documents delivered at the end of the conceptual design phase. The requirements document is then refined as the instrument project proceeds through the various design phases.

The requirements document is structured from the common disciplines that make up a typical scientific instrument for observational astronomy. The requirements document for a particular project is tailored from a general format by deleting sections that do not apply, and adding sections to cover unique requirements. The systems engineering process results in a "product structure" for the instrument, which leads in turn to the Work Breakdown Structure (WBS). The WBS relates to the requirements document in a matrix, where elements of the WBS have associated requirements in a variety of disciplines.

The primary function of the requirements document is to guide the design process for the instrument. At the conclusion of the design phase a final specification document is created and this document incorporates the performance and features requirements of the requirements document. The specification is used as the basis for review of the instrument during the fabrication phase. The specification also leads to the creation of an Acceptance Test Plan (ATP). The ATP describes the process through which the performance of the instrument is verified against the specifications.

2 SCOPE AND APPLICABILITY

This document describes the requirements for the HIRES Instrument CCD Upgrade at the Keck Observatory. This document reflects requirements that were previously established on a more informal basis and as such is not generally intended to impose requirements on components that have already been fabricated. The document does intended to clarify various requirements and to impose design and implementation requirements on components such as software and interfaces that have not been fully determined or completed.

This document establishes requirements for all aspects of the HIRES CCD Upgrade. This document also establishes requirements for changes to related sub-systems and software of the HIRES instrument as needed.

This is revision 1.1 of the document and it is in a draft form to be reviewed by CARA and HIRES CCD Upgrade team members.

3 RELATED DOCUMENTS

HIRES CCD Upgrade for The Keck 1 Telescope, Mauna Kea, Hawaii, Revision 2.91, Engineering Services, UCO/Lick Observatory, Santa Cruz, CA, July 24, 2002

This document is based in part on a preliminary outline of requirements written by Grant Hill.

4 REVISION HISTORY

Revision	Date	Author	Reason for revision / remarks
1.0	March 18, 2003	SMA	Original Issue
1.1	March 24, 2003	SMA	Comments from B. Kibrick and D. Cowley

5 BACKGROUND

The current HIRES Instrument has operated since commissioning with an engineering grade CCD detector with a 2048 x 2048 format and 24 micron pixels. There have been several improvements in CCDs suitable for HIRES since the instrument was commissioned. These improvements include:

- higher pixel counts
- smaller pixels
- improved quantum efficiency, particularly at short wavelengths
- faster readout rates
- lower read noise

The HIRES CCD Upgrade will replace the detector and associated electronics along with the Dewar and the field flattening optics. The current intent is to make the upgrade package a “plug and play” interchange with the current detector and related components.

6 OVERVIEW

The requirements document consists of ten major sections. In each section the requirements may be grouped into three broad categories: performance, implementation and design. Each requirements document may add or delete sections as needed and not every section will have all three categories of requirement.

6.1 PERFORMANCE REQUIREMENTS

Performance requirements will ultimately translate into a system specification. The performance requirements must fully define the expected system performance and will drive all of the design and implementation processes for the instrument.

Performance requirements are broadly classified as parametric and operational. Parametric requirements are quantitative and the full specification of the parameter requires a definition of the units of measure and the method of measurement.

Operational requirements define aspects of system function or usage. Operational requirements are qualitative, and their specification requires a description of the feature and how it functions. The description must include a procedure for verification of the operational requirement through test or inspection.

6.1.1 Parametric Performance Requirements

Parametric requirements include numbers that typically give a range of values for each parameter. These ranges are specified in one of two ways: typical and goal.

Typical parameter values are tabulated as follows:

Parameter	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*

These parameters have a range of values with a statistical mean represented by the typical value. Systems are normally designed to remain functional over the full range of parameter values in the worst-case combinations. It is important to note that the parameter definition must indicate when values in excess of the minimum or maximum value are a failure to meet the requirements.

Typical parameter values will normally be a major element of the specifications, and many of the parameter values in the requirements document will transition directly to the specifications. Verification of the specifications will be performed in the ATP. The parameter values in the specification will be verified through test and measurement, and it is assumed that best current practice will be used when making such measurements. If the test conditions and method of measurement are not obvious they must be specified in the

requirements. It is also expected that when the test data is presented the data will be accompanied by a detailed description of the test conditions and methods used.

Goal parameter values are tabulated as follows:

Parameter	*Min.*	*Goal*	*Max.*	*Units*	*Notes*

Some performance requirements are given as goal values accompanied by a minimum and maximum acceptable value. This is done when it is recognized that the desired value for the parameter pushes the state of technology, and therefore may not be achievable within time and budget constraints. However, it is expected that best efforts will be made to achieve the goal value. It should also be clear that it is essential to achieve at least the minimum or maximum value. It is important to note that the parameter definition must indicate when values in excess of the minimum or maximum value are a failure to meet the requirements.

Goal parameter values will normally be a smaller element of the specifications, and many of the goal parameter values in the requirements document will transition directly to the specifications. Goal parameters in the specifications will also be verified in the ATP, and it is important that the test conditions and method of measurement be specified for the testing of goal parameters.

7 OVERALL SYSTEM DEFINITION

The HIRES CCD Upgrade will replace major components of the HIRES instrument. The components to be replaced are shown in the block diagram of figure 1.

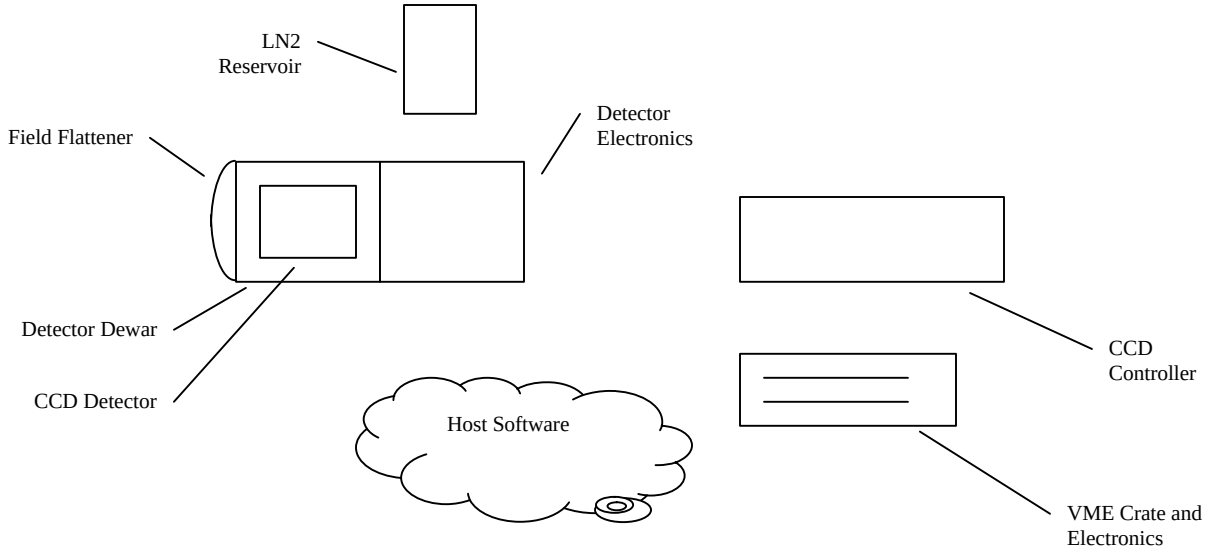

Figure 1: Upgraded Components

The main features of the upgrade are as follows:

1. 6K x 4K mosaic detector
2. Smaller detector pixels
3. Improved detector QE, lower noise
4. Faster readout speed
5. Updated detector electronics
6. Updated VME Crate electronics
7. Improved electronics packaging
8. Improved detector control software
9. New display software

The requirements for these features are included in the performance, implementation and design requirements detailed in the rest of this document.

8 OPTICAL REQUIREMENTS

8.1 PERFORMANCE REQUIREMENTS

8.1.1 Overall System

Parameter	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*
System PSF	1	2	3	pixels	FWHM, 1,2
Spectroscopic Efficiency	5	10	-	%	at 0.32µm, 3
Spectroscopic Efficiency	5	10	-	%	at 0.4µm, 3
Spectroscopic Efficiency	9	10	-	%	at 0.5µm, 3
Spectroscopic Efficiency	9	10	-	%	at 0.6µm, 3
Spectroscopic Efficiency	8	10	-	%	at 0.7µm, 3
Spectroscopic Efficiency	6	8	-	%	at 0.8µm, 3
Spectroscopic Efficiency	3	6	-	%	at 0.9µm, 3
Spectral Range	0.3	-	1.1	µm	
Spectral Resolution (R)	60,000	-	67,000	/	4
Parameter	***Min.***	***Goal***	***Max.***	***Units***	***Notes***
Velocity Resolution	<2	1.5	-	m/s^{-1}	5

Notes:

1. Measured as follows:

    1. filter1 = KV 370, filter2 = clear
    2. D5 decker (pinhole)
    3. Red collimator, Red cross disperser
    4. Echelle angle = -0.0446
    5. Cross disperser angle = -0.545
    6. 1 X 2 binning
    7. NG3 filter in front of ThAr 2 lamp
    8. 8 exposures of 8 seconds each
    9. The IRAF task SPECFOCUS is used to measure the average FWHM of all lines over the entire detector

2. Total system PSF includes detector PSF and the contribution from the instrument optics (field flattener, collimating mirrors and correction optics) and the telescope.

3. Spectroscopic efficiency is measured with both the Red and UV-blazed cross dispersers, by acquiring "slitless" spectra of spectrophotometric standard stars. Measurements are made under photometric conditions with the following procedure:

    1. 6 Observations are taken of each star
    2. the image rotator is utilized at the sky parallactic angle for each of the 6 observations
    3. Custom 6" square decker hole
    4. Calibration exposures taken with the long slit set to a 3-pixel projected width setting
    5. Cross disperser and echelle angles set to cover right-of-center of each order's blaze profile
    6. The spectra are reduced as follows:

A. Bias subtraction of stellar spectrum and calibration images
B. Flat-fielding of stellar and arc-lamp spectrum images; the correction preserves the blaze profiles
C. Extraction of stellar spectra at every column with linear background subtraction, and straight summation of signal
D. The ThAr calibration spectra are extracted and fit with a 2-d polynomial; the stellar spectra are linearized with dispersion in each order
E. The extracted spectra are extinction corrected, divided by the K1 telescope (primary*secondary*tertiary) reflectivity, and integrated over bandpasses from the STScI "medium"-resolution tables (2-10A spacing). Then, the spectra are fluxed against the tabulated brightness values
F. The maximum of the efficiency in each order is found, and the wavelength at maximum identified

4. R depends on slit width.

5. The goal value is the theoretical photon limited resolution for the wavelength range of 0.38 – 0.6 μm at the Keck 1 telescope assuming an R of 60,000 and a SNR of 300:1.

8.1.2 Detector

8.1.2.1 PSF

The detector PSF should be equal to or better than the PSF limits of the spectrograph and telescope optics.

8.1.2.2 Fringing

The detector should exhibit the smallest possible fringing amplitude in a stable pattern. There should be no detectable fringing at wavelengths less than 0.9 μm.

8.1.2.3 Format

The detector will be composed of a mosaic of three 2K x 4K CCDs with a pixel pitch of not more than 15 μm. The detectors will be arranged as shown in figure 2.

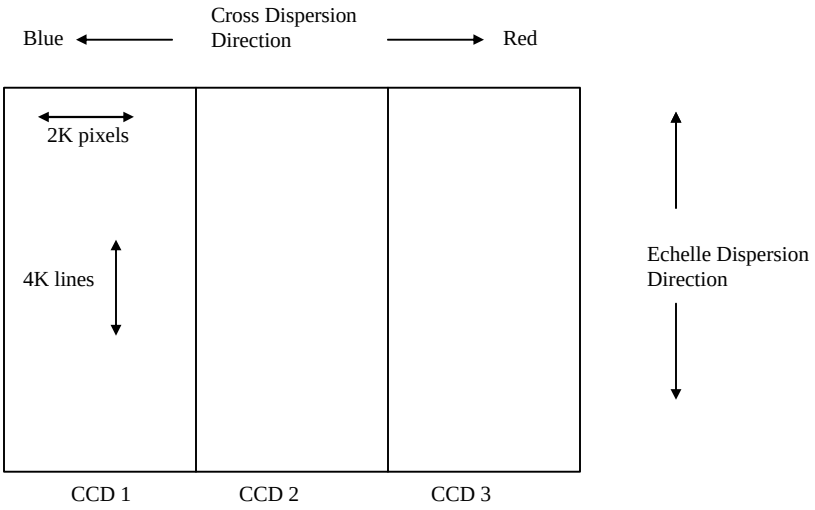

Figure 2: CCD Image Format

Devices 1 and 2 will be UV optimized devices, and device 3 should be a red optimized device.

8.1.2.4 Fill Factor

The pixel fill factor for all three CCDs should be 100%.

8.2 IMPLEMENTATION REQUIREMENTS

8.2.1 Overall System

The optical implementation of the dewar, detector and field flattener should be 100% compatible with the remaining optical components of the HIRES instrument.

8.2.2 Field Flattener Throughput

The field flattener should be AR coated to minimize transmission loss over the wavelength range of 0.3 to 1.1 μm.

8.3 DESIGN REQUIREMENTS

There are no design requirements specific to the optical components of the system.

9 MECHANICAL REQUIREMENTS

9.1 PERFORMANCE REQUIREMENTS

9.1.1 Detector

9.1.1.1 Format

The detector will be composed of a mosaic of three 2K x 4K CCD devices with a pixel pitch of not more than 15 µm.

9.1.1.2 Mosaic

Parameter	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*
Gap between devices	50	60	100	µm	1
Straightness	-	±20	-	µm	
Flatness	-	±10	-	µm	2

Notes:

1. The minimum gap has been chosen to ensure that the worst-case deviation from two parallel edges (straightness) does not cause the devices to collide.

2. The three chips must be co-planar to the extent that the PSF does not vary by more than 10% between chips.

9.1.2 Vibration

The upgraded HIRES components will have equal or better tolerance to vibration compared to the existing system. The upgraded HIRES components will not produce any new sources of vibration in the instrument or the telescope.

9.2 IMPLEMENTATION REQUIREMENTS

9.2.1 Focus Adjustment

The new dewar assembly must retain the full range of focus adjustment motion currently available in order to compensate for long term focus drift.

9.2.2 Accessories

9.2.2.1 Decker Plates

The following additional Decker plates should be provided:

Plate	Height (arc seconds)	Width (arc seconds)	Projected height (pixels)	Projected width (pixels)
E1	3.5	0.36	18	2
E2	7.0	0.36	36	2
E3	14.0	0.36	74	2
E4	28.0	0.36	147	2

9.2.2.2 Dark Cover

The dimensions of the new detector must allow the current dark cover to be used or a new dark cover must be supplied.

9.2.2.3 Special Tools

Extractor tools for plug-in printed circuit boards must be supplied. It is noted that the current design of the SDSU-II timing board does not permit use of an extractor of any kind.

Any special tools or parts necessary for spectrograph integration must be supplied.

9.3 DESIGN REQUIREMENTS

9.3.1 Overall Dimensions

All components to be installed inside the HIRES enclosure must be sized to fit through the enclosure entry door

9.3.2 Configuration

9.3.2.1 Space Envelope

The upgraded HIRES components should remain within the space envelope defined by the existing components.

9.3.2.2 Access for Cross Disperser Swaps

No portion of the upgraded HIRES components should interfere with access for cross disperser swaps.

9.3.2.3 CCD Controller Enclosure

The CCD controller enclosure (a.k.a. the foot locker) should be easily accessible for service. In the event of the loss of coolant flow provisions for rapid transition to air convection cooling are required.

9.3.2.4 Service Access

Where components that are enclosed may be removed for servicing the access doors or removable cover parts provided must be designed to create an opening large enough to permit easy and safe removal of those components.

9.3.2.5 Connector and Cable Mounting

Cable and wiring strain relieves should be designed so that strain relief and wiring integrity is not compromised by opening access doors or removing service access covers.

Connectors should not be mounted on service access covers or on access doors.

10 ELECTRONIC/ELECTRICAL REQUIREMENTS

10.1 PERFORMANCE REQUIREMENTS

10.1.1 Overall

10.1.1.1 Power Dissipation

The additional heat load imposed on the HIRES enclosure by the dewar electronics box should not exceed 2 watts. Any heat generated by "in beam" electronics must not degrade the PSF by more than 0.5% with respect to the values currently obtained from the instrument.

10.1.1.2 Compatibility

All new electronic and electrical components must be compatible with the power quality and electromagnetic environment provided by the current HIRES electrical and electronic interfaces.

10.1.1.3 Temperature and Humidity

The complete detector and electronics system shall be designed for operation in an ambient temperature range of -10° C to 30° C and a relative humidity of 95% non-condensing.

10.1.2 Detector Performance

The detector mosaic will have the following performance. All measurements are at a temperature of -120°C unless noted otherwise.

Parameter	*Min.*	*Goal*	*Max.*	*Units*	*Notes*
Quantum Efficiency	90	95	-	%	at 0.300 µm, 1
Quantum Efficiency	75	85	-	%	at 0.400 µm, 1
Quantum Efficiency	75	85	-	%	at 0.500 µm, 1
Quantum Efficiency	75	85	-	%	at 0.600 µm, 1,2
Quantum Efficiency	75	85	-	%	at 0.700 µm, 2
Quantum Efficiency	75	85	-	%	at 0.800 µm, 2
Quantum Efficiency	60	75	-	%	at 0.900 µm, 2
Quantum Efficiency	10	30	-	%	at 1.000 µm, 2
Quantum Efficiency	3	5	-	%	at 1.100 µm, 2
Residual Charge	-	1:50,000	-	ratio	3
Diffusion MTF	70	90	-	%	4
Dark Current	-	<2	<4	e-/pixel/hour	5

Notes:

1. Mean value for the UV optimized CCD devices, measured with a 10 nm line width source.
2. Mean value for the red optimized CCD devices, measured with a 10 nm line width source.
3. Residual charge is the ratio of charge remaining to full well capacity when an erase cycle is preceded by exposure to the saturation level.
4. The diffusion MTF at all wavelengths should be not less than the specified percentage of the theoretical MTF, method of measurement to be specified.
5. Measurement method to be specified.

10.1.2.1 Cosmetic Defects

All defects are characterized at a temperature of -120°C unless noted otherwise.

Parameter	***Min.***	***Goal***	***Max.***	***Units***	***Notes***
Bad Columns	-	0	4	per CCD device	1
Hot Pixels	-	<250	500	per CCD device	2
Dark Pixels	-	<500	750	per CCD device	3
Traps	-	<20	<30	per CCD device	4

Notes:

1. A bad column is one that contains at least 100 hot or dark pixels.

2. A pixel is considered hot when the spontaneous generation rate is greater than 100 e-/pixel/hour.

3. A pixel is considered dark when the responsivity over the wavelength range of 0.3μm to 1.1μm is less than 80% of the local mean signal.

4. Pixels where any charge held temporarily is greater than 200 e-.

10.1.3 Detector and CCD Controller

As a system the performance of the detector and CCD controller will be as follows:

Parameter	*Min.*	*Goal*	*Max.*	*Units*	*Notes*
Charge Transfer Efficiency	99.9990	99.9995	-	%	1
Noise	-	<3	4	RMS e-/pixel	2
Crosstalk	10,000:1	50,000:1	-	ratio	3
Readout Time	-	25	30	seconds	4
Readout Time	-	30	60	seconds	5
Spurious Charge Generation	-	<3	4	RMS e-/pixel	6
Parameter	***Min.***	***Typ.***	***Max.***	***Units***	***Notes***
Non-linearity	-	-	<1	%	7

Notes:

1. Serial and parallel, measured using charge generated by X-ray photons of known energy. Details of measurement technique to be specified.
2. Measured at a readout rate of 200 KHz (per amplifier) under laboratory conditions.
3. Between any 2 amplifiers, method of measurement to be specified.
4. Full mosaic, both amplifiers used on all three CCDs.
5. Full mosaic, one amplifier used on each CCD.
6. Using the actual operational timings required to meet the specified readout rate, method of measurement to be specified.
7. System incident flux to digitizer count transfer function non-linearity over the full range from dark to saturation, method of measurement to be specified.

10.2 IMPLEMENTATION REQUIREMENTS

10.2.1 Code Compliance

All AC line connected electrical or electronic components shall be enclosed, connected and wired in conformance with the National Electrical Code and any local codes.

Removable covers that permit access to circuits with voltages in excess of 30 volts RMS AC or 30 volts DC shall be marked with a warning label.

Removable covers that permit access to circuits of less than 30 volts RMS AC or 30 volts DC that are capable of fault currents in excess of 3.3 amperes shall be marked with a warning label.

All AC line connected equipment shall be internally protected by a fuse or circuit breaker of a type and rating that conforms to the requirements of the National Electrical Code and any local codes.

10.2.2 Detector Format

10.2.2.1 Mosaic

The detector will be composed of a mosaic of three 2K x 4K CCDs with a pixel pitch of not more than 15 µm. Two of the devices will be UV optimized, and the third device will be red optimized.

10.2.2.2 CCD Architecture

The CCDs will be full frame parallel line transfer, serial column transfer devices each having two serial register taps and amplifiers.

10.2.3 CCD Controller

10.2.3.1 Gain

At least 2 user selectable video amplifier gain settings per video input channel should be provided.

10.2.3.2 Readout Clock Rates

At least 3 different user selectable readout clock rates, common to all three CCDs, should be provided.

10.2.3.3 Readout Configurations

The readout configuration should be user selectable to use one or two serial outputs per CCD.

10.2.3.4 Binning

Pixel binning should be provided to bin 2, 3 or 4 pixels in both the line and column directions of the detector. Because 3 pixel binning is not an integer multiple of the line or column count it is understood that the last 3 pixel binned line or column nearest the center of each CCD will consist of only 2 pixels.

10.2.3.5 Windowing

Detector windowing will be provided as shown in figure 3.

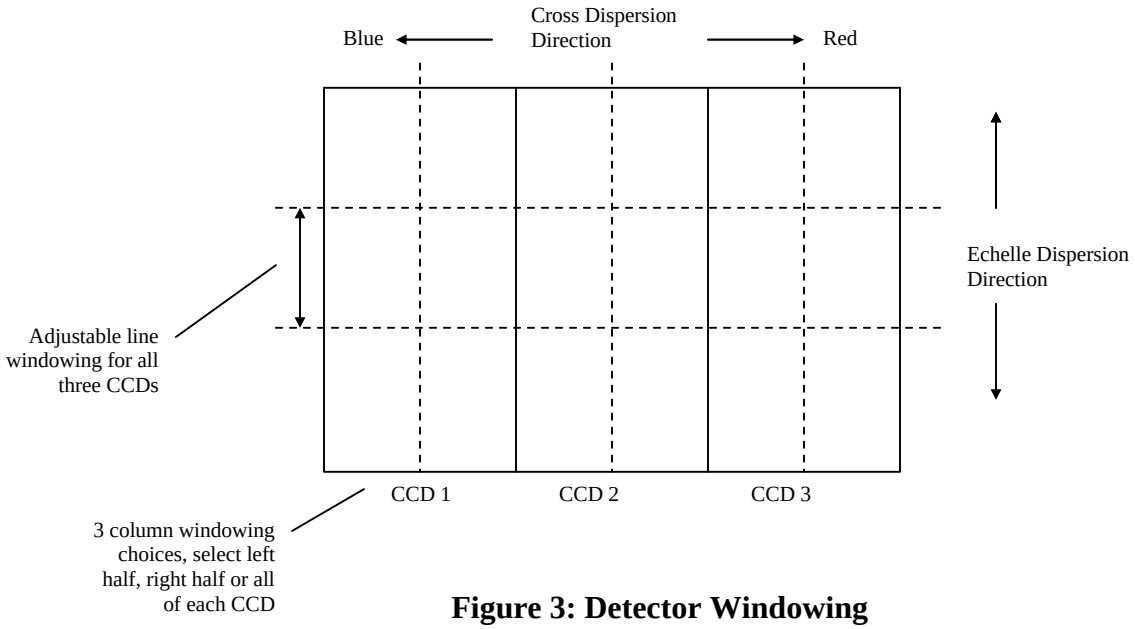

Figure 3: Detector Windowing

Selecting which CCD serial register outputs are read will perform column windowing.

Selecting the start and stop points for parallel register transfers will perform line windowing for all three CCDs.

10.2.3.6 Readout Formats

Display and storage will be selectable for any combination of the three CCDs.

The data must contain pre and post scan columns for data reduction packages that require them.

10.2.3.7 Exposure Control

Integration times will be settable in 1 second increments. Actual exposure accuracy will be a function of the performance of the existing shutter.

10.2.4 Wiring and Interconnections

10.2.4.1 Connector and Cable Mounting

Cable and wiring strain relieves should be designed so that strain relief and wiring integrity is not compromised by opening access doors or removing service access covers.

Connectors should not be mounted on service access covers or on access doors.

10.2.4.2 Cable and Wire Routing

Cables and wiring must be routed so that they do not interfere with the spectrograph beam. Cables and wiring must be routed so that full travel of moving or adjustable parts is not affected and does not place a strain on the mounting or connections of any cables or wiring.

10.2.4.3 Internal Wiring

All AC power line connected internal wiring of equipment shall be UL listed type TEW or AWM of an ampacity and voltage rating that complies with the National Electric Code and any applicable local codes.

10.2.4.4 Interconnections

All external AC power line connections shall be made with UL listed connectors and cable.

External interconnections of low voltage AC and DC circuits should be shielded whenever there is a reasonable possibility that those interconnections will be subject to electromagnetic interference or unwanted coupling.

Connectors used for low voltage AC and DC circuits should be types conforming to military specification MIL-C-26482, Series 1 and Series 2. MIL-C-5015 series connectors are also acceptable.

10.2.4.5 Cable and Wire Ratings

All wire and cable will be rated for an ambient temperature range of –30 to 100° C.

10.2.4.6 Grounding

The enclosures of all AC power line connected devices shall be provided with a protective earth ground in accord with the requirements of the National Electric Code and any applicable local codes.

All other equipment shall be ground or isolated as required by the ground circuit and shielding requirements of the instrument.

10.2.4.7 Code Compliance

All wire and cable will be of types approved by the National Electrical Code for the application.

10.3 DESIGN REQUIREMENTS

10.3.1 Exposure Control

The hardware and software implementation of the detector exposure control system should permit future implementation of different exposure times for each CCD.

10.3.2 Connector and Cable Mounting

Cable and wiring strain relieves should be designed so that strain relief and wiring integrity is not compromised by opening access doors or removing service access covers.

Connectors should not be mounted on service access covers or on access doors.

11 SOFTWARE REQUIREMENTS

11.1 PERFORMANCE REQUIREMENTS

The combined system of upgraded CCD controller software, VME crate software and host software should not crash or require a restart more than once every 400 hours of continuous operation.

The VME crate and host software should not impose additional time overheads beyond the CCD readout times.

11.2 IMPLEMENTATION REQUIREMENTS

The upgraded software will consist of three major components running on three processors, each linked via a high speed bi-directional data link.

11.2.1 CCD Controller Software

The CCD controller software will be written in DSP56K assembly language to run on the proprietary SDSU-II CCD controller implementation of the Motorola 56K family DSP.

The CCD controller software will communicate with the VME crate software via a proprietary bi-directional fiber optic data link protocol.

11.2.2 VME Crate Software

The VME crate software will be written in the ‘C’ language to run on a Power PC processor.

The VME Crate software will communicate with the Host software via TCP/IP.

11.2.3 Host Software

The host software will be written in the ‘C’ language and the Tcl language to run under Solaris 8 or Linux on a Sun SPARC or Intel x86 architecture.

11.2.4 Image Display

The image display software must provide at least the following image display and manipulation features:

1. Mouse motion performs adjustment of image contrast
2. A menu option or button will allow inverting the gray scale
3. A single mouse click will re-center the image
4. A menu option or button will allow zooming in or out by user selectable increments.
5. Selection of regions and performing statistical operations over those regions as follows:
    1. Minimum pixel value
    2. Maximum pixel value
    3. Standard deviation of pixel values
    4. 1^{st} and 2^{nd} moments for pixel values
6. A menu option or button in conjunction with a mouse selection will allow display of a one dimensional slice through the image, showing pixel value versus pixel number.
7. A menu option will be provided to allow loading images from disk for display and manipulation.
8. A menu option will be provided to allow printing an image to a hard copy device.

11.2.5 Graphical User Interface

The HIRES detector readout system should be controlled by a graphical user interface software package that provides at least the following features:

1. Gain selection
2. Readout clock rate selection
3. Readout configuration
4. User selectable pixel binning

5. User selectable windowing

6. User selectable storage and display formats

7. Exposure control setting

11.2.6 Echelle Simulator

New configuration files for the echelle simulator should be supplied.

11.2.7 Deliverables

Software deliverables should be consistent with the requirements of CARA document KSD-3 "*Software Items for the Acceptance Review*" as described in section 1 of that document.

11.3 DESIGN REQUIREMENTS

11.3.1 Keyword System

All new software must implement the existing CARA keyword system. Keywords may be added or deleted from the software as required by the changes in the instrument software.

Keywords must be provided that implement the following functions:

1. Status information for exposure, detector readout, disk I/O

2. Ion pump status information – this part of the GUI may be made obsolete by the planned move of ion pump status to the DCS. Exact requirements with respect to the ion pump are TBD.

3. Command to fill the dewar reservoir with LN2

11.3.2 Data File Formats

Data is to be written as a multi-HDU FITS file.

Multi-HDU format FITS files are to be IRAF compatible subject to the availability of current file format information.

UCO/Lick has commented:

"We recognize that there can be files, which conform to the FITS standard, from which the current routines in the IRAF package 'mscred' cannot access some of the HDUs.

We recognize that NOAO does not publish a specification for the FITS extension structure of multi-HDU mosaic files, nor for the keyword names and semantics that are expected by IRAF.

We recognize that the specifications that NOAO has published regarding multi-HDU FITS files for mosaic detectors are spread over many different web pages, incomplete, and self-contradictory.

We recognize that the IRAF software may be modified at any time such that it expects different HDU structure and/or keywords.

Nevertheless, Multi-HDU format FITS files produced by the new HIRES mosaic CCD system SHOULD be compatible with the current version of the IRAF package 'mscred' inasmuch as the input expectations of that package can be ascertained from the documentation published by NOAO."

12 INTERFACE REQUIREMENTS

12.1 PERFORMANCE REQUIREMENTS

12.1.1 Cooling Hold Time

Parameter	*Min.*	*Goal*	*Max.*	*Units*	*Notes*
Cooling Hold Time	20	24	-	hours	1

Notes:

1. Defined as the boil-off time for 90 percent of the capacity of the LN2 reservoir.

12.1.2 Implementation Requirements

12.1.2.1 LN2 Fill

The LN2 fill must have an overflow shield so that loss of vacuum does not result from O-ring freezing.

In the event of auto-fill failure, manual fill must be possible without entering the HIRES enclosure.

12.1.2.2 Stray Light

Any new encoders supplied must not introduce stray light into the spectrograph.

12.1.2.3 Vacuum

The vacuum pump port must allow use of standard fittings and mate with the Varian pumps in use on the summit.

The new dewar must be compatible with CARA's choice of ion pump.

12.1.3 Design Requirements

12.1.3.1 LN2 Fill

The dimensions of the LN2 can must allow the current liquid nitrogen fill lines to be used.

13 RELIABILITY REQUIREMENTS

The Mean Time Between Failure (MTBF) of the HIRES spectrograph when the upgrade is completed should be equal to or better than the MTBF of the instrument prior to the upgrade.

14 SERVICE AND MAINTENANCE REQUIREMENTS

The HIRES CCD upgrade should not introduce any new serviceability or maintenance requirements other than those necessitated by the additional electronic components and interconnections.

15 SPARES REQUIREMENTS

The following spare parts should be delivered with the HIRES CCD upgrade:

1. 1 “half stuffed” SDSU-II Video Board
2. 1 SDSU-II Timing board
3. 1 SDSU Clock boards
4. 1 SDSU Utility board
5. 1 spare of each power supply
6. 1 spare of each configuration of CCD interconnect cable (internal to dewar)
7. 1 spare CCD interface analog switch board, pre-amp board and filter board.

All spares should be tested by actual operation in the complete system and documentation of the testing should be provided.

16 DOCUMENTATION REQUIREMENTS

Unless otherwise specified all documents should be provided in electronic form on CD-ROM and printed in bound hardcopy form. The electronic form of documentation should be supplied in the editable file format of the software used to create the documentation and also in the Adobe® Portable Document Format (PDF) file format.

16.1 DRAWINGS

16.1.1 Introduction

The drawing package shall conform to the following standards, unless otherwise indicated.

16.1.2 Drawing Standards

16.1.2.1 Format

Each sheet shall conform to ANSI Y14.1-1980, A "*Size and Format*". Drawing size shall be determined on an individual basis.

16.1.2.2 Title Block

The title block shall identify the following:

- Development group
- Drawing number
- Title
- Designer
- Draftsman
- Scale
- Method for determining next higher assembly.

16.1.2.3 Parts Lists, Data Lists and Index lists

All drawings shall include parts and materials lists in accordance with ANSI Y14.34M-1982. All items shall be identified with an item number or other label (with reference to the drawing number if one exists) for each part or component with all information required for procurement.

16.1.2.4 Assembly Drawings

Assembly drawings shall include all relevant views required to clearly define the assembly including isometric and exploded views.

16.1.2.5 Detail Drawings

All detail drawings shall include all views, geometry, dimensions and feature controls required to duplicate the existing part in accordance with ANSI 14.5M-1982.

16.1.2.6 Multi and Sectional View Drawings

Multi and Sectional View Drawings shall be developed in accordance with ANSI 14.3M-1975 (R1980).

16.1.2.7 Fluid Power

Fluid power systems shall include schematics in accordance with ANSI14.7Y-1966 (R1980).

16.1.3 Dimensions and Tolerances

Dimensions and tolerances shall be indicated in accordance with ANSI 14.5M-1982.

16.1.4 Finishes

Surface finishes shall be described in accordance with ANSI 14.5M-1982.

16.2 MANUALS

16.2.1 Operating Manuals

Updated operation manuals shall be provided.

16.2.2 Maintenance Manuals

Updated maintenance manuals shall be provided and shall conform to the following:

- Maintenance manuals shall indicate preventive or corrective maintenance
- Maintenance procedures shall list all steps required to perform the specified maintenance
- Maintenance manuals shall reference figures (with item numbers or labels) and relevant drawings
- Maintenance manuals shall identify required tools and describe how specialty tools are obtained

- Maintenance manuals shall list supplies and where to obtain specialty supplies
- Preventive maintenance manuals shall include schedules of required maintenance
- Corrective maintenance manuals shall include trouble shooting procedures
- Corrective maintenance manuals shall include repair procedures

16.3 SOFTWARE

Software documentation should be consistent with the requirements of CARA document KSD-3 "*Software Items for the Acceptance Review*" as described in section 1 of that document.

16.4 TEST DATA

Results from all tests performed to verify conformance to these requirements are to be supplied.

All test results from characterization of the CCD devices are to be supplied. CCD test results should be supplied in the format normally used by UCO/Lick. The original raw CCD data should also be provided on an appropriate storage format (data tape or CD-ROM).