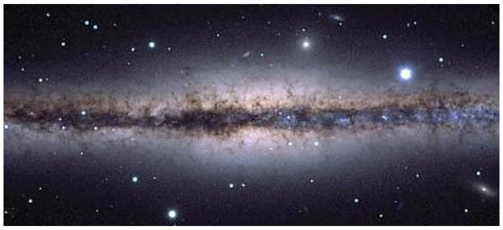

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Date

FUNCTIONAL AND PERFORMANCE REQUIREMENTS DOCUMENT

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Revision History

Revision No.	Author & Date	Approval & Date	Description
Revision 1	Andrew Sheinis July 7 2008		Original document.

Contents

1 Purpose

The SALT Robert Stobie Spectrograph NIR (**RSS-NIR**) Operational Concept Definition Document (OCDD; DOCNUMBR) defines the scientific requirements of the **RSS-NIR** instrument and describes operational scenarios. These are translated into technical requirements in the **RSS-NIR** Functional and Performance Requirements Document (FPRD). Other technical requirements for SALT facility instruments derive from the **RSS-NIR** Conceptual Design Study Statement of Work. The scientific and technical requirements are summarized in this FPRD, and their relationships are identified so that all functional and performance requirements can be traced from top-level science requirements.

The two purposes of the **RSS-NIR** FPRD are to provide the SALT scientific community with an understanding of what **RSS-NIR** will do and how quickly or how well it will do it, and to provide engineers with the requirements on which to base the **RSS-NIR** design. The design is derived from this document. This document takes precedence over other design and fabrication documents. The design must serve the requirements in this document completely. Every feature of **RSS-NIR** should be traceable to a requirement in this document, and there should be no features of **RSS-NIR** that are not required by this document.

RSS-NIR will be designed in stages, with a review after each stage is complete. Comments from the review committee will be folded into the design, so the requirements will change as the design changes. Therefore, this document will be updated as needed after each major design review to maintain the correspondence between requirements and design. This current version reflects the status at the Conceptual Design Review.

2 Applicable Documents

Document ID	Source	Title
	UWAST	**RSS-NIR** CoDR
	SALT	**RSS-NIR** CoDR report
	UWAST	**RSS-NIR** Statement of Work
	UWAST	**RSS-NIR** Operational Concept Definition Document
	EPPS	**RSS-NIR**-NIR Preliminary Optical Design
	EPPS	**RSS-NIR**-NIR Preliminary Optical Design, Appendices
	UWAST	SALT Software Design Description
	SALT	SALT Telescopes Optical Design Summary
	SALT	SALT telescope IQ summary
	SALT	Telescope to Instruments ICD
	RSS-VIS	**RSS-VIS** to **RSS-NIR**-NIR ICD
	SALT	Interlock System to Science Instruments ICD
	SALT	Science Instruments to Data Handling ICD
	SALT	Science Instruments to System Services ICD
	SALT	Instrument Components Controller ICD
	SALT	Instrument Sequencer ICD
	SALT	On-Instrument Wavefront Sensor ICD
	SALT	SALT System Error Budget Plan
	SALT	SALT Electronic Design Specification

3 Introduction

This document represents the current understanding of the capabilities and performance of the Robert Stobie Spectrograph NIR to be designed, fabricated, tested, delivered, and commissioned by the UW Madison Astronomy Instrument group for use on the SALT 11-m telescope.

The SALT 11-m telescope is designed to achieve the most light gathering capability for the smallest cost, primarily for spectroscopic science. A high-throughput, moderate spectral resolution, near-infrared, spectrograph, F-P imager and spectropolarimeter has been identified as a desirable complement to **RSS-VIS** in order to realize the scientific potential the SALT telescope. **RSS-VIS** was a fast-tracked instrument that is intended to provide this capability on the shortest possible timescale and at low cost, the **RSS-NIR**-NIR beam is an upgrade to the Visible beam that was planned from the beginning. With the exception of X-shooter, on the VLT, **RSS-NIR** will be unique among instrumentation for 8-10 meter class telescopes in its ability to simultaneously record data in the visible and NIR. It will open a new window for the discovery and study of the most distant and earliest galaxies in the universe.

The **RSS-NIR** upgrade will specialize in very high throughput, low to medium resolution spectroscopy, narrow-band Fabry-Perot imaging and spectropolarimetry over 0.8 to 1.7 microns (with at least one mode covering the entire wavelength range simultaneously). The design includes an articulated camera, Volume Phase Holographic (VPH) gratings and a single-etalon Fabry-Perot system. This is an opportunity to produce a unique instrument at relatively low-cost because it leverages the considerable effort and expense undertaken by UW researchers and others for the visible system, while preserving all of the visible capability.

RSS-NIR has passed a Conceptual Design Review (CoDR) held in Capetown, South Africa on May 7-8 2006, which resulted in full endorsement of the instrument from the SALT Board of Directors, who represents all partners in the SALT consortium. In addition **RSS-NIR** has passed a Preliminary Design Review (PDR) held in Madison Wisconsin on July 18-19 2008. At that time the review panel recommended that the instrument have a Midterm review prior to placing orders for most of the large capital items. In order to prepare for the MTR, the preliminary spectrograph design was completed, primarily at UW. The pre-construction optical design was completed by optical designer, Professor Harland Epps from the Univ. of California. A preliminary performance model was developed by the PS to analyze the effects of thermal emission, scattered light and operating temperature. A preliminary mechanical design was developed collaboratively with the University of Wisconsin engineering staff. At present this design team is analyzing critical risks and risk mitigation in advance of a Midterm Design Review scheduled in May 2009.

4 Optical Requirements

4.1 Science Requirements

The optical requirements in this section flow directly from the science cases considered in the OCDD. They are defined in the OCDD and are repeated here. **RSS-NIR** shall meet all science requirements listed below.

4.1.1 Field Size

The **RSS-NIR**-NIR will image the full 8 arcminute **RSS-VIS** FOV across the linear dimension of the 2K x 2K Hawaii 2 RG chip from Rockwell-Teledyne. Given the fixed focal-length of the visible/NIR collimator, this results in a reimaged plate-scale of 76.0 microns/arcsec. The optical design must accommodate this field size for imaging and for spectroscopy.

The reimaged scale corresponds to 0.233 arcsec/pixel or 4.2 pixels/arcsec. This plate scale is a compromise between the desire to have as large a longslit/multi-object space and imaging area as possible while simultaneously having a reasonable spatial/spectral sampling of the smallest possible slit/best seeing disc. This Nyquist-limited slit will be 0.5”, with 2 pixels across.

4.1.2 Wavelength Coverage

The wavelength coverage agreed to at CoDR 0.90-1.4 μm. The actual wavelength coverage of the system will be 0.8-1.7 μm based on the responsivity of the H2RG chip. The Dewar will contain 3 low-pass filters to limit this wavelength coverage in order to produce images and spectra that are limited in signal-to-noise ratio (SNR) by sky noise. . The wavelength range limited by the longest cut-off filter will be defined as Hshort.

4.1.3 Spatial Resolution

RSS-NIR will have slit widths of ~ 0.5” to 1.25″ and a scale of ~ 0.233″/pixel in the spatial direction.

4.1.4 Spectral Resolution

RSS-NIR will deliver spectral resolving powers of ≥ 7000 per arcsecond in each of the *J*, and *Hshort*, bands.

4.1.5 System Sensitivity

RSS-NIR should be capable of detecting unresolved sources with a *J*-band magnitude of 20.2 and in the Hshort band with a magnitude of 18.7 in 3600 s with a SNR of 10 per resolution.

4.1.6 Scattered Light Level

The total amount of scattered light illuminating the science detector must be < 2% of the total amount of light entering the **RSS-NIR** instrument ..

4.1.7 Focusing Optics Ghost Images

Ghost images generated in the **RSS-NIR** optics must be at a level below 5×10^{-4} at radii > 2″ from the parent image.

4.1.8 Polarimetry

RSS-NIR will have the capability to acquire stokes parameters of a **TBD** mag source at **TBD** percent polarization in 3600 s.

4.1.9 Calibration
An array of slits will be supplied for calibration purposes in the Focal Plane.

RSS-NIR will derive artificial calibration sources from the facility SALT Calibration Unit, which will need to be equipped with the following PenRay lamps:Ar-Hg,Xe,Ne, Kr. (See RSS-NIR ICD)

4.2 Image Quality and Optical Tolerances

4.2.1 RMS spot size
The increase in total RMS spot size of the NIR beam due to wavefront error introduced by the **RSS-NIR** portion of the spectrograph optical system will be no greater than 10 um rms radius over the wavelength range of 0.8 to 1.7 microns, in spectroscopic mode and no greater than 15 um rms radius in polychromatic J or Hshort band imaging.

4.2.2 Alignment
The ability to accurately align the instrument with the telescope is critical to minimizing background flux. A means of establishing alignment of the cold stop to within 1% of the projected size of the primary mirror shall be provided.

Notes and Comments
1. This requirement does not necessarily lead to the inclusion of interactive alignment aids in the design. Off-telescope alignment, together with a verification test could suffice.

4.2.3 Focus
A means to focus the NIR beam independent of the visible beam will be possible. Nominally this will be a focus stage on elements L4-L5 in the camera, alternatively this will be a focus stage on the detector.

4.3 Internal Instrument Background

4.3.1 Thermal background Light Level
The total amount of thermal background light at the science detector must less than the intra-OH sky background at an R=7000 using one of the 3 wavelength cutoff filters.

4.3.2 Background due to Dust on Entrance Window
Although not strictly 'internal', the contribution to instrument background from ambient temperature dust on the **RSS-NIR** entrance window and other surfaces upstream can be significant. The design calls for an enclosed purged space by the entrance window to the pre-Dewar, which mitigates thermal emission from that surface. Nonetheless, RSS-NIR shall be deemed as having satisfied stray light and ambient background levels with a clean entrance window as well as clean telescope optics feeding the spectrograph.

4.4 Throughput

4.4.1 System Efficiency in VPH Mode
RSS-NIR will have a total system throughput of the NIR portion of the beam over its required wavelength range of ≥ **40% at peak blaze and 28% at the edge of the order if SolGel coatings are used and** ≥ 35% at peak blaze and 25% at the edge of the order if conventional AR coatings are used, including grating, dichroic and filter losses.

4.4.2 Filters
RSS-NIR shall have a bay of 12 filters, which will be changeable with no impact to the optical system during the daytime operations support.

4.5 General Optical Requirements

RSS-NIR shall meet the general optical requirements listed below.

4.5.1 Cold Stop
RSS-NIR shall provide a cold stop operated at the ambient temperature of the pre-Dewar (-40 C nominal), at or close to an image of the telescope pupil (the primary mirror).

4.5.2 Coatings
The characteristics of all optical coatings shall be specified in design documentation.

All coatings shall be unaffected by repeated thermal cycling over the operating, storage, and transportation temperature ranges.

4.5.3 Pre-Dewar Thermal Environment
All pre-Dewar optical components and coatings shall meet all performance requirements when operated at the pre-Dewar operational temperatures, nominally -40 C.

4.5.4 Vacuum Environment
All cryogenic Dewar optical components and coatings shall meet all performance requirements when operated in a vacuum of less than 10^{-5} Torr at operational temperatures down to 100 K.

4.5.5 Thermal Cycling
The performance of all optical components and coatings in the cryogenic Dewar shall not be degraded by repeated thermal cycling at a maximum rate of temperature change of 0.5 K/minute.

5 Detector Requirements

The **RSS-NIR** detector systems shall conform to the following requirements.

5.1 Science Detector Performance Requirements

5.1.1 Detector Read Noise
RSS-NIR should employ read noise reduction techniques, such as linear fitting up the ramp, to achieve an effective read noise of < 20 e.

5.1.2 Dark Current
The **RSS-NIR** detector should have a dark current < 0.1 e s^{-1} pix^{-1} with a goal of < 0.01 e s^{-1} pix^{-1}.

5.1.3 Stability

5.1.3.1 Bias Variations
Over a period equal to the longest integration time of 3600 s, bias variations shall be less than the read noise.

5.1.3.2 Gain Variations
Over a period equal to the longest integration time of 3600 s, gain variations shall be less than the photometric stability of the atmosphere, which is taken to be 1%.

5.2 Science Detector Requirements

5.2.1 Detector Format
RSS-NIR shall be designed to use a HgCdTe science detector array with a format of 2048×2048, with 18 μm square pixels.

5.2.2 Characteristics
The **RSS-NIR** shall be designed to take the fullest possible advantage of an HAWAII-2 HgCdTe detector with the following characteristics:

a) Number of pixels: 2048 (H) × 2048 (V).
b) Architecture: 4 independent 1024×1024 quadrants.
c) Pixel size: 18 μm, square.
d) Effective fill factor: 90%.
e) Maximum frame rate: 1 frames/0.33 seconds.
f) IR material: HgCdTe.
g) Full well: > 65,000 electrons at optimum bias.
h) Wavelength range: 0.8 to 1.7 μm.
i) Nominal operating temperature: 120 K.
j) Dark current: <1 electron/second, goal 0.01 electron/second.
k) Read noise: < 20 electrons (rms), goal 5 electrons (rms).
l) Quantum efficiency: >50% (0.8 to 1.7 μm).

5.2.3 Mechanical Interface
The detector shall be mounted such that, once adjusted, it can be removed and reinstalled without necessitating optical realignment.

5.2.4 Thermal Interface

The science array will be thermally coupled to the cold head by high thermal conductivity material. The detector shall be maintained at operating temperature by an actively controlled electric heating element.

5.2.5 Optical Interface

Means will be provided to measure the science detector defocus error under operational conditions, and then adjust the position of the science detector with a precision that is finer than that corresponding to the spatial resolution of the instrument.

5.2.6 Electrical Interface

The electrical interface to the detector is through a suitable connector.

5.3 Science Detector Controller

RSS-NIR will use as the science detector controller, the SIDECAR ASIC controller and the JADE-2 subsystem interface card, both provided by Teledyne.

5.3.1 Mechanical Interface

The SIDECAR controller shall be mounted internal to the cryostat. The JADE-2 controller interface card will ,be mounted on the cryostat, external to the vacuum enclosure.   The power supply shall preferably be mounted in one of the near-by electronics enclosures.

6 Mechanical Requirements

6.1 Rigidity

RSS-NIR shall be designed to be rigid, and to meet all the requirements listed below.

6.1.1 Alignment of the Instrument to the Telescope Optics

The position of the **RSS-NIR** cold stop with the primary mirror image shall be maintained to 1/10th the accuracy specified in 4.2.2 in any attitude of the telescope and rotator.

6.1.2 Movement of Spectra on the Detector

RSS-NIR shall be designed so that flexure in the instrument shall result in the image of the spectra on the detector moving less than 1 pixel per any 1 hour integration of the instrument.

6.2 Mechanical and Thermal Tolerances

Where adequate mounting precision cannot be provided by dead reckoning, convenient means will be provided to measure the misalignment of optical components of the spectrograph under ambient conditions, and then adjust their alignment with a precision that allows the optical performance specification to be met. Where thermally induced misalignment is significant, theoretically derived compensation will be applied.

6.3 Thermal Performance

6.3.1 Temperature Gradients

Thermal effects due to temperature gradients outside the cryostat and pre-Dewar , inside the cryostat, and near the detector shall be considered in the design of **RSS-NIR**. Realistic limits will be set according to performance requirements.

6.3.2 Thermal Transients

Thermal transient effects during cool-down or warm-up shall be considered in the design of **RSS-NIR**. Realistic limits will be set according to the performance requirements.

6.4 Space Requirements

RSS-NIR shall be designed to fulfill the space requirements as specified in the instrument ICD.

6.4.1 Electronic Enclosures

All **RSS-NIR** electronic enclosures mounted on the payload shall be counted in the space requirements given above.

6.4.2 Access to Electronic Enclosures

The electronic enclosures shall be accessible without removing **RSS-NIR** from the PAYLOAD.

6.4.3 Access to SALT Facility Glycol Ports

SALT facility glycol ports on **RSS-NIR** shall be accessible without removing the instrument from the PAYLOAD.

6.4.4 Access to Dry Air Ports

Dry air ports on **RSS-NIR** shall be accessible without removing the instrument from the PAYLOAD.

6.4.5 Mechanical Connections
All subsystems on the **RSS-NIR** shall be accessible without removing the instrument from the PAYLOAD with the exception of slit cooling if implemented.

6.5 Mass and Center of Gravity Requirements

RSS-NIR shall meet all mass and center of gravity requirements listed in the instrument ICD.

6.5.1 Total Mass
RSS-NIR, including its support frame, thermal enclosures, electronics, and all cabling and services connections, that reside on the payload, shall have a mass as defined in the ICD.

6.5.2 Center of Gravity
RSS-NIR, including its support frame, thermal enclosures, electronics, and all cabling and services connections, that reside on the payload, shall have a center of gravity, in all configurations, on the port axis as specified in the ICD from the mechanical interface on the PAYLOAD.

6.5.3 Ballast Weight
A ballast weight and its supporting structure shall be supplied as required to meet the above requirements.

6.6 Cryogenic Cooling System

RSS-NIR shall meet all cooling system requirements listed below.

6.6.1 Cool Down Time
The **RSS-NIR** cryogenic cooling system shall have the capability to cool the instrument from room temperature to operating conditions in 7.2 hours or less.

The **RSS-NIR** Pre-Dewar cooling system shall have the capability to cool the instrument from room temperature to operating conditions in 2.5 hours or less.

6.6.2 Warm Up Time
RSS-NIR shall not require more than 7.2 hours to warm up the entire instrument from operating conditions to room temperature.

6.6.3 Thermal Stability of cryogenic Dewar
The surface on which the dewar optical system is mounted shall have a passive temperature control system providing a variable temperature to be referenced to the center of the cold work surface between 100 K and 140 K with a stability of ± 1.0 K.

The **RSS-NIR** detector assembly shall have an active temperature control system providing a variable temperature to be set at the optimum temperature for the detector between 100 K and 140 K, with a stability of ≤ ± 0.1 K.

6.6.4 Thermal Stability of Pre-Dewar
The interior volume of the Pre-Dewar in which the optical system is mounted shall have an active temperature control system providing a variable temperature to be referenced to the center of the cold work surface between -33C and -40C with a stability of ±0.5 K.

6.6.5 Vibration
Adequate measures shall be taken to ensure that the use of cryogenic closed cycle coolers shall not introduce sufficient vibrations into the mechanical structure to prevent meeting all rigidity, alignment, tracking, and other performance requirements.

6.7 Vacuum System

6.7.1 Staging and Holding Areas
RSS-NIR will use the same vacuum system facilities in the staging and holding area as the **RSS-VIS**.

6.8 Operational Requirements for Mechanisms

The **RSS-NIR** mechanisms shall meet the requirements listed below.

6.8.1 Safety
No mechanism shall move in the event of loss of electrical power.

6.8.2 Time to Function
A complete reconfiguration of the instrument should be achieved in < 1 min for 80% of the reconfigurations and < 1.5 minutes for 100% of the reconfigurations.

6.8.3 Repeatability of Configuration
The total error at the detector resulting from reconfiguration of all mechanisms shall be less than 5.0 pixels.

6.9 Instrument Handling

The **RSS-NIR** support frame shall have mounting points allowing the instrument to be lifted, moved and stored free-standing, and attachment points for the SALT instrument handling facilities.

6.10 Metric Dimensioning

Metric dimensions and drawing conventions per ISO standards shall be used in **RSS-NIR**.

6.10.1 Metric Dimensions on Drawings
Metric dimensions in millimeters shall be used in all as-built drawings.

6.10.2 Metric Fasteners
All screws, bolts, nuts, tapped holes, and fasteners shall be of standard metric sizes, and called out as such on the as-built drawings, except for off-the-shelf equipment required in the RSS-NIR.

7 Control System Requirements

RSS-NIR shall meet all general control system requirements given below.

7.1 Operability

Filter and grating change mechanisms, and other controllable features of **RSS-NIR** shall be controllable by computer through the standard LabView control paths from the Instrument Control System.

7.2 Configuration Time

The control system overhead on the mechanism configuration times shall be such that the total **RSS-NIR** configuration time is within the limit set by section 6.8.2.

7.3 General Control System Requirements

7.3.1 Impact on Mechanism Accuracy
The control system for **RSS-NIR** shall be designed so that the accuracy of the controllable mechanisms is not limited by the performance of the control system.

7.3.2 Impact on Scientific Performance
The control system shall not impact on the scientific performance of **RSS-NIR**. In particular, attention shall be given to the impact of the control actuators and sensors on the thermal regime of the instrument, including their thermal radiation.

7.4 Temperature Control

The control system shall control the temperature of the detector, SIDECAR and the optical elements.

7.4.1 Detector Temperature
The control system shall regulate the detector temperature as specified in section 6.6.3.

7.4.2 Cryogenic Dewar Optical Elements Temperature
The design of **RSS-NIR** shall provide for optical elements in the cryogenic dewar to be temperature stabilized by heat sinking to a cold plate which is temperature controlled by the control system.

7.4.3 Pre-Dewar Optical Elements Temperature
The design of **RSS-NIR** shall provide for optical elements in the pre-Dewar to be temperature stabilized by convective cooling of an inert dry gas or dry air.

7.4.4 Limiting Rate of Temperature Change-cryogenic Dewar
If the thermal characteristics of **RSS-NIR** introduce extreme rates of temperature change on cooling down, the temperature control system shall limit the rate of change at the detector to 0.5 K per minute.

7.4.5 Limiting Rate of Temperature Change-Pre-Dewar
If the thermal characteristics of **RSS-NIR** introduce extreme rates of temperature change on cooling down, the temperature control system shall limit the rate of change in the Pre-Dewar to 0.5 K per minute.

7.4.6 Warming Up of the Dewar

If the thermal characteristics of **RSS-NIR** are such that warming up by turning off the cryo-coolers will not meet the requirement in section 6.6.2, the temperature control system shall actively heat the detector and the cold plate to speed the warming up, so that **RSS-NIR** meets this requirement, but the rate of change of temperature shall be limited to 0.5 K per minute.

7.4.7 Warming Up of the Pre-Dewar

If the thermal characteristics of **RSS-NIR** are such that warming up by turning off the Pre-Dewar chiller will not meet the requirement in section 6.6.2, the temperature control system shall actively heat the Pre-Dewar to speed the warming up, so that **RSS-NIR** meets this requirement, but the rate of change of temperature shall be limited to 0.5 K per minute.

8 Electrical and Electronic Requirements

8.1 Electronic Design Requirements

8.1.1 Grounding and Shielding

Separate ground returns shall be provided for low level signals, noisy components such as relays and motors, and hardware components such as mechanical enclosures, chassis, and racks.

8.1.2 Electrostatic Discharge

The **RSS-NIR** design shall protect sensitive components from electrostatic discharge.

8.2 Cable Wrap Interfaces

The requirements on the electrical and electronics interfaces with the cable wrap are included in the instrument ICD

8.3 Temperature Monitoring

In addition to the sensors for temperature control, temperature sensors are required to monitor the cryogenic environment within the Dewar's vacuum jacket and at the detectors. These will be used to tune the thermal regime of the instrument and for maintenance purposes.

8.3.1 Temperature Sensor Locations

Auxiliary temperature sensors will be located as follows:

1. On the cold head of the cryocooler, inside of the Dewar.
2. On the attachment of the coldstrap to the detector heater block.
3. On the detector cold frame.
4. On the SIDECAR cold frame.
5. On the attachment of the coldstrap from this cryocooler to the cold work surface.
6. On the edge of the cold work surface furthest removed from the cryocooler cold straps.
7. On the getter assembly which is connected to the second stage of the cryocooler which is not used to cool the science detector.
8. On the filter wheel motor

8.3.2 Temperature Sensor Interfaces

The temperature sensor read-out interface shall be part of the Engineering Interface as described in 9.3.

Notes and Comments

1. **RSS-NIR** electronics temperature is monitored by the SALT thermal enclosure system. Power to the thermal enclosures will be cut if the temperature exceeds 50°C.

9 Software Requirements

9.1 Software Design Requirements

RSS-NIR shall be a "conforming" instrument, in that it shall use Labview and conform to SALT software and control system standards and the requirements listed below.

*9.1.1 Use of **RSS-VIS** Controller Software Package*

The **RSS-NIR** software engineers shall be guided by the SALT-furnished **RSS-VIS** Instrument Control System (ICS).

9.2 SALT Furnished Software

SALT shall furnish a complete and final set of all Interface Control Documents, and shall provide updates as they become available.

9.3 Engineering Interface

RSS-NIR shall provide a means for command and control of **RSS-NIR** mechanisms and science array controller, and data capture from the science array without the need for having SALT control systems (i.e., the Observatory Control System and the Telescope Control System) present or connected.

9.3.1 User Interface

To the extent practicable, the user interface in the Engineering Interface should appear to a user to be similar to the **RSS-VIS** User/Engineering Interface.

9.3.2 Command and Control

The Engineering Interface shall be capable of commanding and controlling all **RSS-NIR** mechanisms and reading status from all **RSS-NIR** sensors.

9.3.3 Data Capture

The Engineering Interface shall be capable of capturing data from **RSS-NIR**.
Notes and Comments

1. Not all data readout modes need be supported. The data that is captured may require extensive processing normally done by the **RSS-NIR** Instrument Control System or the SALT Data Handling System to be intelligible. There is no requirement for the Engineering Interface to perform this data processing, which may be done off-line on another system to analyze results. The Engineering Interface may send de-scrambled data to the DHS to be shown in a Quick Look Display.

9.4 Data Processing

The **RSS-NIR** Detector Controller software will perform data processing and send the processed data to the SALT Quick Look Displays as well as the raw data to the Data Handling System.

On-line data assessment will be provided for **RSS-NIR** in accordance with the descriptions in the Operational Concept Definition Document through a combination of Quick Look Displays and the Data Handling System data pipeline.

Separate View Mode and Observe Mode Quick Look Display channels will be maintained.

View Mode data will be processed for display by the Detector Controller and displayed in the View Mode Quick Look Display, but will not be archived.

Observe Mode data will be processed for display by the Detector Controller and displayed in the Observe Mode Quick Look Display and the raw data will be archived.

The View Mode and Observe Mode Quick Look Displays will display the detector image, a reformatted image of the sky compressed in the spectral direction, and a sky-subtracted spectrum extracted from a specified position within that image.

Separate pre-recorded images will optionally be subtracted from raw data by the Detector Controller before display in the View Mode and Observe Mode Quick Look Displays.

The image compression region of the View Mode and Observe Mode reformatted images of the sky will be specified by a central wavelength in microns and an image compression spectral range in either microns or velocity in km s^{-1}.

The compressed image of a continuum spectral region will optionally be subtracted from the View Mode and Observe Mode reformatted images of the sky by the Detector Controller before display.

The continuum spectral region subtracted from the View Mode and Observe Mode reformatted images of the sky will be specified by a central wavelength in microns and a spectral range in either microns or velocity in km s^{-1}.

The View Mode and Observe Mode extracted spectra will be specified by a central (x,y) pixel coordinate in the image of the sky, a circular aperture radius in pixels, a sky annulus inner radius in pixels, and a sky annulus width in pixels.

Acquisition and display of data obtained in View Mode will be defined by a set of View Mode parameters; detector read out method, integration time, number of coadds, number of Fowler samples, Non-Destructive Read (NDR) period, number of NDRs, image subtraction flag, subtraction image file name, image compression region central wavelength, image compression region wavelength range, continuum spectral region central wavelength, continuum spectral region wavelength range, extracted spectrum (x,y) center, extracted spectrum aperture radius, extracted spectrum sky annulus inner radius, extracted spectrum sky annulus width.

Acquisition and display of data obtained in Observe Mode will be defined by a set of Observe Mode parameters; detector read out method, integration time, number of coadds, number of Fowler samples, Non-Destructive Read (NDR) period, number of NDRs, image subtraction flag, subtraction image file name, image compression region central wavelength, image compression region wavelength range, continuum spectral region central wavelength, continuum spectral region wavelength range, extracted spectrum (x,y) center, extracted spectrum aperture radius, extracted spectrum sky annulus inner radius, extracted spectrum sky annulus width.

The View and Observe Mode Quick Look Displays will be capable of processing and displaying data frames in less than 10s.

10 External Interfaces

10.1 Payload Interfaces

10.1.1 Instrument Support Structure Interface
RSS-NIR shall interface mechanically to the SALT Instrument Support Structure (PAYLOAD) through **RSS-VIS**.

10.1.2 Dry Air Interface
REQ-FPR-0606: **RSS-NIR** shall obtain dry-air and return low-pressure air through the connectors provided inthe payload as specified in the ICD.

10.1.3 Electric Power Interface
REQ-FPR-0611: **RSS-NIR** shall derive its electric power through the connectors provided on the payload.

10.1.3.1 Number of Electrical Connections
RSS-NIR shall have two electric power connections for the entire instrument. One connection will provide "clean" power for the computer and electronics, while the other will provide "dirty" power for the cryo-coolers and fans. The "dirty" connection should provide optional 220 Volt, 3 phase power for the cryo-coolers. **RSS-NIR** shall have appropriate runs from a junction box to serve all instrument power needs.

10.1.4 SALT Facility Glycol Interface
RSS-NIR shall derive cooling SALT facility glycol supply (and return) for electronic enclosures and any other use through the connectors provided on the payload.

10.1.4.1 Number of Plumbing Connections
RSS-NIR shall have one glycol supply connection and one return line connection for the portion of the instrument on the payload. **RSS-NIR** shall have appropriate tees from these lines to serve all instrument payload needs.

10.1.4.2 Resistance to Glycol
The glycol lines and connectors shall not be damaged in any way when used with a cooling solution containing ethylene glycol.

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10.1.5 Signal, Control, and Data Interfaces
RSS-NIR shall receive and provide all signal, control, and data paths through the connectors provided on the payload.

10.1.5.1 Number of Signal, Control, and Data Connections
RSS-NIR shall have one connection for the entire instrument to the appropriate Cassegrain Rotator Utility Box for each of the following, if needed:

Circuit	Connector Type Cable Wrap	Instrument	Cable Connector
TBD	TBD	TBD	TBD

RSS-NIR shall have appropriate tees from these lines to serve all instrument needs. In/out signals marked with * must be bridged at the cable wrap connector plate when not connected to instruments.

10.1.6 Dry Air Interface
RSS-NIR shall derive dry air for flushing the cryostat window from the supply line on the payload as per the instrument ICD.

10.1.6.1 Number of Air Line Connections
RSS-NIR shall have one connection to the air supply for the entire instrument. **RSS-NIR** shall have appropriate tees from this line to serve all instrument dry air supply needs.

11 Environmental Requirements

11.1 Altitude Environment

RSS-NIR shall be capable of being transported, stored, and operated in a wide range of altitude environments.

11.1.1 Transportation Altitudes
RSS-NIR shall be capable of being transported at any altitude between -70 m and 4,200 m by any transportation mode. **RSS-NIR** shall be capable of being transported by commercial jet with pressurized cargo compartments at altitudes up to 15 km.

11.1.2 Storage Altitudes
RSS-NIR shall be capable of being stored in or out of its shipping container at any altitude between -70 m and 4,200 m.

11.1.3 Operation Altitudes
RSS-NIR shall be capable of being operated at any altitude between -70 m and 2000 m.

11.2 Temperature Environment

11.2.1 Operational Environment
RSS-NIR operational temperature environment shall be limited to -10 to +25°C.

11.2.2 Survival Environment
RSS-NIR shall be capable of surviving a temperature range of -20 to +45°C without damage.

11.2.3 Transport Environment
RSS-NIR shall be capable of withstanding a temperature range of -20 to +50°C during transport without damage.

11.3 Humidity Environment

RSS-NIR shall be capable of being transported and stored, in a wide range of humidity environments in the range 0 to 100% relative humidity, with condensing moisture.

Notes and Comments

1. Operation of **RSS-NIR** at high relative humidity levels may cause condensation on the Pre-Dewar window. Using heaters on the window or a hot air system are incompatible with the thermal management of the telescope. Dry, ambient temperature air will be provided in the PAYLOAD for window flushing.

11.4 Vacuum Environment

RSS-NIR shall maintain a vacuum inside the cryostat.

11.4.1 Creating the Vacuum

REQ-FPR-0708: **RSS-NIR** shall provide a means to evacuate its cryostat while the instrument is on its handling rig in the instrument support area, and while it is attached to the PAYLOAD.

11.4.2 Vacuum Quality and Duration

RSS-NIR shall be capable of being kept cold and operated without measurable degradation of scientific performance for 6 months.

If needed, the instrument shall be capable of being kept at room temperature without contamination of the detector or internal optics significantly affecting the scientific performance, for at least 3 months without pumping.

Notes and Comments

1. Instruments will be pumped down in the instrument support facility, then transported to the telescope.
2. Operating vacuum may only be obtained with a cold instrument.

11.5 Mechanical Environment

RSS-NIR shall be capable of operating in the mechanical environment of the SALT telescopes and their base facilities, and shall be capable of withstanding shipment among Madison, Capetown and Sutherland.

11.5.1 Telescope Slew Rates

RSS-NIR shall be capable of withstanding slew rates of 2° per second in combination with rotation of the rotator to maintain alignment with the parallactic angle as it changes at these slew rates. All optics and mechanisms shall meet their flexure and alignment specifications at these rates.

Notes and Comments

1. The rotator requires faster slew rates than specified for maintaining parallactic angle.

12 Other Requirements

12.1 Documentation

RSS-NIR shall be delivered with adequate documentation to facilitate the operation, maintenance, and repair of the instrument.

12.1.1 User's Manual
The Users Manual shall be written to enable a new user of **RSS-NIR** to easily get acquainted with the operation of the instrument.

12.1.2 Service and Calibration Manual
A manual shall be written to enable SALT technical support personnel to maintain **RSS-NIR**. This manual shall include documentation to describe the observations required to allow spectral and spatial calibration of **RSS-NIR** data.

12.1.3 Software Maintenance Manual
A Software Maintenance manual shall be provided to enable SALT software maintenance staff to maintain the **RSS-NIR** software.

12.1.4 As-Built Drawings
The as-built drawings shall be as specified in section 6.10.

12.1.5 Drawing Standards
All drawings shall comply with SALT approved standard.

12.1.6 Drawing Numbering System
All drawings shall be numbered in accordance with SALT instructions.

12.1.7 Drawing Filing System
Drawings will be maintained in electronic format. Final drawings will be converted to PDF format and paper based print-outs will be produced when necessary. A database of drawings will be maintained in Microsoft Access format.

Notes and Comments
1. Final released drawings will be maintained by UWAST.
2. The software applications needed to access or read the electronic versions includes:
   Solidworks version 2009.

12.2 Training

The **RSS-NIR** development team shall provide training documentation and a training course to SALT operations personnel on the operation, maintenance, and repair of **RSS-NIR**.

12.3 Reliability

RSS-NIR shall be designed and built to be reliable.

12.3.1 Downtime

RSS-NIR will have a downtime of < 5% scheduled time on the telescope and where possible, component failure shall result in gradual performance degradation.

12.3.2 Spares

Single point failures that may result in significant downtime shall be determined and, where necessary, critical spares shall be identified.

12.3.3 Continuous Duty

RSS-NIR shall be designed and built for continuous operation. Modules containing moving parts, e.g., cryo-cooler cold heads, shall be designed or selected to meet the ICD assuming continuous operation.

12.4 Maintainability and Serviceability

RSS-NIR shall meet the SALT requirements for maintainability.

12.4.1 Standard Components

Wherever possible, **RSS-NIR** shall use unmodified commercially available standard components.

12.4.2 Modularity

To the extent possible, **RSS-NIR** shall be designed to be modular.

12.4.3 Access

Access to components and subassemblies shall be considered in the **RSS-NIR** design, particularly for those elements that are accessed frequently. Tool and hand clearances shall be considered, as well as space required to remove modules, visual access to components (or a means to feel their correct position and alignment, e.g., for electronic connectors).

12.4.4 Alignment

Alignment of optical components shall be achieved to the greatest extent possible by accurate machining of locating fixtures.

12.4.5 Relative Equipment Arrangements

Equipment shall be located with due consideration of the sequence of operations involved in maintenance procedures. To the greatest extent possible, the most accessible locations shall be reserved for the items requiring most frequent access.

12.4.6 Handling

Modules greater than 15 kg in mass shall have suitable handles for use in removing, replacing, and carrying them. Handles shall be located such that the vector sum of resultant handling forces shall pass close to the center of gravity of the unit.

12.5 Lifetime

RSS-NIR shall be designed for an operational lifetime of 15 yr without a major overhaul. Components likely to affect the lifetime requirement shall be identified.

12.6 Materials

12.6.1 Toxic Products and Formulations

No toxic products and formulations are required for the development, construction, and maintenance of **RSS-NIR**.

12.7 Electromagnetic Radiation

12.7.1 Electromagnetic Radiation Generation

RSS-NIR shall not significantly add to the electromagnetic radiation of its operating environment.

12.7.2 Susceptibility to Electromagnetic Radiation

RSS-NIR performance shall not be compromised by the existing electromagnetic radiation of its operating environment.

12.8 Workmanship

Standard RSAA workshop practices shall apply to workmanship in development and construction.

12.9 Safety

Normal considerations, including compliance with applicable regulations shall apply in the areas of mechanical, electrical, and electrostatic safety.

12.10 Human Engineering

Human engineering considerations shall apply especially with respect to handling of system items required in readying **RSS-NIR** for use on the telescope and its removal after use, and in the design of the user interfaces.

13 Appendices

13.1 List of Acronyms

FPRD	Functional and Performance Requirements Document
RSS-NIR	Robert Stobie Spectrograph, NIR
ICD	Instrument Control Document
ICS	Instrument Control System
UWAST	UW Madison Astronomy Department
PAYLOAD	Instrument Support Structure
OCDD	Operational Concept Definition Document
OCS	Observatory Control System
TCS	Telescope Control System

13.2 Requirements Tabulation

The following table shows the progress towards meeting the requirements at each of several milestones.

Notes and Comments

TBD The requirement has not been (fully) defined yet.
UWAST Des The requirement should be met by UWAST design.
(UWAST)Des The requirement will be met by fabrication phase adaptation of UWAST design.
Des The requirement is met by the current state of the design.
RSAA The requirement is met by RSAA design and manufacturing procedures.
TOC A table of contents has been prepared for this manual.
Doc A (draft) document has been prepared.
SALT The requirement is to be met by extensions to the SALT Observing Tool.
OK SALT has supplied the required information.
No The current state of the design does not meet the requirement.

Requirement	Description	PDR	CDR	Integration Tests	Acceptance Tests
	Wavelength Coverage				
	Spatial Resolution				
	Field of View, distortion				
	Strehl Ratio				
	Spectral Resolution				
	System Efficiency				
	System Emissvity				
	Scattered Light				
	Ghost Images				
	Contrast Ratio				
	Detector Read Noise				
	Detector Dark Current				
	Mechanisms Time to Function				
	Not used				
	Downtime				
	Data assessment				
	View and Observe Mode OLDs				
	View Mode data displayed				
	Observe Mode data displayed and archived				
	Continuum subtraction				
	Continuum subtraction specification				

Requirement	Description	PDR	CDR	Integration Tests	Acceptance Tests
	Spectra display specification				
	View Mode parameters				
	Observe Mode parameters				
	Display Time				
	Artificial Calibration Sources				
	Polarimetry				
	System Sensitivity				
	Point sources K≥3				
	Not used				
	Cold Stop Alignment				
	Focus				
	Not Used				
	Optical Baffling				
	Not Used				
	Vignetting				
	Order Sorting Filters				
	Not Used				
	Cold Stop				
	Coatings Characteristics				
	Coatings and Thermal Cycling				
	Not Used				
	Optical Components in Vacuum				
	Optical Comp Temp Cycling				
	Detector Bias Variations				
	Detector Gain Variations				
	Detector Format				
	Not Used				
	Detector Characteristics				
	Not used				
	Detector Mechanical Interface				
	Detector Thermal Interface				
	Detector Optical Interface				
	Detector Electrical Interface				
	Detector Controller				
	Detector Controller Mech I/F				
	Detector Controller Thermal I/F				
	OIWFS Detector				

Requirement	Description	PDR	CDR	Integration Tests	Acceptance Tests
	OIWFS Detector Controller				
	OIWFS Det Contr Mech I/F				
	OIWFS Det Contr Thermal I/F				
	OIWFS Detector Optical I/F				
	OIWFS Detector Electrical I/F				
	Cold Stop Alignment				
	Movement of Spectra				
	Not Used				
	Mech and Thermal Tolerances				
	Temperature Gradients				
	Thermal Transients				
	Space Requirements				
	Electronic Enclosures				
	Access to Electr Enclosures				
	Access to Vacuum Ports				
	Access to Cooling Water Ports				
	Access to Dry Air Ports				
	Mechanical Connections				
	Total Mass				
	Center of Gravity				
	Balance Tolerance				
	Ballast Weight				
	Spectrograph Thermal Stability				
	Cool Down Time				
	Warm Up Time				
	Detector Thermal Stability				
	Vibration				
	Vacuum System Holding Areas				
	Vacuum Pump Capacity				
	Vacuum System Operating Proc				
	Vacuum System Test Set-up				
	Mechanism Safety				
	Metric Dimensioning				
	Metric Dimensions on Drawings				
	Metric Fasteners				
	Repeatability of Configuration				
	Instrument Handling				
	Control System Operability				
	Configuration Time				
	Impact on Mechanism Accuracy				
	Impact on Science Performance				
	Temperature Control				
	Detector Temperature				
	Optical Elements Temperature				
	Rate of Temperature Change				
	Speeding the Warming up				
	Not Used				

Requirement	Description	PDR	CDR	Integration Tests	Acceptance Tests
	Grounding and Shielding				
	Electrostatic Discharge				
	Not Used				
	Not Used				
	Surface Temperatures				
	Not Used				
	Temperature Monitoring				
	Temperature Sensor Locations				
	Temperature Sensor Interfaces				
	Software Design Requirements				
	Not Used				
	Interfaces to SALT System				
	SALT Supplied ICDs				
	Engineering Interface				
	Engineering I/F Physical I/F				
	Engineering Interface User I/F				
	Eng I/F Command and Control				
	Engineering I/F Data Capture				
	PAYLOAD Interface				
	PAYLOAD Ports				
	Mounting Plate Flatness				
	Mounting Plate Material				
	Fasteners				
	Optical Feed				

Requirement	Description	PDR	CDR	Integration Tests	Acceptance Tests
	Vacuum Interfaces				
	Dry Air Interface				
	Transportation Altitudes				
	Storage Altitudes				
	Operation Altitudes				
	Operational Environment				
	Survival Environment				
	Transport Environment				
	Humidity Environment				
	Vacuum Environment				
	Creating the Vacuum				
	Vacuum Quality and Duration				
	Room Temperature Vacuum				
	Mechanical Environment				
	Telescope Slew Rates				
	Documentation				
	User's Manual				
	Service and Calibration Manual				
	Software Maintenance Manual				
	As-Built Drawings				
	Drawing Standards				
	Drawing Numbering System				
	Drawing Filing System				
	Training				
	Reliability				
	Spares				
	Continuous Duty				
	Maintainability				
	Standard Components				

Requirement	**Description**	**PDR**	**CDR**	**Integration Tests**	**Acceptance Tests**
	Modularity				
	Access				
	Alignment				
	Relative Equipment Arrangemnt				
	Subassemblies				
	Handling				
	Revisability				
	Lifetime				
	Toxic Products				
	EM Radiation Generation				
	Susceptibility to EM Radiation				
	Workmanship				
	Safety				
	Human Engineering				