Southern African Large Telescope
High-Resolution Spectrograph

SALT HRS

3200BP0019 Testing, Assembly and Commissioning Plan

P.L. Cottrell
Michael D. Albrow
Stuart Barnes
Graeme Kershaw
University of Canterbury

Graham Hodge
Unilogix Ltd

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Issue History

Number and file name	Person	Issue	Date	Status
3200BP0019 R4 testing	PLC	1.0	6 July 2004	Revision of 3200BP0006
	PLC	1.1	9 July 2004	Specific R4 updates
3200BP0019 testing	PLC	2.0	22 Feb 2005	CDR updates
		2.1	3 March 2005	Functional tests
	SIB	2.2	16 Mar 2005	Revision
	PLC	2.3	16 March 2005	Mechanical, electrical, control tests

TABLE OF CONTENTS

1 Scope

This document specifies the testing, assembly and a draft commissioning plan for SALT HRS. It provides an overview of this aspect of the SALT HRS project. A detailed Acceptance Testing Plan (3200BP0031) provides the benchmarks against the Functional Performance Requirements Document (3200AE0015).

Figure 1 shows the whole SALT HRS system.

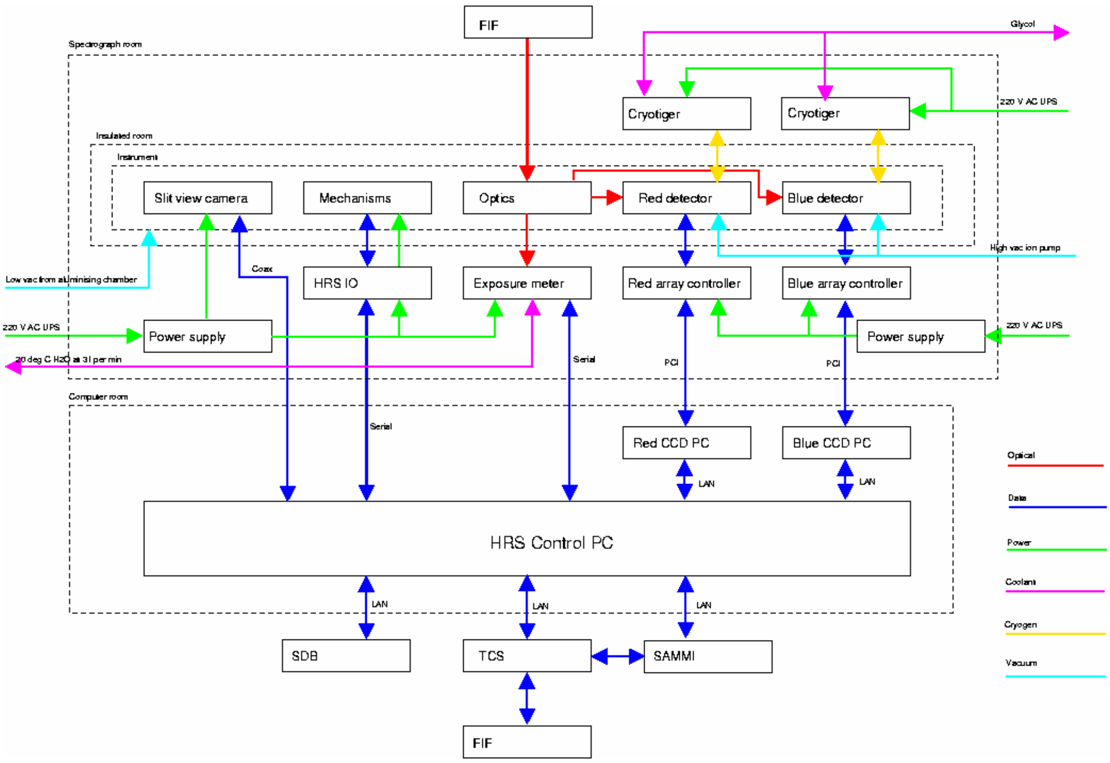


Figure 1: Block diagram of SALT HRS system and its interfaces.

2 Management of Testing, Assembly and Commissioning

These areas have been identified as part of the work breakdown structure. They are presented here as rolled out Gantt charts (Figure 2) for those areas that are relevant to the integration of the whole SALT HRS structure, as well as a detailed breakdown for the shipping and commissioning phase.

One of the risks associated with this project is the number of times the various optical elements will need to be handled. Robust handling procedures will be developed and tested to ensure that they are reliable. Some dummy freight, with accelerometers inserted inside will be tested both nationally and internationally.

SALT HRS Workflow (v3.5 Mar 11, 2005)

ID		Task Name	Duration	Start	Finish
1		**Provide SALT with High Resolution Spectrograph**	**1137 days**	**Mon 06/10/03**	**Tue 12/02/08**
2		**KEY DATES ARE HIGHLIGHTED IN PURPLE & UNDERLINED**	0 days	Thu 01/07/04	Thu 01/07/04
3		**Concept development Phase**	**109 days**	**Mon 06/10/03**	**Thu 04/03/04**
12		**Preliminary Design Phase**	**97 days**	**Fri 05/03/04**	**Mon 19/07/04**
20		**PDR**	1 day	Thu 29/07/04	Thu 29/07/04
21		**revise PDR documentation**	**20 days**	**Thu 09/09/04**	**Thu 07/10/04**
25		**SSWG and SALT Board Meeting**	1 day	Thu 18/11/04	Thu 18/11/04
26		**Critical Design Phase**	**111 days**	**Tue 16/11/04**	**Tue 19/04/05**
37		**CDR (spectragraph)**	0 days	**Tue 12/04/05**	**Tue 12/04/05**
38		CDR (detectors)	0 days	Tue 12/04/05	Tue 12/04/05
39		**SALT technical approval received (at May Board Meeting)**	0 days	**Wed 11/05/05**	**Wed 11/05/05**
40		**SALT - UC contract approved for signing (at May Board Meeting)**	0 days	**Wed 11/05/05**	**Wed 11/05/05**
41		**HRS Construction Begins**	0 days	**Tue 31/05/05**	**Tue 31/05/05**
42		**Design & Construction Phase**	**391 days**	**Tue 18/01/05**	**Tue 18/07/06**
298		**Integration Phase (in Christchurch) (UC)**	**205 days**	**Wed 17/05/06**	**Tue 27/02/07**
314		**Pre-ship acceptance tests (in Christchurch)**	0 days	**Tue 27/02/07**	**Tue 27/02/07**
315		**Shipping Phase**	**85 days**	**Wed 28/02/07**	**Tue 26/06/07**
316		perform pre-ship acceptance testing (Project Scientist in NZ)	10 days	Wed 28/02/07	Tue 13/03/07
317		disassemble & install into shipping crates	10 days	Wed 14/03/07	Tue 27/03/07
318		ship optics to Capetown (risk spreading)	10 days	Wed 28/03/07	Tue 10/04/07
319		ship structure to Capetown (risk spreading)	50 days	Wed 28/03/07	Tue 05/06/07
320		inspect on arrival into Capetown	5 days	Wed 06/06/07	Tue 12/06/07
321		transport to Sutherland	5 days	Wed 13/06/07	Tue 19/06/07
322		unpack and inspect	5 days	Wed 20/06/07	Tue 26/06/07
323		**Commissioning Phase (at Sutherland)**	**325 days**	**Wed 28/06/06**	**Tue 25/09/07**
324		appoint commissioning team	2 days	Wed 28/06/06	Thu 29/06/06
325		prepare environment for assembly operation	20 days	Thu 01/02/07	Wed 28/02/07
326		**assemble HRS in spectrograph room**	20 days	**Wed 27/06/07**	**Tue 24/07/07**
327		connect and commission all interfaces	10 days	Wed 25/07/07	Tue 07/08/07
328		test & prove completed instrument	15 days	Wed 08/08/07	Tue 28/08/07
329		perform SITE calibration	10 days	Wed 29/08/07	Tue 11/09/07
330		**final test of all functions (Acceptance Tests)**	10 days	**Wed 12/09/07**	**Tue 25/09/07**
331		train permanent SALT HRS Operators & Astronomers	20 days	Wed 25/07/07	Tue 21/08/07
332		hand over all documentation	0 days	Fri 24/08/07	Fri 24/08/07
333		HRS completed & commissioned (project finished)	0 days	Fri 24/08/07	Fri 24/08/07
334		**Project Complete**	0 days	**Tue 25/09/07**	**Tue 25/09/07**
335		**Administer Project**	**1137 days**	**Mon 06/10/03**	**Tue 12/02/08**

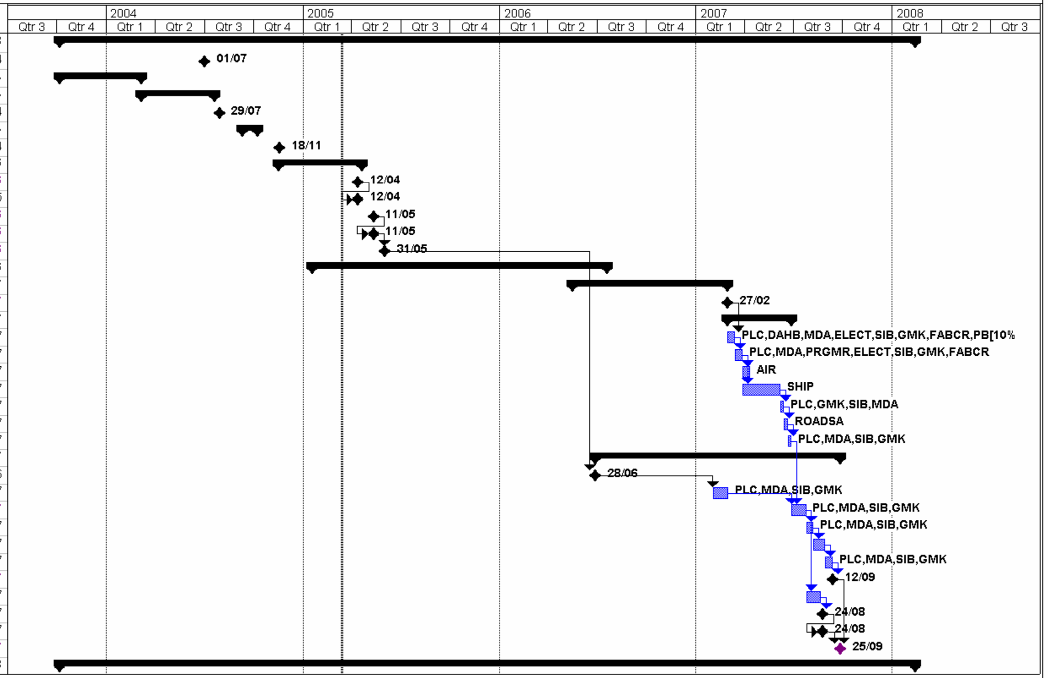


Figure 2: SALT HRS Testing, Shipping and Commissioning Phases

3 Optical

The optics of SALT HRS will be tested at the time of manufacture against their specification, and again at UC when they are integrated into the spectrograph structure. The assembly and testing procedure followed at UC will be repeated when the instrument is delivered to Sutherland.

3.1 The Fibre Instrument Feed

Fibres for SALT HRS which are to be integrated into FIF will be selected by UC. Fibre performance (e.g., focal ratio degradation (FRD) and/or transmission) will be measured by UC and/or the fibre supplier. Fibres will be have their end faces prepared and mounted into input and output ferrules and fitted with windows and/or micro-lenses as appropriate. The looming of the prepared fibres will then be undertaken.

Assembly and testing of the Fibre Instrument Feed (FIF) will be the responsibility of the FIF PI. Test fibres may be provided by UC [**TBD**]. A facility should be provided for measuring the performance of SALT HRS fibres once they are integrated into FIF. This facility may be the same used to make the initial fibre selection.

3.2 Injection optics

3.2.1 Direct injection optics

The individual fibres for direct injection will be assembled and tested as described in 3.1. The complete set of direct injection fibres (including the 100μm reference fibre) will be installed in the output mechanical assembly and tested. A repeat of the FRD measurement will then be made.

3.2.2 Intermediate injection optics

Each image slicer and input optics will be tested using laboratory light sources and a benchtop mounting. The fibre selector mechanism will be used for final testing and alignment. The fibre selector will be mounted in a laboratory along with all transfer optics, the slit plate, and slit viewing optics for integrated testing and alignment. This laboratory test may involve the partially assembled HRS. Light sources will include those to be later used for CCD flat-fielding.

3.2.3 Fold mirror

The fold mirror will be installed and tested following collimator assembly and alignment. Correct alignment will be determined first by using a source placed at the intermediate focus. Final alignment can take place after installation of the intermediate injection optics and slit plate.

3.3 Collimator

During collimator (M_1) installation a plane mirror will be placed in the front of (but not totally obscuring) the échelle grating assembly. The direct injection 100μm reference fibre will be used for auto-collimating the M_1. The off-axis location of the

image will be determined by placing a pinhole mask at the intermediate focus location. A mask placed on a dummy échelle grating will ensure the collimated beam correctly illuminates the grating. It will be necessary to iterate between locating the off-axis image and centring of the collimated beam. It may be necessary to switch between using white light for auto-collimation and laser light for beam centring.
A schematic of the auto-collimation test is shown in Figure 1.

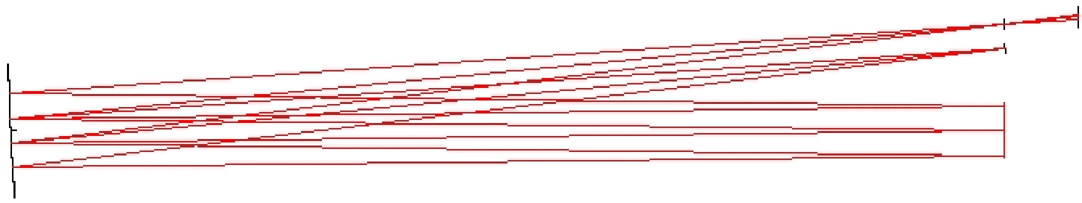


Figure 1: Auto-collimation of the collimator by using a plane mirror and the direct injection reference fibre. The size of the plane mirror has been exaggerated.

The auto-collimation mirror should remain in place during installation of the dichroic and pupil mirrors (see Sections 3.4 and 3.5).

3.4 Dichroic

The alignment of the dichroic mounting assembly may be checked after collimation by placing a mask in the mount. Light exiting the pinhole mask (at the intermediate focus) will be found in the geometric centre of the dichroic aperture (see Figure 2).

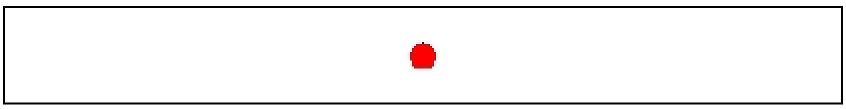


Figure 2: The footprint of dichroic.

The alignment of the dichroic will be determined in conjunction with the alignment of the pupil mirrors.

3.5 Pupil mirrors

A removeable pupil mask should be placed approximately halfway between the blue and red arm pupil mirrors. The pupil formed by each arm will be approximately coincident. Sub-aperture plane mirrors placed either side of the pupil mask should be used to project an image to the intermediate focus. The dichroic alignment will be done in conjunction with the alignment of the blue pupil mirror. A schematic of the pupil mirror alignment is shown in Figure 3.

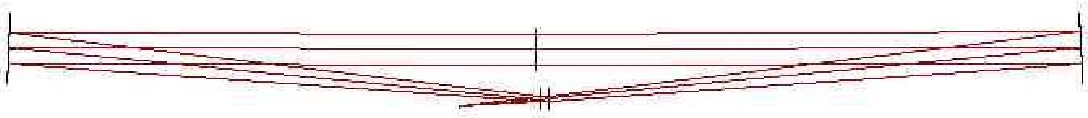


Figure 3: The blue and red arm pupil mirrors.

Pupil mirror focus will be determined following camera integration.

3.6 Fold mirror

Fold mirrors will be aligned to ensure the beam is directed to the centre of the camera/VPH mounting. Lasers and/or theodolites will be used to determine tip and tilt. It will be necessary to replace the dichroic mirror with a plane mirror (with identical dimensions) to align the blue fold mirror unless an appropriate blue light source is obtained.

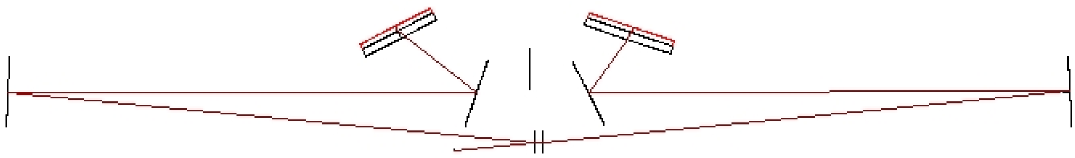


Figure 4: Fold mirrors. The dichotic may be replaced by a plane mirror for blue arm alignment.

3.7 Echelle grating

The échelle grating mosaic will be installed and aligned. Echelle roll and yaw will be determined by placing a mask over the dichroic. A white light source will be used to approximately centre the intermediate spectrum on the dichroic aperture. Echelle pitch will be precisely determined following camera integration.

3.8 VPH gratings

The VPH gratings will be mounted in their respective cell mount and aligned and tested. Grating yaw must be determined during integration of the VPH and camera cells. VPH grating roll and pitch must be determined following camera integration. This will be done in conjunction with échelle pitch adjustment to precisely orientate the spectral format and to maximize blaze efficiency.

3.9 Cameras

3.9.1 Fabrication

As part of the optical fabrication process, acceptance testing will be undertaken at the facility performing the work. The optical elements of the cameras will be integrated into their respective cells and then a series of acceptance tests performed. The cells will be provided by UC, and will also be used for optical testing during the manufacture of the camera optics.

The design of the cameras will be progressively optimized throughout manufacture. This will begin with the use of manufacturer's data on refractive indices and homogeneity. As manufacture progresses the dimensions of each completed surface will be measured, and the design reoptimized on the remaining elements.

The following is noted by Prime Optics in 3210AD0006 with respect to the blue camera:

> "[BCM]5.1R1 and [BCM]5.1R2 are critical whilst other similar length radii are nearly so. It will be desirable to have these test plates made and measured first. A refit will be necessary if these plates are outside tolerance. Progressive refits will take place, as necessary, as other test plates are finished."

For the red camera, Prime Optics notes:

> "There are no critical radii. However, a progressive refit to manufactured test-plates, starting with some of the shorter radii, would be highly desirable."

Two complementary acceptance test methods are discussed in 3210AA0007 optical tolerancing. These are shown in Figures 5 and 6.

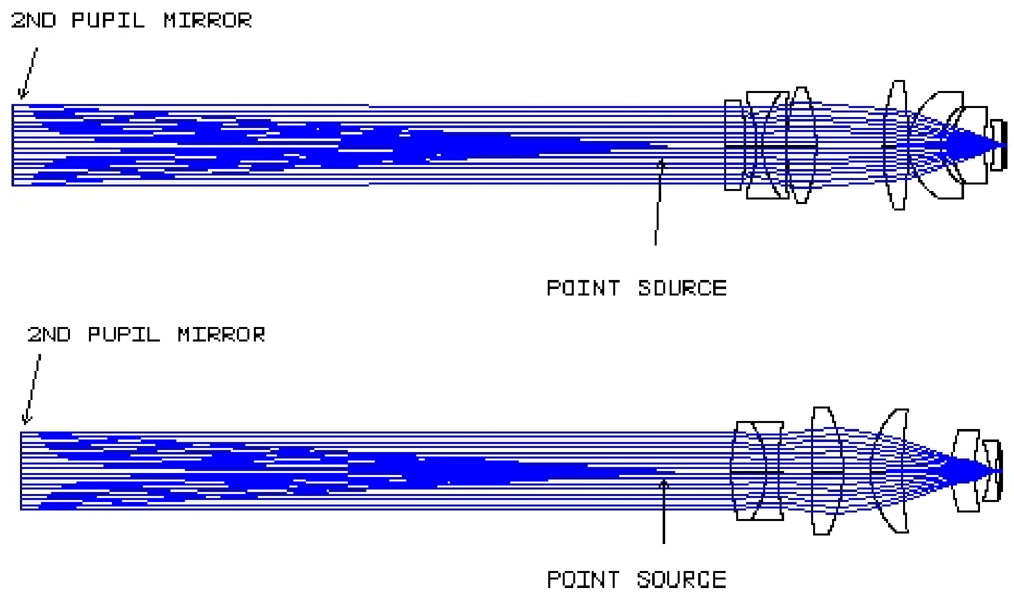
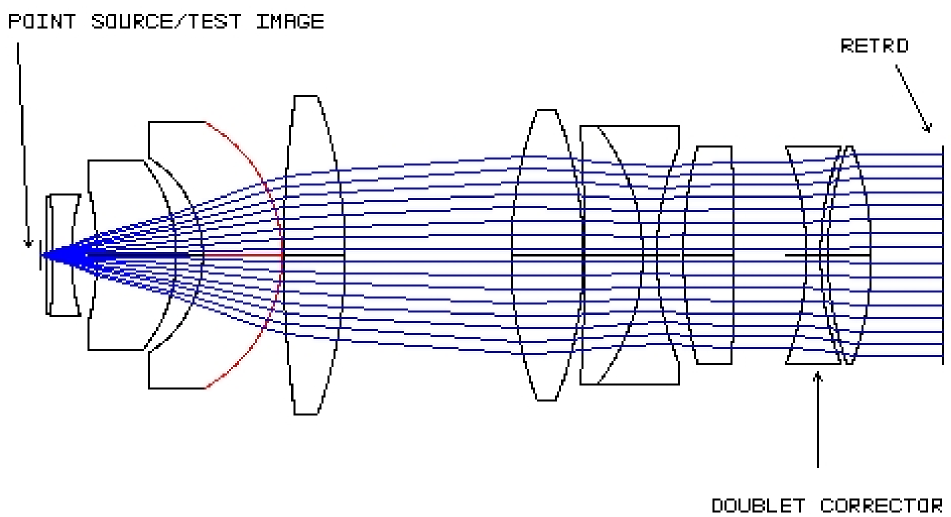


Figure 5: Blue (top) and red camera acceptance "star test". See 3210AA0007 optical tolerancing for details.



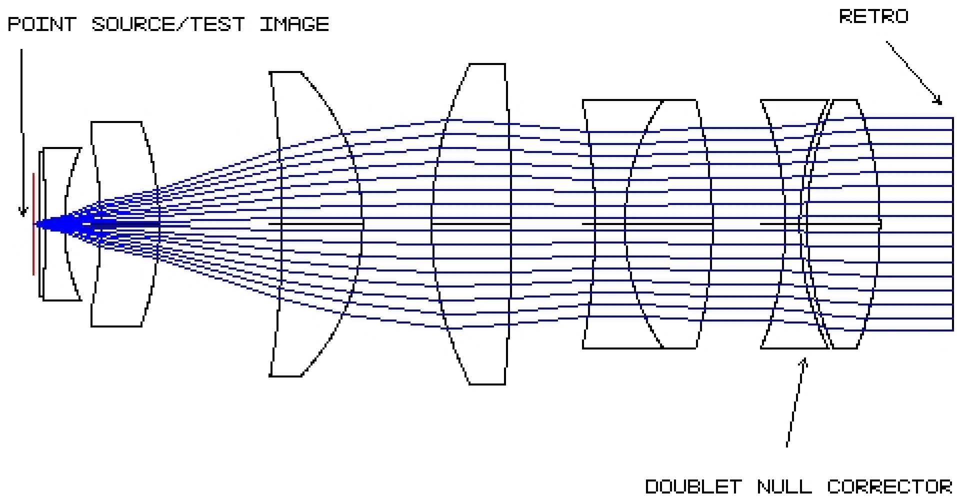


Figure 6: Blue (top) and red (bottom) double-pass acceptance tests. See 3210AA0007 optical tolerancing for details.

3.9.2 Installation

As described above, the performance of the cameras will be verified independently of the spectrograph during manufacture. Percise alignment of the camera optical axis with respect to the optical bench will be done in the absence of the VPH gratings and field-flattening lens. Laser light and/or theodilites will be used.

4 Mechanical

4.1 Optical bench weldment

The position of the drill and taps in the optical bench weldment will be measured against their specifications. The trusses for the collimator mount and the mounts for the pupil mirrors, échelle grating and dichroic, fold mirrors will be positioned on the optical bench. These will be installed without the optics to check for mechanical conflicts.

The optical bench with the camera cell mounts will be connected to the main optical bench. All adjustments will be tested for functionality and to check for mechanical conflicts.

The optical elements will then be integrated with their respective mounts and the optical tests undertaken. Extreme care will need to be taken with all the optical elements. Extra special attention will need to be given to the mounting of the échelle grating.

The integrated optical structure will then be dismantled for integration of the optical bench with the vacuum enclosure.

4.2 Fibre selector

The fibres will be supplied which have had their input and output faces prepared as per the FIF and fibre selector specification. The fibre output ferrules, image slicers and transfer optics will be mounted onto their respective *xyz* positioners in the fibre selector head and aligned to the required tolerances. This module will then be mounted into the slit pocket.

4.3 Structure

The spectrograph structure, which includes the optical mounts, the vacuum enclosure, the thermal enclosure and any handling fixtures for the optical components, will be fully assembled and tested at UC.

4.3.1 External

Assemble and test the thermally insulated enclosure. Disassemble for shipping.

4.3.2 Vacuum enclosure

The vacuum will be tested at UC with a temporary pump. At the telescope the mirror coating plant may supply the vacuum [**TBC**].

4.3.3 Internal

The completed optical bench weldment will be placed inside the vacuum enclosure through one of the removable ends (lids). The camera optical bench will be connected to the main optical bench through the side lid. The various optical mounts will then be reintegrated with the optical benches.

The optical elements will be re-integrated with the optical bench and the optical tests repeated.

4.4 Cryostat mountings

4.4.1 Testing and assembly

The cryostat mount will be assembled and tested using a dummy mounting point on which an equivalent cryostat mass will be placed.

4.4.2 Commissioning

The Detector subsystem vendor will deliver the completed and fully assembled cryostats and associated hardware. These will be installed and tested with the assistance of a member of the Detector subsystem vendor's staff.

4.5 Shipping containers

Robust safety procedures will need to be developed and strictly adhered to. Accelerometers will be used, and some dummy ships may be done. Freight of the optical elements will be undertaken by air. The structure is likely to be shipped by sea freight.

5 Electrical

5.1 Power

It will be the responsibility of the SALT facility to provide appropriate clean UPS power to the position of SALT HRS in the Spectrograph Room.

5.2 Electrical control

All the actuators and control systems for the subsystems described in Section 3.1 of 3250AE0029 will be assembled using the items specified and tested using control software developed according to Section 4 of the same document.

Items will be assembled and tested independently and then integrated into the SALT HRS structure and tested for functionality.

Some of the electrical components (e.g., focus actuators for the pupil mirrors) will be removed for shipping and then re-assembled and re-tested at SALT.

5.3 Cable connections

All cable connections to the inside of the vacuum enclosure will be made through vacuum feed through connectors in one of the end ‘lids’ on the mechanical structure and the interior cables loomed so that they do not interfere with the optical path or mechanical functions of the instrument. Sufficient spare cable will be retained inside the enclosure to enable testing and maintenance to be undertaken without having to disconnect the cables.

6 Instrument Control

The instrument control application software will be thoroughly tested during development. This process will include interfacing with the various instrument subsystems as they become available. Appropriate simulation models will be developed for testing of communication protocols with the Detector subsystems and external facility systems.

The completed spectrograph structure with all the active components attached will be assembled without the outer tank or thermally insulated enclosure and all the functions tested. SALT HRS will then be prepared for shipping and once re-assembled in the Spectrograph Room at SALT the laboratory tests will be repeated. Full control of the instrument through the LAN will be tested and then commissioning science using spectrophotometric and radial velocity standards undertaken for calibration and instrument verification.

7 Identified Risks and Safety Issues

7.1 Risk Issues

The number of times that the optical elements will have to be handled is a risk, which will be mitigated by constructing appropriate shipping containers and testing with dummy deliveries to national and international destinations via air-freight.

Covers will be in place on all the optical elements while mechanical and electrical installation is being undertaken to prevent damage to the optical surfaces.

7.2 Safety Issues

Crushing hazards could be a significant safety issue during testing, assembly, installation and commissioning of the vacuum enclosure and the installation of the major optical components. Only appropriately trained personnel will be allowed near the instrument during these phases and signage will inform all people of the dangers.

Safe electrical working practices will be maintained at all times and only trained and registered personnel will be permitted to install and test these aspects of the instrument. Appropriate signage will inform all people of the dangers.