OSCA Engineering Guide

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Table of Contents

1 System Overview

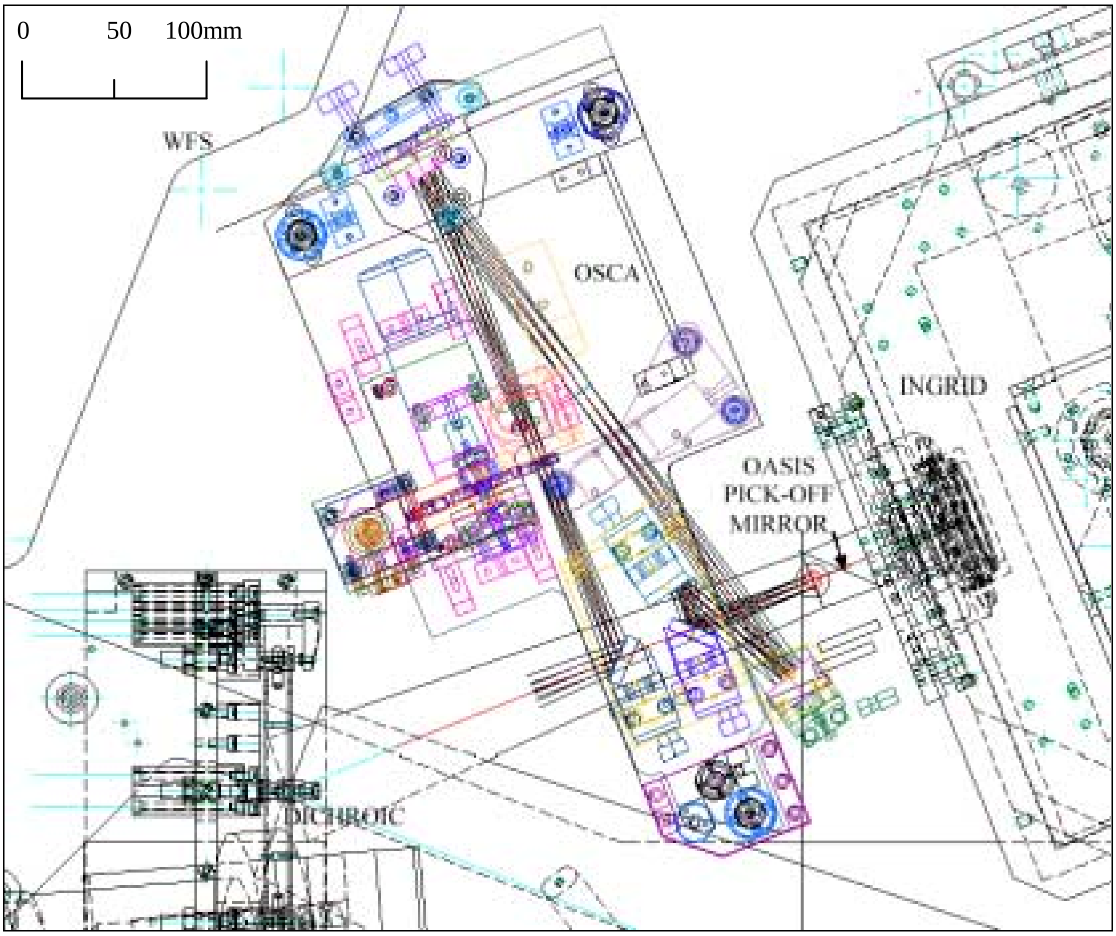


Figure 1.1 OSCA unit relative to the other components on the NAOMI optical table in GHRIL.

The Optical Stellar Coronograph for Adaptive Optics (OSCA) is a coronographic unit designed to be used with in conjunction with the NAOMI adaptive optics system.

The system is situated in the converging beam exiting from the dichroic beamsplitter in the NAOMI system (see figure 1.1). OSCA can be deployed remotely in and out of the beam, by raising the system up or down.

The control electronics for the system are situated in the GHRIL control room next to the GHRIL optics room

2 OSCA Optical Design

2.1 Zemax Optical design

Shown below is the optical design of the OSCA coronographic unit. The system consists of the following. The converging beam from the NAOMI port is interrupted by a steering mirror, which diverts the focus across the optical table. At the focus is a focal plane stop assembly where a selection of focal plane stops on 3mm thick transmissive substrates can be inserted into the focal plane. The beam is then collimated by an off axis paraboloid mirror. In the collimated beam at a pupil conjugate a Lyot stop is placed that can be rotated to match the secondary strut position in the pupil image. A second paraboloid reconverges the beam and this is relayed to the original NAOMI focus via a pair of flat mirrors.

The substrate on which the focal plane stop is mounted is a 3mm thick optical wedge with a wedge angle of 1.5 degrees to remove ghosting effects.

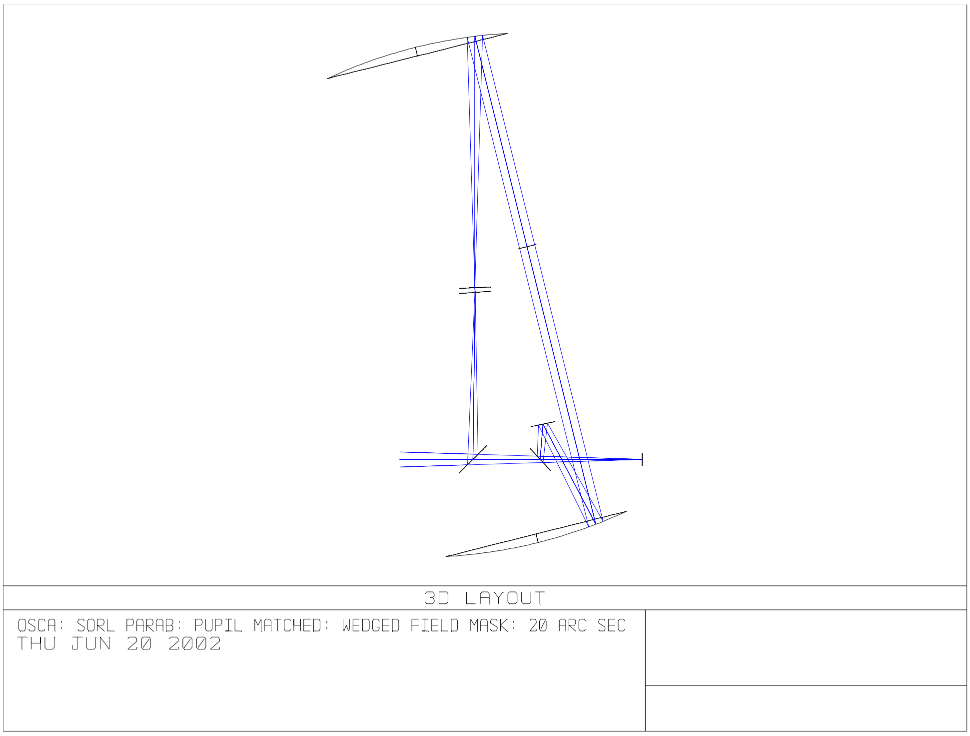


Figure 2.1 Zemax optical design of the OSCA system

The spot diagrams are shown below for various wavelengths and at three different field positions corresponding to on-axis, and 11 arcseconds off-axis. Also shown is the size of the diffraction pattern at 0.6 microns.

The system has an unvignetted field of view of ~27 arcseconds (limited by the mask wheel aperture).

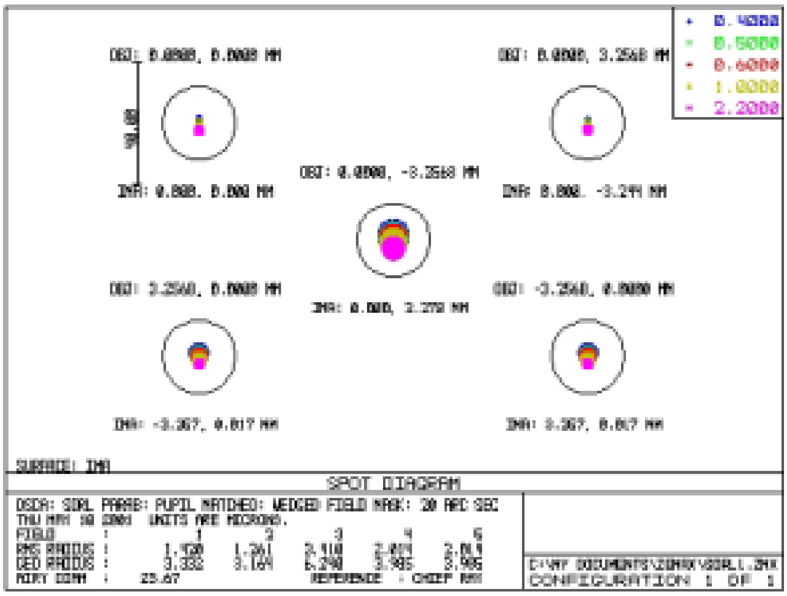
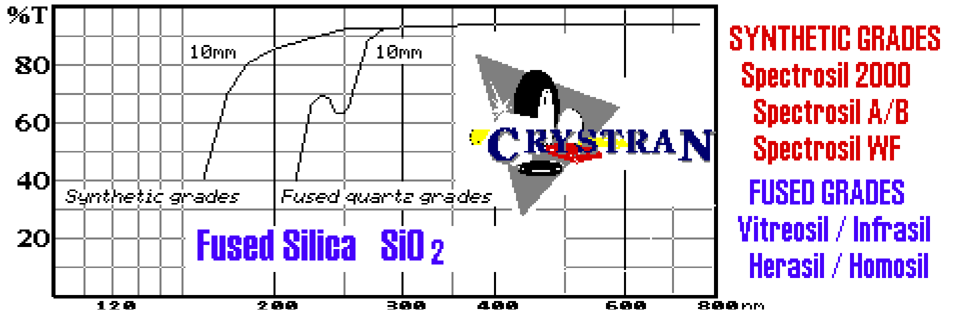


Figure 2.2 OSCA spot diagrams

2.2 Specification of OSCA optics.

The following table shows the optical components along with the supplier and optical specification.

Component	Supplier	Specifications
Off-axis parabolas (2)	SORL	Radius of curvature 304.8mm. Flatness λ/10 Overcoated silver Off –axis angle 14^{o}
Flat mirrors (3)	Newport 10Z40	Diameter 25.4mm Thickness 6mm Flatness λ/20 Overcoated silver
Mask substrates (10)	Crystan	Diameter 12mm Thickness 3mm Wedge angle 1.5^{o} IR grade fused silica (Spectrosil WF)



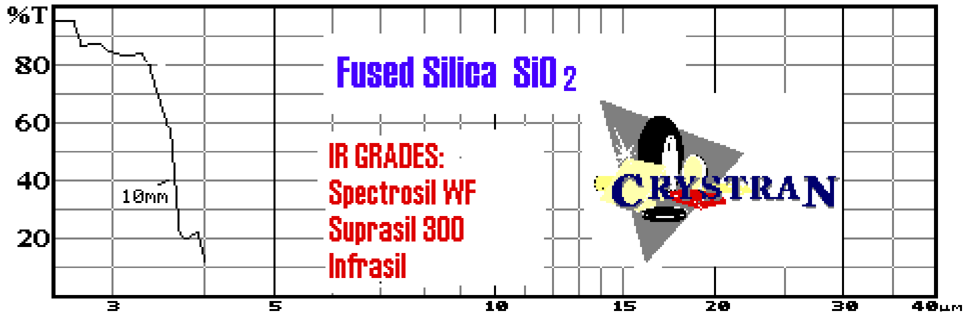


Figure 2.3 Optical Transmission of focal plane mask substrates

3 Opto-Mechanical Design

3.1 Overview

Below are schematic diagram showing a top and side view of the OSCA instrument.

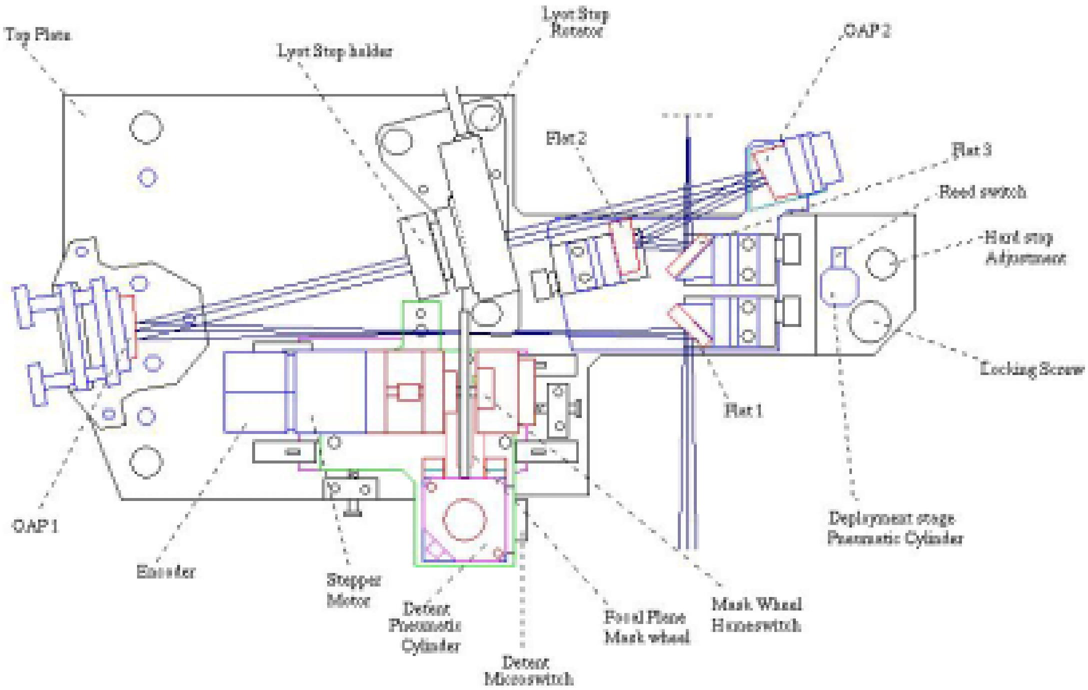


Figure 3.1 Schematic top view of the OSCA unit

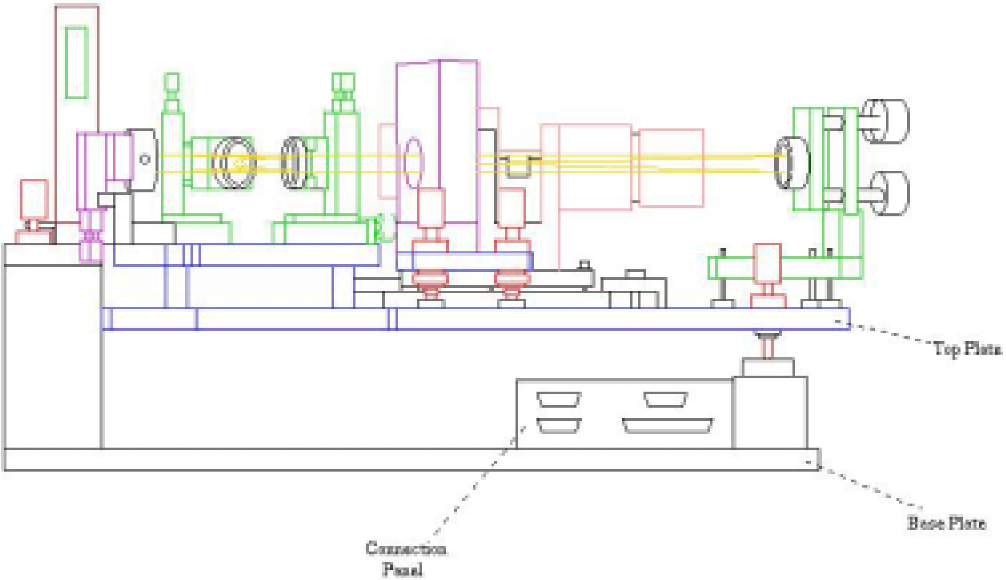


Figure 3.2 Schematic side view of the OSCA unit

OSCA consists of following components

3.2 Deployment Stage (top plate)

The OSCA system is deployed by a pneumatic cylinder system controlled by a solenoid valve that moves the OSCA top plate in and out of the NAOMI beam. The OSCA top plate is mounted on a kinematic 3 point push/pull system. Kinematics give 2 axis rotations plus piston. Third rotation is by an adjustable screw system on one of the three points. The final positioning of the top plate is provided by a manually adjusted hard stop. Position/status feed back is provided by 2 magnetic reed switches on the deployment stage pneumatic cylinder.

3.3 Steering mirror supports

The flat steering mirrors are mounted on top-adjust XY commercial mounts (Coherent 22-8643) to provide tip/tilt motion of the mirrors. These are mounted on manually adjusted linear stages (Eliot Scientific N55-017) to enable a piston movement.

3.4 Collimating Mirror supports

The first paraboloid is mounted on a manually back-adjusted mount (Melles Griot 07MFM513) three screws allowing tip/tilt and piston positioning. Height adjustments are provided by a 3 point screw system with locking screws. The second paraboloid is mounted on a bottom adjusted XY mount (Coherent 22-8643).

3.5 Focal Plane Mask Assembly

This can carry up to 10 focal plane masks on a wheel arrangement. Drive is by an on axis stepper motor and position and status feedback is provided by an incremental encoder and home switch. A pneumatically actuated pivoting detent arm locates in V-notches on the wheel circumference, providing a very accurate repeatability. The co-alignment accuracy of masks is achieved by using the actual wheel unit and detent arm during assembly. After the first mask is glued in position an optical reference of its centre is made. The other masks are glued centred to this reference. This eliminates any errors due to machining inaccuracies.

Positioning of the focal plane masks is by closed loop operation using the encoder feedback. When in nominal position the stepper motor is switched off and the detent mechanism positions the mask to the required accuracy.

The sizes of focal plane stop that the wheel contains are shown below.

Stop Number	Stop Size (arcsec)	Physical Size (micron)	Stop Edge Type
1	0.26	87	Hard
2	Target	327	Target
3	0.4	130	Hard
4	0.65	217	Hard
5	0.8	260	Hard
6	1.6	520	Hard
7	2.0	650	Hard
8	Empty		-
9	Empty		-
10	Empty		-

Table 3.1 Stop Sizes

These focal plane stops are mounted on thin (3mm) substrates (IR grade fused silica) that have a wedge angle of 1.5 degrees to remove ghosting effects. The focal mask wheel is mounted on a lockable tilt stage to give height adjustment. The whole assembly can be adjusted in position on the top plates by the action of 4 adjustment screws and can then be locked in position with clamps

Mask alignment and removal

The masks are glued into the wheel using Norland 81 UV setting glue. To maintain the position of the pupil on the Lyot mask within allowable tolerances, the angle of the wedge in the wheel must be the same for all the masks to within +/-5 degrees. The masks must also be centred to a common position to an accuracy of +/- 5microns.

The mask can be removed by dissolving the glue using liquid paint stripper.

3.6 Lyot stop assembly

The Lyot stop assembly consists of a Newport SR-50 rotation stage unit (see SR50.pdf). This is a stepper motor driven system incorporating a home switch. The accuracy that the Lyot stop can be positioned is 0.06 degrees, whilst the smallest step size is 0.006 degrees.

Mounted on the rotation stage is the Lyot mask. This is an etched aperture mask that is situated at the conjugate pupil position. This is located on extension tube attached to the rotation stage and adjusted to be at a pupil conjugate.

The Lyot stop rotates so as to keep alignment between the secondary and tertiary mirror struts and the masking vanes in the Lyot stop, in order to eliminate the central star light that arises along these strut edges in the pupil plane.

As there is no status or positional feedback system in the Lyot rotation stage, the following method of system check has been implemented. On deployment the Lyot stop will rotate to the home position, then away by a fixed number of counts and then back again to provide a check that the motor is moving.

The Lyot stop size is not remotely changeable but two different size stops are available that can be interchanged manually. The masks are attached to a holder that can be slipped on an attachment on the front of the Lyot stop holder. Registration of the masks is provided by a doweling road and hole key. The position of the Lyot stop along the collimated beam can be altered by adjustment of a grub screw stop on the holder.

Lyot Stop (Outer, Inner) %	Mask Diameter (Outer, Inner) mm	Vane Mask Size mm
80,20	7.84, 3.64	0.37
90,10	8.82, 3.01	0.37

Table 3.2 Available Lyot Mask Sizes

The Lyot rotation stage itself is mounted on a 3 point lockable support to allow adjustments in height and translation (small).

3.7 Pneumatic system

The deployment stage and focal plane mask wheel detent are driven using compressed air. The system uses 6mm piping with SMC one-touch KQ series push in connectors**.**

Control of the pneumatic cylinders is achieved via two SMC SY3240-5L0Z 24V valves located next to the OSCA unit on the GHRIL table.

The air system is connected to one of the control flow valve units in GHRIL.

3.8 Pre-NAOMI focal plane Assembly (*to be implemented*)

A pre-NAOMI focal plane dichroic stop will be provided to suppress stray light when the NAOMI is being used in a partial correction mode. The size of the stop is limited by the seeing disk to a size of ~0.7 arcseconds (close to the median seeing conditions). The stop itself will be small dichroic disk on a larger substrate. The dichroic should match the transmission/reflection properties of the appropriately selected dichroic in the universal port though due to cost constraint only one mask can be provided.

Space constraints at the pre-NAOMI focus mean the stop can not be easily positioned with a remotely operated drive, and the position is also used for the artificial star system in NAOMI. It is therefore proposed to use the same system of kinetic mounting as used by NAOMI for placement of the focal plane dichroic stop. This kinetic mount can reposition to a few microns, though the required accuracy on positioning the dichroic spot is of the order of 20 microns (10% of disk size).

4 OSCA Electronics

4.1 Overview

The drive electronics for the OSCA coronagraph, for use with the NAOMI adaptive optics system, provide Epics control of the Mask Wheel, Lyot Stop, Deployment pneumatics and Mask Wheel detent pneumatics within the instrument.

The drive electronics are housed in a standard 19” enclosure and comprise two sub-rack assemblies: a VME167 based computer system with an Oregon motion control card and Xycom I/O card; and a custom electronics interface rack which contains the stepper motor drive cards, solid state relays for the pneumatic valves, associated power supplies and signal conditioning. An overview of the connections between the opto-mechanics and the drive electronics is shown below.

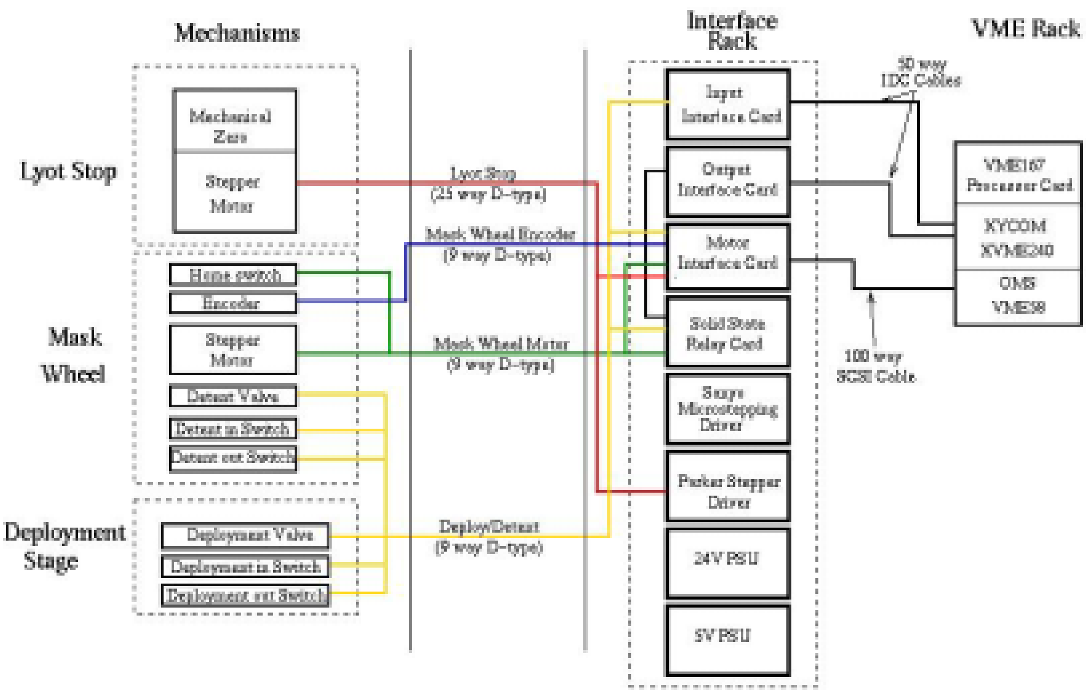


Figure 4.1 Schematic of OSCA electronics

4.2 VME Sub-rack

The VME sub-rack was procured from Wordsworth Technology and contains a five slot P1 / P2 VME backplane, power supply and network / console connections. Wordsworth have added their own port replicator card to the P2 connector and the connector pin-outs for this are included in the document TB1X7.PDF.

Included in the VME rack is an Oregon Micro Systems (OMS) VME58-4E which provides motion control with encoder feedback for up to four stepper motor channels. No connections are made to the P2 connector of this card, all connections are taken from the front 100way SCSI-type connector to a Durham-produced interface card (see “Motor Interface Card” below). The OMS card must be placed in the central slot of the VME backplane as it was found that a capacitor at the edge of the board was shorting to earthing clips found in the card guides (the clips have been removed from the central slot only). The manual for the VME58 card is attached as VME58.PDF. A Xycom XVME-240 I/O card has been added to provide the control signals to the pneumatic valve drivers and to accept the feedback signals from the stage and detent limit switches. Again, no connections are made to the P2 connection of this card, all signals are routed from the front panel I/O ports to Durham produced interface cards. The manual for the XVME-240 card is attached as XVME240.PDF

4.3 Interface Electronics Sub-rack

Mounted directly above the VME rack is a custom built sub-rack containing the interface cards and stepper motor drive cards for the instrument. From the left of the sub-rack, the cards are:

- input interface card (connected to JK1 of the XVME-240, card ID OSCA3)
- output interface card (connected to JK2 of the XVME-240, card ID OSCA2)
- motor interface card (connected to the 100-way connector on the VME58-4E, card ID OSCA1)
- Omega solid state relay card (part number SSS-PC4-C, see document SSS.PDF, mounted on a Eurocard sized panel)
- Sanyo micro-stepping motor drive unit (part number PMM-MD-23120-10, see PMM.PDF, mounted on a Eurocard sized panel)
- Parker SD12 stepper motor drive card (see document SD.PDF)
- 24VDC 5A power supply (Vero/APW PK120-24, see document PK120.PDF)
- 5VDC 6A power supply (Vero/APW PK30-5, see document PK30.PDF)

The pin-outs of the connectors at the rear of this rack are specified in tables 3.4-3.8. The internal wiring of the rack is specified in figure 3.2

(Socket output from drive rack, plug input to opto-mechanical assembly)
(All connector shells connected to earth)

1 Phase 1a	14 Shield GND
2 N.C.	15 N.C.
3 Phase 1b	16 0V Logic
4 N.C.	17 N.C.
5 Phase 2a	18 N.C.
6 N.C.	19 N.C.
7 Phase 2b	20 N.C.
8 N.C.	21 5V
9 N.C.	22 N.C.
10 N.C.	23 N.C.
11 N.C.	24 N.C.
12 N.C.	25 N.C.
13 Mechanical Zero	

Table 4.4
25-way Connector for SR50 rotations stage

1 Phase A	6 Phase B
2 Phase A common	7 Phase B common
3 Phase A~	8 Phase B~
4 Home switch	9 N.C.
5 GND	

Table 4.5
9 way - Power Connector for mask wheel

Phase A - Red	Green - Phase B
Phase A Common - White	Yellow - Phase B Common
Phase A~ - Blue	Black - Phase B~

Table 4.6
PX24 Series Stepper Motor

1 5V	6 Encoder C+
2 Encoder A+	7 Encoder C-
3 Encoder A-	8 0V
4 Encoder B+	9 N.C.
5 Encoder B-	

Table 4.7
9 way - Connector for mask wheel encoder

1 Stage in switch	6 Deploy valve (24V)
2 Stage out switch	7 Deploy valve (0V)
3 Switch 0V	8 Detent valve (24V)
4 Detent in switch	9 Detent Valve (0V)
5 Detent out switch	

Table 4.8
9 way - Connector for deployment stage and detent

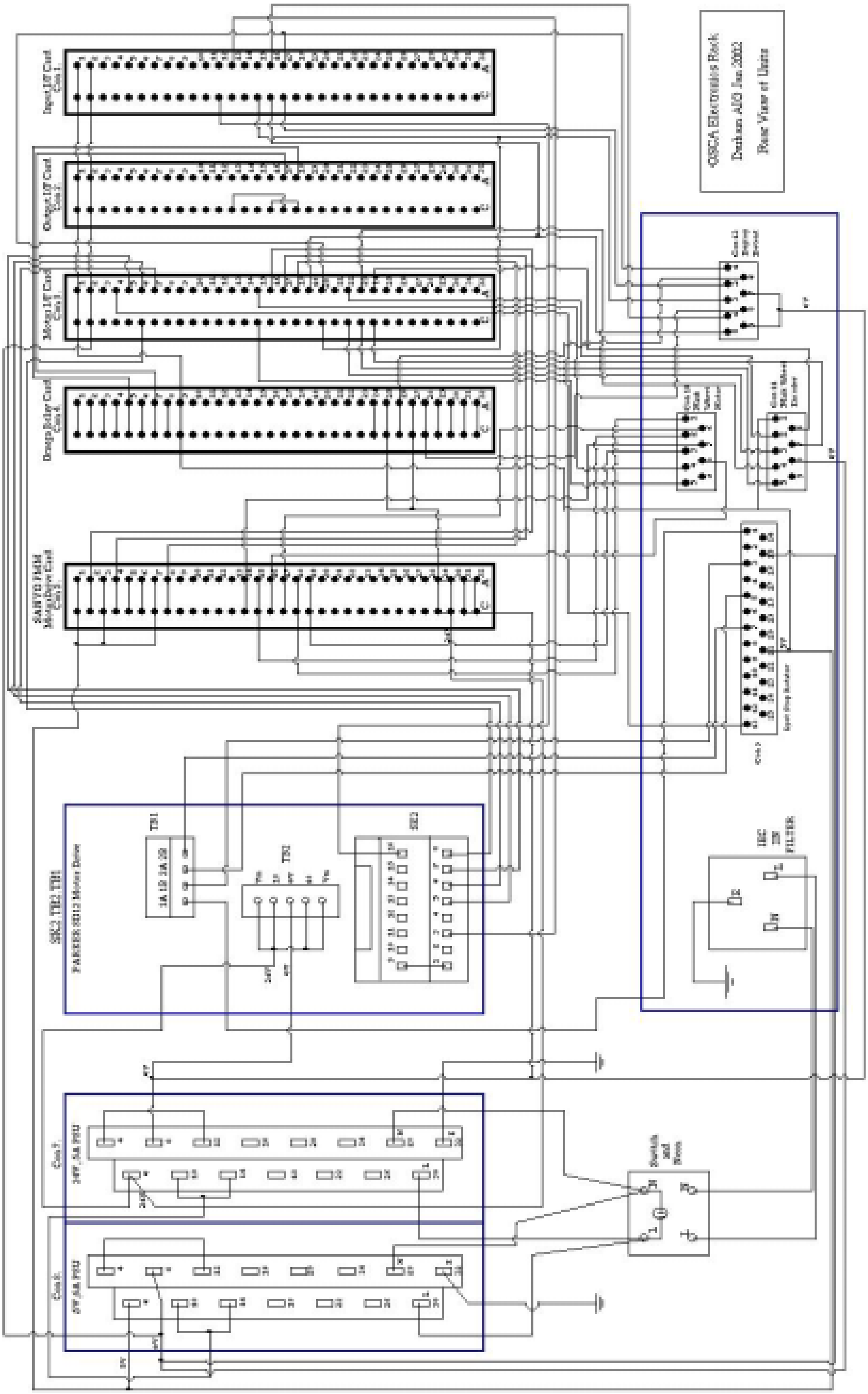


Figure 4.2 OSCA rack connections diagram

4.4 Input Interface Card

The purpose of the input interface card is to buffer signals from the deployment and detent limit switches to the Xycom input port JK1. The card has been designed to be general purpose and makes provision for RS422, HCT/TTL and opto-coupled inputs. In practice, only five of the HCT/TTL inputs are used.

The limit switches for the detent are also cross-wired to the motor control card to provide a hardware interlock which prevents the mask wheel from rotating while the detent is engaged. The Sanyo microstepping driver is only energised when the Detent-In switch is open, the Detent-Out switch is closed and the auxiliary line from the OMS VME58 card is enabled.

The schematic and overlay for the card are in the document OSCA3.PDF. The full Innoveda/PADS PCB design is included in file OSCA3.PCB. The signals processed by the interface card are as follows:

1. Detent-In Microswitch
This microswitch detects the position of the mask wheel detent when in the ‘in’ or engaged position (the switch is closed at this point). The signal is routed through pin 4 of the ‘Deploy / Detent’ connector, through pin A16 at the rear of the input interface card, through pin 17 of the 50way connector at the front of the card, and onto Port 1 Bit 4 of the Xycom card (Epics input channel 20).

2. Detent-Out Microswitch
This microswitch detects the position of the mask wheel detent when in the ‘out’ or disengaged position (the switch is closed at this point). The signal is routed through pin 5 of the ‘Deploy / Detent’ connector, through pin C16 at the rear of the input interface card, through pin 18 of the 50way connector at the front of the card, and onto Port 1 Bit 5 of the Xycom card (Epics input channel 21).

3. Deployment-In Reed Switch (see document DC80.PDF)
This reed switch detects the position of the deployment actuator when OSCA is in the beam path of NAOMI (the switch is closed at this point). The signal is routed through pin 1 of the ‘Deploy / Detent’ connector, through pin A17 at the rear of the input interface card, through pin 19 of the 50way connector at the front of the card, and onto Port 1 Bit 6 of the Xycom card (Epics input channel 22).

4. Deployment-Out Reed Switch (see document DC80.PDF)
This reed switch detects the position of the deployment actuator when OSCA is out of the beam path of NAOMI (the switch is closed at this point). The signal is routed through pin 2 of the ‘Deploy / Detent’ connector, through pin C17 at the rear of the input interface card, through pin 20 of the 50way connector at the front of the card, and onto Port 1 Bit 7 of the Xycom card (Epics input channel 23).

5. Lyot Motor Drive Fault
This signal is picked up from the Parker SD12 drive card for the Lyot motor. The signal is routed from pin 3 of SKT2 at the rear of the SD12, through pin A13 at the rear of the input interface card, through pin 13 of the 50way connector at the front of the card, and onto Port 1 Bit 0 of the Xycom card (Epics input channel 16).

All the above signals are active-low. A pull-up resistor is provided on each channel on the input interface card. The card actually inverts the signals and so they become active-high upon reaching the XYcom I/O card. The microswitches and reed switches are simply used in a ‘pull to ground’ configuration. The ground wires of all four switches are connected to 0V via pin 3 of the Detent / Deploy connector.

4.5 Output Interface Card

The purpose of the output interface card is to buffer signals from the Xycom output port JK2 to the solid-state relays that control the pneumatic valves for the deployment and detent actuators. The card has been designed to be general purpose and makes provision for RS422, HCT/TTL and opto-coupled outputs. In practice, only two of the opto-coupled outputs are used.

The schematic and overlay for the card are in the document OSCA2.PDF. The full Innoveda/PADS PCB design is included in file OSCA2.PCB. The signals processed by the interface card are as follows:

1. Deploy In/Out Signal
This signal is routed from Port 6 Bit 0 of the Xycom card (Epics output channel 8), via pin 25 of the 50way connector on the front of the interface card, through pins A17 & C17 at the rear of the card, and onto the solid-state relay on the Omega card (the one nearest the rear of the card). Here the signal drives the opto-isolated input of the solid state relay, which in turn energises the pneumatic valve via a 24V circuit through pins 6 and 7 of the Deploy / Detent connector.

2. Detent In/Out Signal
This signal is routed from Port 6 Bit 1 of the Xycom card (Epics output channel 9), via pin 26 of the 50way connector on the front of the interface card, through pins A18 & C18 at the rear of the card, and onto the solid-state relay on the Omega card. Here the signal drives the opto-isolated input of the solid state relay, which in turn energises the pneumatic valve via a 24V circuit through pins 8 and 9 of the Deploy / Detent connector.

4.6 Motor Interface Card

The purpose of the motor interface card is to buffer signals between the OMS VME58card and the Parker SD12 and Sanyo microstepping motor drive cards. The card has been designed to be multi-purpose and so contains a large number of jumper links which can be used to enable/disable and change the active state of all the signals on the card. The card makes provision for:

- Buffered open-drain Step, Direction and Enable (Aux) signals for each of two motor channels
- An interlock circuit, which prevents the Aux signal from being made true unless an active high and active low enable signal are present and in the correct state. This is used on the mask wheel to prevent the motor from being moved when the detent is in place. This feature is unused on the Lyot drive. The Sanyo microstepping driver is only energised when the Detent-In switch is open, the

Detent-Out switch is closed and the auxiliary line from the OMS VME58 card is enabled.

- An RS422 three channel receiver circuit which buffers signals from an external encoder back to the VME58 card. This feature is unused on the Lyot drive but is fully operational on the mask wheel drive. The schematic and overlay for the card are in the document OSCA1.PDF.

The full Innoveda/PADS PCB design is included in file OSCA1.PCB. The ‘x’ channel of the card is connected to the X channel of the VME58 card via the 100way connector on the front edge of the card. The X channel is used to control the Lyot stop drive and connects via the Parker SD12 drive card (non-microstepping) to the Newport SR50PP rotation stage which provides motion to the Lyot stop (see document SR50.PDF). The SR50 rotates by 0.001 degrees per step at a maximum rate of 4 degrees per second. This rate is limited to 1 degree per second to keep the step rate at a level which Epics can handle.

The ‘y’ channel of the card is connected to the Y channel of the VME58 card via the 100way connector on the front edge of the card. The Y channel is used to control the mask wheel and connects via the Sanyo microstepping driver to the PX24 series motor which used to drive the wheel direct. The encoder which is coupled directly to the motor to provide positional feedback is a British Encoder model 755 with 800 pulses per revolution (actually 3200 signal transitions per revolution or 0.1125 degree resolution, see 755Encoder1.PDF, 755Encoder2.PDF and 755Encoder3.PDF). The Sanyo microstepping driver has been set up to provide 180 divisions per step, increasing the motor resolution from 200 to 36000 steps per revolution (0.01 degrees per step). This resolution provides a very smooth motion while the mask wheel is being moved to the next position. The detent provides the ultimate positional accuracy of the wheel and the stepper motor is disabled while the detent is in place.

4.7 Interface Cables

Four cables connect the drive electronics rack to the opto-mechanics assembly. Eachcable is wired as a straight-through pin-for-pin male-to-female connection with D connectors at each end. The two cables which connect the Xycom I/O card to the input and output interface cards are simple straight-through 0.05” pitch IDC ribbon cables with each end terminated in a 50-way IDC socket. The cable which connects the OMS motor drive card to the motor interface card should be a custom 100-way SCSI style male-male pin-for-pin straight-through cable terminated in AMP Amplimite 749111-8 connectors. Unfortunately the cost of having such a custom cable made was prohibitively expensive so a 68-way 0.635mm pitch IDC cable has been used instead with the connector shells removed to allow the connectors to be inserted part way along the 100-way connector on each card. The 68-way cable should be positioned to allow pins 10 through 43 and 60 through 93 to be connected. See document VME58.PDF page 4-5 (47) for further details.

5 Documentation

Osca1.pdf	Stepper motor interface card layout
Osca2.pdf	Output interface card layout
Osca3.pdf	Input interface card layout
OSCA1.pcb	Innoveda/PADS PCB design
OSCA2.pcb	Innoveda/PADS PCB design
OSCA3.pcb	Innoveda/PADS PCB design
SD50.pdf	Newport SD50 rotation stage manual
VME58.pdf	VME58 user manual
755Encoder1.pdf	755 encoder manual
755Encoder2.pdf	755 encoder manual
755Encoder3.pdf	755 encoder manual
DC80.pdf	DC80 magnetic reed switch technical doc
XVME240.pdf	XVME240 manual
SD.pdf	Parker Knowle stepper card manual
SSS.pdf	Omega solid state switches technical doc
PK120.pdf	Power supply PK120 technical doc
PK30.pdf	Power supply PK120 technical doc
PMM.sdf	Sanyo stepper motor drive technical doc
TB1X7.pdf	VME transition board description
OSCA_layout.zmx	Zemax optical design document

Appendices

A.1 Opto-mechanical Components and Functions

Mechanism	Component Type	No	Supplier	Notes
Deployment mechanism valve	Solenoid valve Pneumatic Cylinder Status switch	1 1 2	SMC SY3240-5L0Z SMC CDJ 2B16-4ST-B SMC C80L reed switch	24V unit
Focal plane mask	Stepper motor Encoder Home switch	1 1 1	Time and Precision TPX24-TP755 British encoder V4 button microswitch	
Detent valve	Solenoid valve Pneumatic Cylinder Status switch	1 1 2	SMC SY3240-5L0Z SMC CDQ2B25-5S V4 lever microswitch	
Lyot stop rotator	Rotation stage (stepper with internal mechanical zero)	1	Newport SR50-PP	24 step motor type UE16PP Open loop operation 0.25A, 12.5Ω,5.5mH 2 phase 4 wire

Table A.1 List of Electro-mechanical components

Item	**Adjustments/functions**	**Mechanism/Method**
Whole assembly bottom plate	Move along optical path ±5mm ±50microns	Manual screw stops
Deployment linear slide carriage	Locate/Relocate system to ±5 microns. Stroke 125mm	Manually adjustable hard-stop. Pneumatic drive 2 limit switches.
Top plate adjustment	Kinematic 3 point plus rotation by adjustable screw system on one of the three points. Vertically ±3mm ±20µm Rotation ±1mm ±20µm.	Manually adjustable using screws and pull screws to lock.
Folding flat mirror supports	Rotate reflected beam about XY $\pm 2^{o}$ $\pm 0.045^{o}$ Move along incoming / outcoming beam ±2mm ±40µm	Manually adjustable kinematic mount with 2 screws with point 3 fixed.
Off-axis 1 mirror support	Rotate reflected beam about XY $\pm 10^{o}$ $\pm 15''$ Piston ±2mm ±40µm	Manually adjustable kinematic mount with 3 screws.
Off-axis 2 mirror support	Rotate reflected beam about XY $\pm 2^{o}$ $\pm 0.045^{o}$	Manually adjustable kinematic mount with 2 screws with point 3 fixed.
Focal plane mechanism	10-position wheel Home switch Stepper motor Detent	
	Translation XY ±1mm ±5µm Focus adjust 2mm ±40µm	Manually adjustable on three point lockable screws.
Lyot stop mechanism	Mask rotation Stepper motor Home switch	360^{o} rotation $\pm 0.06^{o}$
	Translation along beam ±1mm ±40µm Translation XY ±1mm ±40µm	Manually adjusted on 3-point screw mounting.

Table A.2 List of Opto-mechanical functions

A.2 Parts List

DRG No	TITLE	QTY	MATERIAL	NOTES
Osca0001	Osca Base Plate	1	Aluminium Tooling Plate	
Osca0002	Base Block	1	Aluminium Alloy H30	
Osca0003	Cone Pad (large)	1	Hardenable Stainless Steel	
Osca0004	Groove Pad (large)	1	Hardenable Stainless Steel	
Osca0005	Flat Pad (large)	1	Hardenable Stainless Steel	
Osca0006	Spring Adjuster	1	Brass	
Osca0007	M8 Spring Nut	2	Brass	
Osca0008	Lock Nut	1	Brass	
Osca0009	Pivot Rod	2	Stainless Steel	
Osca0010	Pivot Rod Base	2	Brass	
Osca0011	Base Adjuster	5	Aluminium Alloy	
Osca0012	Base Clamp	6	Stainless Steel	
Osca0013	Spring Guide	4	Stainless Steel	
Osca0014	Deployment Screw	1	Stainless Steel	Modified Wixroyd Thumb Screw 3715.W055
Osca0015	Deployment Screw Block	1	Brass	
Osca0016	Small Pillar	1	Aluminium Alloy	
Osca0017	Large Pillar	1	Aluminium Alloy	
Osca0018	Bridge Plate	1	Aluminium Alloy	
Osca0019	Lyot Stop Base Plate	1	Aluminium Alloy	
Osca0020	Lyot Unit Spacer Block	1	Aluminium Alloy	
Osca0021	OAP1 Spacer	1	Aluminium Alloy	
Osca0022	Oap1 Base Plate	1	Aluminium Alloy	
Osca0023	OAP1 Adaptor	1	Aluminium Alloy	Drawn by Sam Thompson
Osca0024	Occulting Mask Wheel	1	Aluminium Alloy	V2
Osca0025	Button	1	Stainless Steel	

Osca0026	Shaft	1	Stainless Steel	
Osca0027	Minor Pillar	1	Aluminium Alloy	V2
Osca0028	Shaft Cover	1	Aluminium Alloy	V2
Osca0029	Main Pillar	1	Aluminium Alloy	V2
Osca0030	Cylinder Block	1	Aluminium Alloy	
Osca0031	Microswitch Base 1	2	Aluminium Alloy	
Osca0032	Detent Arm	1	Aluminium Alloy	
Osca0033	Bearing Axle	1	Stainless Steel	
Osca0034	Arm Rod Pivot	1	Stainless Steel	
Osca0035	Microswitch Rod	1	Stainless Steel	
Osca0036	Pivot Pad	2	Black Delrin	
Osca0037	Microswitch Base 2	1	Aluminium Alloy	
Osca0038	Bearing Axle Spacer	1	Aluminium Alloy	
Osca0039	Wheel Unit Top Plate	1	Tooling Plate	V2
Osca0040	Mirror 1 & 3 Wedge	2	Aluminium Alloy	Drawn by Sam Thompson
Osca0041	Mirror 1,2 & 3 Spacer	3	Aluminium Alloy	Drawn by Sam Thompson
Osca0042	Mirror 2 Wedge	1	Aluminium Alloy	Drawn by Sam Thompson
Osca0043	Wheel Unit Bottom Plate	1	Tooling Plate	
Osca0044	Platform	1	Tooling Plate	
Osca0045	Platform Foot	2	Aluminium Alloy	
Osca0046	OAP2 Adaptor	1	Stainless Steel	Drawn by Sam Thompson
Osca0047	Cone Pad Small	2	Hardenable Stainless Steel	
Osca0048	Groove Pad Samll	2	Hardenable Stainless Steel	
Osca0049	Flat Pad Small	2	Hardenable Stainless Steel	
Osca0050	OAP1 & Lyot Studs	4	Stainless Steel	50mm M3 Studs
Osca0051	Patch Panel	1	Aluminium Alloy	
Osca0052	Patch Panel Brackets	2	Aluminium Alloy	
Osca0053	Wheel Unit Clamps			

Osca0054	Wheel Unit Adjusters			
Osca0055	OAP2 Bracket	1	Aluminium Alloy	
Osca0056	Cage Base			
Osca0057	Deployable Plate	1	Tooling Plate	
Osca0058	OAP2 Top-adjust	1		Coherent Ealing Part 22-8643
Osca0059				
Osca0060				
Osca0061				
Osca0062				
Osca0063				
Peter Doel	Beamsplitter Support	1	Aluminium Alloy	
Sam Thompson	Sam's Holder	1	Aluminium Alloy	
Peter Doel	Mask Holder (to fit on Lyot Mask tube)	1	Brass	
Peter Doel	Lyot Mask Tube	1	Brass	

PART No	NAME and DESCRIPTION	QTY	SUPPLIERS CODE	SUPPLIED BY	NOTES
001	Spring Tension Pin 14 x ∅2.5mm	2	RS 374-014	Radio Spares	Comes in packet with selection of sizes
002	Thumb Screw M5x25	1	3715.W055	Wixroyd	Modified to suit Drawing Osca0014V1
003	Ball Bearing	3		Radio Spares	Shielded 16x10x5
004	Ball Bearing 623-2Z	1		Radio Spares	Shielded 10x4x3
005	Internal Circlip	1	B016M		OD 16.76
006	Ball Tipped Screws	4	3404,W758	Wixroyd	M4x16mm
007	0.5mm Thick Washers	2			Wear protection for sides of pivot arm on detent.

A3 Spares List

British Encoder Company 755-1-5HS-HV-0800 encoder
Sanyo Stepper Motor Drive Card
Parker Hannifin SD12 Stepper Motor Drive Card
Lyot Stop Masks
Output Interface card
Input Interface card