Prepared by

A.J. Matheson Date

Checked by

D.J. Parker Date

Approved by

D.L. Smith Date

DISTRIBUTION

RAL
J. Payne
M. Ferlet
K. King
T. Lim
S. Sidher
B. Swinyard

Cardiff
P. Hargrave

DOCUMENT CHANGE RECORD

Issue	Date	Affected Pages	Description
Draft 2	28/11/2001	All	Incorporation of comments on Draft 1
Draft 3	12/02/2002	All	Changes by D.L. Smith
Draft 4	25/02/2002	All	Changes by D.L. Smith following meeting with Dave Parker and Ken King

CONTENTS

1. SCOPE OF DOCUMENT

This document specifies the requirements for the SPIRE Test Facility Control System (TFCS). Both the user and software requirements are incorporated in this document.

The TFCS will be developed in two phases. The first, phase A, will cover all the functions that are required for the cryostat commissioning and the STM instrument tests. Phase B will cover the remaining functions that are required for the CQM instrument tests. This release of this document will reflect these development phases.

2. DOCUMENTS

2.1 Applicable Documents

Ref	Document	Doc. No.	Date
AD1	SPIRE Test Facility Requirements Specification	SPIRE-RAL-PRJ-000463	
AD2	Herschel EGSE Packet Router ICD	SRON-G/EGSE/ICD/2001-xxx	
AD3	TFCS TM/TC Packet ICD	SPIRE-RAL-DOC-	
AD4	SPIRE STM Thermal Balance Test Specification	Draft 2	27-Jan-2002

3. ACRONYMS

CBB	Cold BlackBody
CQM	Cryogenic Qualification Model
EGSE	Electrical Ground Support Equipment
FIR	Far InfraRed
FTS	Fourier Transform Spectrometer
ICD	Interface Control Document
PFM	Proto-Flight Model
SPIRE	SPectrometer and Infrared REceiver
STM	Structural Test Model
TFCS	Test Facility Control System
VI	Virtual Instrument

4. INTRODUCTION

This section gives a brief description of the Test Facility Control System, TFCS. The TFCS will provide control and monitoring for the SPIRE calibration cryostat and sources. The key functions will be to:

- Monitor the cryostat temperatures, vacuum pressure and the cryogen levels.
- Control the temperatures within the cryostat, namely the 1.7K, 4.2K and 10K stages.
- Monitor the cold-blackbody temperatures
- Control the cold-blackbody heater
- Control the cold-blackbody flip mirror and heat shunt.
- Control and monitor the telescope simulator
- Monitor the output of the beam monitor.
- Record the selected laser wavelength.
- Set and read back the chopper frequency.
- Provide a 28V power supply to the instrument.
- Display parameters
- Log the data to a file
- Receive telecommand packets from the SPIRE EGSE to control the TFCS subsystems
- Send telemetry packets from the TFCS subsystems to the SPIRE EGSE.

In addition to the above capabilities, it shall be possible to

- Monitor and log the STM instrument temperatures
- Control and monitor the Fourier Transform Spectrometer, FTS.

It is not necessary that these be performed by the TFCS, but they will have some of the functions and interfaces.

The TFCS will be used for the complete operational cycle of the test cryostat:

- Pump-down
- Cool-down
- Instrument testing (thermal, performance tests, calibration)
- Warm Up
- Let-up to air

In all phases the cryostat temperatures and cryogen levels will be logged automatically and will be displayed on a computer screen as required. The vacuum pressure must be recorded and displayed throughout the tests except during instrument testing where the pressure gauge head could be a potential source of stray light and affect the instrument performance. However, periodic checks of the vacuum pressure will still be required to confirm that vacuum is being maintained.

The cold blackbody will be used as source of known radiance for performance and calibration tests. The blackbody will be nominally at 4K when not in use and heated up to 30K when used. A flip mirror will allow SPIRE to view the blackbody cavity. A heat shunt will be employed so that the blackbody plate can be returned to 4K.

The telescope simulator will present SPIRE with an f8.68 beam representative of the Herschel telescope. Due to restrictions on space within the test laboratory, the full SPIRE field of view cannot be completely filled. To ensure that the calibration can be performed for all SPIRE detectors, a series of moving fold mirrors is used to scan the image of a point source across the field of view, while maintaining the focus. A control law has been defined that will be used as the basis of the control software.

A Fourier Transform Spectrometer is being developed by Cardiff University and will be used to measure the spectral response of SPIRE. The TFCS user requirements for the FTS will not be defined in this issue of the URD.

The output of the telescope simulator will be picked off by a beam splitter and measured using a reference detector (probably a Golay cell). The output of the detector will be measured and recorded by the TFCS to allow correlation with the SPIRE measurements.

The wavelength selection of the FIR laser will be performed Manually with a Fabry Perot. The TFCS will allow the selected wavelength to be entered and recorded by the EGSE.

5. GENERAL REQUIREMENTS

5.1 System

All functions of the TFCS will be performed from a single Pentium III PC running Windows NT-4.

The TFCS PC shall have sufficient expansion slots to incorporate

- A GPIB, IEEE-488 interface card
- 2 (TBC) National Instruments data acquisition cards.
- TBD additional serial ports.

The TFCS PC shall have a network link to the SPIRE EGSE.

The TFCS shall be configured so that it can either be controlled as a stand-alone system or remotely from SCOS-2000.

The TFCS shall be time synchronised to the SPIRE EGSE.

The TFCS software shall be written in LabVIEW 6i™.

5.2 Data Logging

All TFCS data must be recorded to a log file.

It shall be possible to stop and restart data logging at any time.

A new log file shall be generated whenever logging restarts.

Existing log files must not be overwritten when logging is started/restarted.

It shall be possible to concatenate data from several log-files.

5.3 Display

The temperatures, heater settings and measured powers, vacuum pressures and cryogen levels and cold-blackbody mirror position and heat shunt position shall be displayed for real-time and archived data for the full SPIRE test period.

The display will be configurable by the user to show data from parameters of interest over a selected time range. The configuration settings shall include as a minimum:

- The parameters to be displayed
- Graphical or Text output
- The output format (precision, linestyle, colour)
- Display type (Linear or Logarithmic)
- Time/Date range
- Time/Date resolution
- Parameter range
- Parameter resolution
- Alarm limits

It shall be possible to call up displays independently of whether the TFCS is operating as a stand-alone system, or from the TFCS.

The configurations of the displays shall be saved to an editable text file so that a particular display format can be reused.

It shall be possible to produce an electronic copy of the display (i.e. pdf file)

It shall be possible to play back data through display system.

Temperature data will be compiled into a data packet for transmission to the rest of the EGSE systems.

5.4 Monitoring

It shall be possible for the user to define upper and lower alarm settings.

The TFCS shall monitor all parameters and check for out of limits conditions.

An audible alarm shall be triggered in the case of a parameter being out of limits.

5.5 Interface to EGSE

5.5.1 TFCS Telemetry

The data from all of the TFCS subsystems will be incorporated into telemetry packets to be sent to the SPIRE EGSE by the packet router. The format and content of the telemetry packets will be defined in the TFCS TM/TC Packet ICD (AD3).

5.5.2 TFCS Commands

Telecommands issued by SCOS-2000 to the TFCS subsystems will be sent via the packet router. The format and content of the telecommand packets will be defined in the TFCS TM/TC Packet ICD (AD3).

6. Phase A Requirements

6.1 Cryostat Monitoring and Control

6.1.1 Temperature Logging and Monitoring

6.1.1.1 Thermometers

Table 1 below specifies the positions, type, measurement range, accuracy and resolution of cryostat thermometers. The accuracy of the sensors is determined by the sensor characteristics, the calibration and the performance of the monitoring units. The TFCS shall ensure that the full measurement ranges are covered and that the temperatures are recorded to at least the resolutions stated in the Table 1.

Table 1: Cryostat thermometer locations, type, measurement range, accuracy and resolution

Sensor No.	Location		Type	Temp Range (K)		Accuracy (+/- K)	Resolution (K)
				min	max		
1	77K Shield	Endcap 1	Si Diode	60	325	1	0.1
2		Endcap 2	Si Diode	60	325	1	0.1
3		Filter Flange		60	325	1	0.1
4	10K Shield	Inlet Pipe	Si Diode	4.2	325	0.1	0.01
5		Outlet Pipe	Si Diode	4.2	325	0.1	0.01
6		Endcap 1	Si Diode	4.2	325	0.1	0.01
7		Endcap 2	Si Diode	4.2	325	0.1	0.01
8		Cylinder End 1	Si Diode	4.2	325	0.1	0.01
9		Cylinder Centre	Si Diode	4.2	325	0.1	0.01
10		Cylinder End 2	Si Diode	4.2	325	0.1	0.01
11		Filter Flange	Si Diode	4.2	325	0.1	0.01
12	10K Support Frame	Vacuum Vessel Standoff 1	Si Diode	4.2	325	0.1	0.01
13		Vacuum Vessel Standoff 2	Si Diode	4.2	325	0.1	0.01
14		Vacuum Vessel Standoff 3	Si Diode	4.2	325	0.1	0.01
15		Vacuum Vessel Standoff 4	Si Diode	4.2	325	0.1	0.01
16	HOB Simulator	Phot JFET Enclosure	Si Diode	4.2	325	0.1	0.01
17		Spec JFET Enclosure	Si Diode	4.2	325	0.1	0.01
18		FPU Foot 1Interface	Si Diode	4.2	325	0.1	0.01
19		FPU Foot 2 Interface	Si Diode	4.2	325	0.1	0.01
20		FPU Foot 3 Interface	Si Diode	4.2	325	0.1	0.01
21		Harness Sink - RF Filters	Si Diode	4.2	325	0.1	0.01
22		Harness Sink - Phot JFET	Si Diode	4.2	325	0.1	0.01
23		Harness Sink - Spec JFET	Si Diode	4.2	325	0.1	0.01
24	4.2K Stage	Vessel Top	Cernox	1.4	325	0.05	0.001
25		Vessel Bottom	Cernox	1.4	325	0.05	0.001
26		FPU Level 1 Strap interface	Cernox	1.4	325	0.05	0.001
27	1.7K Stage	Vessel - Bottom	Cernox	1.4	325	0.01	0.001
28		FPU Box Strap interface	Cernox	1.4	325	0.01	0.001
29		FPU Pump Strap interface	Cernox	1.4	325	0.01	0.001
30		FPU Evap Strap interface	Cernox	1.4	325	0.01	0.001
31		Vessel – Top	Cernox	1.4	325	0.01	0.001

6.1.1.2 Conditioning

Lakeshore type 218 units will be used to monitor the temperature sensors. Each unit is designed to monitor up to 8 thermometers of both types specified in Table 1. The monitoring units will be remotely controlled from the TFCS via an IEEE 488 interface.

6.1.1.3 Logging Requirements

The temperatures of all the thermometers listed in table 1 shall be automatically recorded by the TFCS. The update rate will be every 16 seconds (TBC) for all sensors.

All temperatures shall be logged and monitored continuously throughout the tests.

No other process on the TFCS may interrupt temperature logging unless a specific instruction has been sent.

6.1.2 Cryogen Level

The cryostat will have two level sensors, one for liquid nitrogen and one for liquid helium.

6.1.2.1 Sensors

The cryogen level sensors will be supplied and installed by AS Scientific.

A series of 4x100Ω platinum resistance thermometers (PT100) will be used to give a coarse indication of the level of liquid nitrogen. At 77K the PT100 resistance is 20.2Ω and increases with temperature. To avoid false readings when the sensor is above the liquid and in gas, a 100mA current to ensure that the resistance has some self-heating. The measured voltage will be between 2V and 10V.

The liquid helium sensor consists of a superconductive wire in a stainless steel sheath. The portion of the wire above the helium remains resistive while the portion below the liquid surface will be superconducting, i.e. 0Ω. The voltage across the wire is proportional to the fraction of the wire above the surface. Typically a 100mA current is applied across the probe to give a voltage between 0 and 40V depending on the normal wire resistance.

6.1.2.2 Data Logging

The level sensors will be polled every 16 seconds (TBC).

No other process on the TFCS may interrupt the level logging and monitoring unless a specific instruction has been sent.

The liquid nitrogen and helium levels shall be logged and monitored continuously throughout the tests.

There will be no automatic filling of LN_2 or He.

6.1.3 Pressure

Pressure monitoring will be provided for the pump-down and let-up phases, and periodically at non-critical times during instrument tests.

6.1.3.1 Sensors and Conditioning

The pressure inside the cryostat will be measured using compact Pirani gauges (Pfeiffer Vacuum TPR265) and a compact full range gauge (Pfeiffer Vacuum PKR251) connected to a dual-channel measurement & control unit for compact gauges (Pfeiffer Vacuum TPG262). The Measurement & control unit has an RS232 interface connector and can be driven from a serial port on the TFCS PC.

Table 2: Pressure gauges and ranges

Sensor Type	Range	Accuracy	Resolution
Pirani	1bar → 5 x 10^{-4} mbar	10% of value	1% of value
FullRange	1bar → 10^{-8} mbar	10% of value	1% of value

6.1.3.2 Software

The pressure gauges will be polled every second (TBC).

No other process on the TFCS may interrupt the pressure monitoring unless a specific instruction has been sent.

The pressure readings shall be logged and monitored continuously throughout the tests except when the SPIRE instrument is switched on.

It shall be possible to disable the pressure monitoring without affecting the overall logging system (i.e. temperature, levels…). When the pressure monitoring is disabled the pressure gauges must be switched off.

It shall be possible to reactivate the pressure gauges and monitoring without having to restart the overall logging system.

The rate of change of vacuum pressure shall be calculated and displayed.

6.1.4 Cryostat temperature control

6.1.4.1 Heaters

Table 3: Location of cryostat heaters

Heater No.	Location	Resistance	Temperature Range		Stability mK/ hr	Power Dissipation	
			Min	Max		Nom	Max
1	L0 Interface plate – 1	50Ω	1.6	2.2	TBD	TBD	TBD
2	L0 Interface plate – 2	50Ω	1.6	2.2	TBD	TBD	TBD
3	L0 Interface plate – 3	50Ω	1.6	2.2	9	TBD	TBD
4	L1 Interface plate	50Ω	4.2	7.0	120	TBD	TBD
5	Shield	TBD	9.0	15.0	70	TBD	TBD
6	HOB Simulator	TBD	9.0	15.0	70	TBD	TBD

6.1.5 Interface to EGSE

6.1.5.1 Telemetry

The parameters listed in Table 4 shall be transmitted to SCOS-2000 as telemetry packets.

Table 4: Cryostat parameters to be transmitted to SCOS-2000

Ref:	Parameter Name
1	Date
2	Time
3	Temperature Logging Enabled/Disabled
4	Pressure Logging Enabled/Disabled
5	Cryogen level logging Enabled/Disabled
6	Pirani Gauge Pressure
7	Full Range Gauge Pressure
8	N2 Level
9	He Level
10	77K Shield Endcap 1 Temperature
11	77K Shield Endcap 2 Temperature
12	77K Shield Filter Flange Temperature
13	10K Shield Inlet Pipe Temperature
14	10K Shield Outlet Pipe Temperature
15	10K Shield Endcap 1 Temperature
16	10K Shield Endcap 2 Temperature
17	10K Shield Cylinder End 1Temperature
18	10K Shield Cylinder Centre Temperature
19	10K Shield Cylinder End 2 Temperature
20	10K Shield Filter Flange Temperature
21	Vacuum Vessel Standoff 1 Temperature
22	Vacuum Vessel Standoff 2 Temperature
23	Vacuum Vessel Standoff 3 Temperature

24	Vacuum Vessel Standoff 4 Temperature
25	HOB Sim Phot JFET Enclosure Temperature
26	HOB Sim Spec JFET Enclosure Temperature
27	HOB Sim FPU Foot 1Interface Temperature
28	HOB Sim FPU Foot 2 Interface Temperature
29	HOB Sim FPU Foot 3 Interface Temperature
30	HOB Sim Harness Sink - RF Filters Temperature
31	HOB Sim Harness Sink - Phot JFET Temperature
32	HOB Sim Harness Sink - Spec JFET Temperature
33	4K Vessel Top Temperature
34	4K Vessel Bottom Temperature
35	4K FPU Level 1 Strap interface Temperature
36	1.7K Vessel - Bottom Temperature
37	1.7K FPU Box Strap interface Temperature
38	1.7K FPU Pump Strap interface Temperature
39	1.7K FPU Evap Strap interface Temperature
40	1.7K Vessel – Top Temperature
41	Level 0 Interface 1 Set Point Temperature
42	Level 0 Interface 1 Set Point Temperature
43	Level 0 Interface 1 Set Point Temperature
44	Level 1 Interface Set Point Temperature
45	10K Shield Set Point Temperature
46	HOB Simulator Heater Power
47	Level 0 Heater 1 Power
48	Level 0 Heater 2 Power
49	Level 0 Heater 3 Power
50	Level 1 Heater Power
51	10K Shield Heater Power
52	HOB Simulator Heater Power

6.1.5.2 Telecommands

Table 5: Commands to be sent from SCOS-2000 to the TFCS to control the cryostat control, logging and monitoring

Ref:	Commands	Parameters
1	Activate/Disable temperature logging	Activate/Deactivate
2	Activate/Disable cryogen level logging	Activate/Deactivate
3	Activate/Disable pressure logging	Activate/Deactivate
4	Set interface n temperature	Temperature

6.1.5.3 Events

Table 6: **Cryostat control, logging and monitoring events to be sent to SCOS-2000**

Ref:	Event	Parameters
1	Command Accepted	Command Name
2	Command Rejected	Command Name
3	Command Execution Successful	Command Name
4	Command Execution Failure	Command Name

6	Monitoring Limit Exceeded	Sensor Location Value

6.2 Cold Blackbody

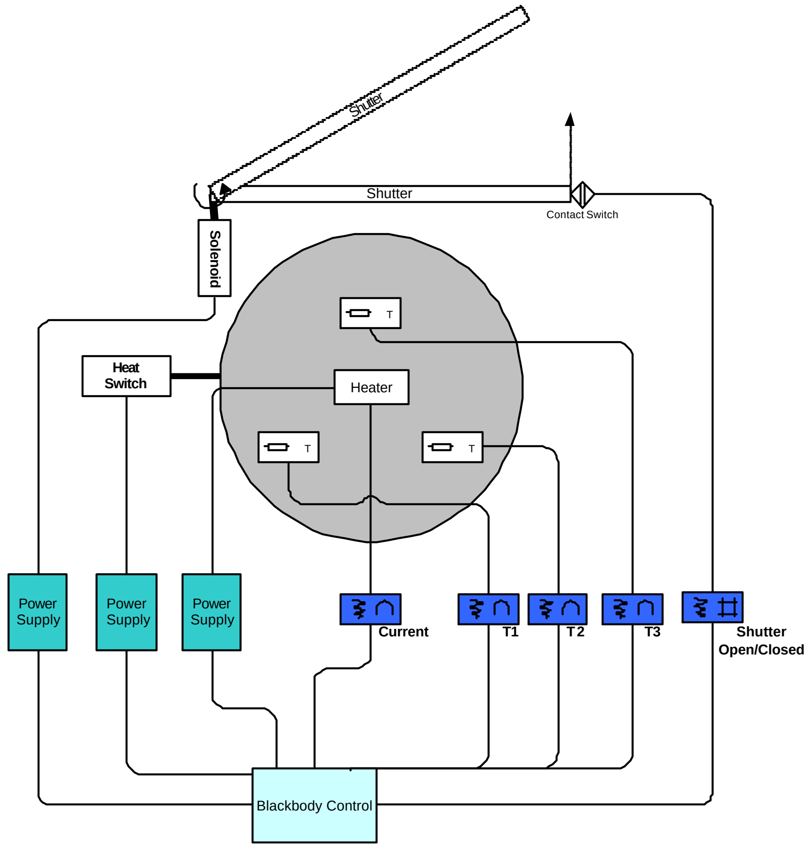

Figure 1: Schematic of the cold-blackbody control and monitoring

The cold black body and its interface electronics are provided by Cardiff University.

- 3 temperature sensors
- Heater
- Flip Mirror
- Heat switch

An electronics box will be provided by Cardiff with a standard interface to a National Instruments board.

6.2.1 Cold Blackbody Software Requirements

A LabVIEW 6i™ VI will be provided by Cardiff that will control and monitor the Cold Blackbody electronics. The VI will have an interface to the TFCS software to enable commands and data to be sent and received by the TFCS. An interface specification for the VI and control electronics will be provided by Cardiff.

The parameters to be passed to the cold-blackbody VI from the TFCS are:

Heater power level (mW)
Flip mirror position (open/closed)
Heat shunt position (open/closed)

The parameters to be sent to the TFCS from the blackbody VI are:

Measured temperatures (3)
Measured heater power (mW)
Actual flip mirror position (open/closed)
Actual heat shunt position (open/closed)

It shall be possible to set the cold-blackbody heater power, flip mirror position and heat shunt position from the SPIRE EGSE.

No other process on the TFCS may interrupt the cold-blackbody control and monitoring unless a specific instruction has been sent.

The temperatures, heater power, mirror and heat shunt positions shall be logged and monitored continuously throughout the tests.

6.2.2 EGSE Interface

6.2.2.1 Telemetry

The parameters listed in Table 7 shall be transmitted to SCOS-2000 as telemetry packets.

Table 7: Cold blackbody parameters to be transmitted to SCOS-2000

Ref:	Parameter Name
1	Date
2	Time
3	Flip Mirror Status
4	Heat Shunt Status
5	Cold Blackbody Temperature 1
6	Cold Blackbody Temperature 2
7	Cold Blackbody Temperature 3
8	Cold Blackbody Heater Power

6.2.2.2 Commands

Table 8: Commands to be sent from SCOS-2000 to the TFCS to control the cold-blackbody

Ref:	Commands	Parameters
1	Activate/Disable Cold Blackbody Logging	Activate/Deactivate
2	Open/Close Flip Mirror	Open/Close
3	Open/Close Heat Shunt	Open/Close
4	Set cold blackbody power	Power setting

6.2.2.3 Events

Table 9: Cold blackbody control, logging and monitoring events to be sent to SCOS-2000

Ref:	Event	Parameters
1	Command Accepted	Command Name
2	Command Rejected	Command Name
3	Command Execution Successful	Command Name
4	Command Execution Failure	Command Name
6	Monitoring Limit Exceeded	Sensor Location Value

6.3 Telescope Simulator

6.3.1 System Description

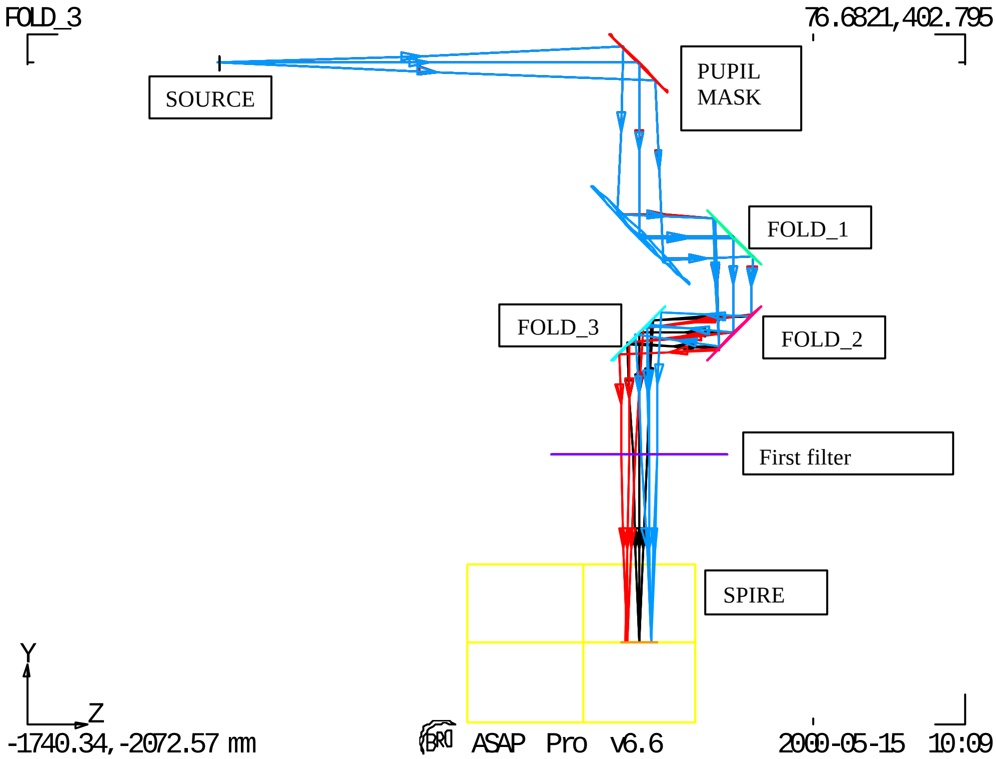

Figure 2: Optical Design of the SPIRE Telescope Simulator

The purpose of the telescope simulator is to present the SPIRE instrument with an F8.68 optical beam representative of the Herschel telescope beam (see Figure 2). In order to keep the point-source aberration free over the SPIRE FOV range, and to keep the simulator imaging simple, the design allows only one point source to be imaged at the spire focal surface. To point source is scanned across the FOV in azimuth and elevation by two of the fold mirrors, F2 and F3. To correct for the non-planar focal surface of SPIRE, two of the mirrors F1 and F2 are mounted on a translation stage in a trombone arrangement. The motions of these mirrors are defined by a set of complex control laws that have been produced by the SSTD Optics group. At the time of writing, the control law for two degrees of freedom have been tested. The control law will be tested for the full system will be tested once the optical layout has been installed.

The telescope simulator motors are driven from a Newport MM4006 multi axis motion controller capable of controlling up to 6 axes. The first four axes will drive the azimuth and elevation of the two fold mirrors and the fifth axis will be used for the focus control actuator. The configuration is given in Table 10 below. Communication between the MM4006 and TFCS can be either via an RS232 or GPIB. Labview drivers have been supplied for both options.

Table 10: Configuration of telescope simulator motion controller

Axis	Movement	Motor	Drive Card
1	Fold 2 – Azimuth	Newport 850-G Actuator	OPT-7D
2	Fold 2 – Elevation	Newport 850-G Actuator	OPT-7D
3	Fold 3 – Azimuth	Newport 850-G Actuator	OPT-7D
4	Fold 3 – Elevation	Newport 850-G Actuator	OPT-7D
5	Focus Adjustment	Newport M-ILS Translation Stage	OPT-7J

Tim Grundy has been prototyping the control laws using the MM4006 controller using Labview to control the experiment and IDL to analyse the measurements. The basic concept of the system is that the control laws have been defined using an optical ray-tracing model (Zeemax). The output is a look-up table that used by the Labview software so that the mirrors can be moved by the correct amount for a given beam position, see Figure 3. For the prototype, the table comprises a set of actuator positions for a complete scan sequence. The actual telescope simulator will require a table consisting of actuator positions for each SPIRE detector position (this will be large!).

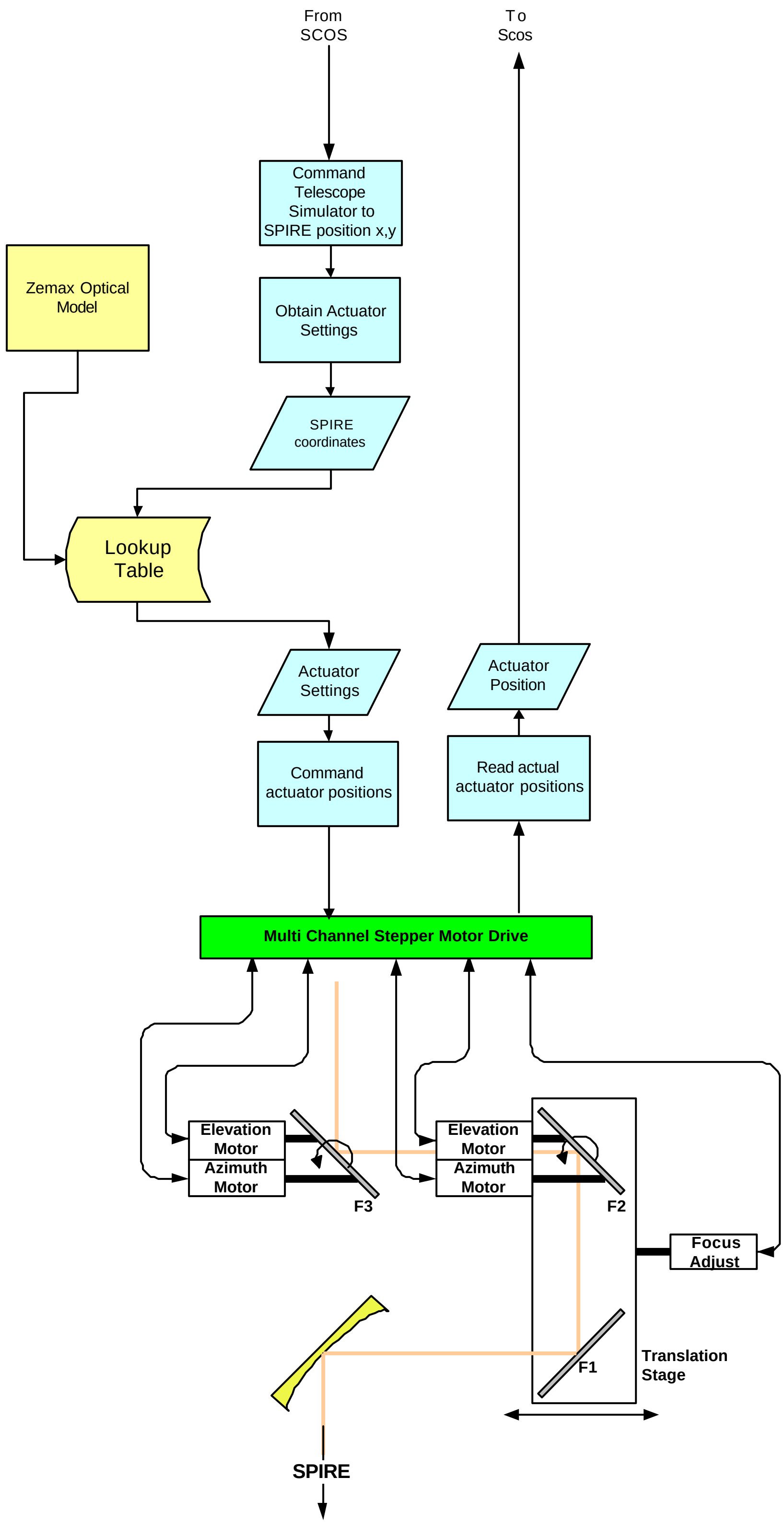

Figure 3: Schematic of Telescope Simulator Control System

6.3.2 Software Requirements

6.3.2.1 Control

It shall be possible to move the image of a point source by the telescope simulator to a given detector position x,y.

It shall be possible to scan the image of a point source across a range of SPIRE detectors.

It shall be possible to automatically find the centre of movement of the telescope simulator actuators.

It shall be possible to reset the co-ordinates of the actuator positions to a defined setting (e.g. zero mm)

It shall be possible to remotely switch-on/off the Newport MM4006 controller.

6.3.2.2 Display

The TFCS shall provide a real-time display of the commanded and actual positions of the actuators.

The TFCS shall indicate the commanded and estimated pixel co-ordinates.

The TFCS shall indicate the status of the Newport MM4006 controller.

The TFCS shall indicate the scanning mode:

- Move to detector x,y
- Scan from x1,y1 to x2,y2
- Centering actuators.

An audible alarm shall sound if an actuator end-stop has been reached.

6.3.3 EGSE Interface

6.3.3.1 Telemetry

Ref:	Parameter Name
1	Date
2	Time
3	Fold Mirror 2 Commanded Azimuth
4	Fold Mirror 2 Measured Azimuth
5	Fold Mirror 2 Commanded Elevation
6	Fold Mirror 2 Measured Elevation
7	Fold Mirror 3 Commanded Azimuth
8	Fold Mirror 3 Measured Azimuth
9	Fold Mirror 3 Commanded Elevation
10	Fold Mirror 3 Measured Elevation
11	Translation Stage Commanded Position
12	Translation Stage Measured Position

6.3.3.2 Commands

Ref:	Commands	Parameters
1	Switch On/Off MM4006 controller	ON/OFF
2	Center actuators	
3	Set actuator position	Actuator no. Position (mm)
4	Move to detector position x,y	x y
5	Scan from detector x1,y1 to x2,y2	x1 y1 x2 y2

6.3.3.3 Events

Table 11: Telescope simulator control, logging and monitoring events to be sent to SCOS-2000

Ref:	Event	Parameters
1	Command Accepted	Command Name
2	Command Rejected	Command Name
3	Command Execution Successful	Command Name
4	Command Execution Failure	Command Name
6	Motor end stop reached	Stepper motor number

6.4 Instrument Monitoring

The SPIRE STM instrument will not have any control and monitoring electronics apart from the cooler EGSE. Therefore it will be necessary to provide some EGSE for the STM thermal tests. The STM will not have any active mechanisms other than the CQM cooler and therefore the only requirement is to provide power to a number of heaters and temperature monitoring.

6.4.1 Heater Power

Standard laboratory power supplies will supply the power to the instrument heaters. There will be no remote control of these units. A list of the STM heaters are provided in Table 12.

Table 12: STM Heater Locations

Heater No.	Location	Resistance	Temperature Range		Stability mK/ hr	Power Dissipation	
			Min	Max		Nom	Max
1	BSM	TBD	TBD	TBD	TBD	TBD	TBD
2	SMECm	TBD	TBD	TBD	TBD	TBD	TBD
3	SCAL	TBD	TBD	TBD	TBD	TBD	TBD
4	PCAL	TBD	TBD	TBD	TBD	TBD	TBD

6.4.2 Temperature Monitoring

A duplicate of the TFCS cryostat temperature logging and monitoring system will perform temperature monitoring of the STM instrument. The main difference will be a PICOWATT, AC resistance bridge (TBD) to measure the temperatures of the 300mK stage. This unit has an IEEE-488 interface and comes with Labview drivers. The STM instrument thermometers are defined in listed in Table 13 below. Sensors 1 to 22 are the flight sensors. Sensors 23 to 42 are additional sensors required to monitor the temperature of the STM FPU and JFET chassis during thermal balance testing.

Table 13: STM Instrument Thermometers

Sensor No.	Location		Type	Temp Range (K)		Accuracy (+/- K)	Resolution (K)
				min	max		
1	**Level 2:**	JFET Phot module 1	Cernox	10	100	1.000	0.500
2		JFET Spec module 1	Cernox	10	120	1.000	0.500
3	**Level 1:**	HSFPU Optical Bench	Cernox	3	100	0.050	0.025
4		M3,5,7 Optical Sub Bench	Cernox	3	100	0.010	0.010
5		Input Baffle	Cernox	3	100	0.010	0.010
6		BSM/SOB I/F(SOB side)	Cernox	3	100	0.010	0.010
7		SCAL Structure	Cernox	3	100	0.010	0.010
8		Cooler Pump	Cernox	3	100	0.025	0.025
9		Cooler Evap	Cernox	0.2	5	0.001	0.001
10		Cooler Pump Heat Switch	Cernox	1	50	0.005	0.005
11		Cooler Evap Heat Switch	Cernox	1	50	0.005	0.005
12		Cooler Shunt	Cernox	0.2	5	0.001	0.001
13		SCAL 4%	Cernox	10	80	0.005	0.005
14		SCAL 2%	Cernox	10	80	0.005	0.005
15		BSM	Cernox	3	20	0.010	0.010

16		SMEC	Cernox	3	20	0.010	0.010
17		SMEC/SOB I/F	Cernox	3	100	0.050	0.025
18	**Level 0:**	Photometer Level 0 Encl.	Cernox	1	10	0.002	0.002
19		Spectrometer Level 0 Encl.	Cernox	1	10	0.002	0.002
20	**300mK:**	300mK PH Busbar 1	Cernox	0.2	5	0.001	0.001
21		300mK PH Busbar 2	Cernox	0.2	5	0.001	0.001
22		300mK SP Busbar 3	Cernox	0.2	5	0.001	0.001
23	**Level 2:**	Phot JFET Chassis	Cernox	3	100	0.050	0.025
24		Spec JFET Chassis	Cernox	3	100	0.050	0.025
25	**Level 1:**	Shutter Vane	Cernox	3	100	0.010	0.010
26		FPU Structure +Y	Cernox	3	100	0.050	0.025
27		FPU Structure -Y	Cernox	3	100	0.050	0.025
28		FPU Structure +X	Cernox	3	100	0.050	0.025
29		FPU Structure -X	Cernox	3	100	0.050	0.025
30		FPU Structure +Z	Cernox	3	100	0.050	0.025
31		FPU Structure -Z	Cernox	3	100	0.050	0.025
32		SOB +X	Cernox	3	100	0.050	0.025
33		SOB -X	Cernox	3	100	0.050	0.025
34		SOB +Z	Cernox	3	100	0.050	0.025
35		SOB -Z	Cernox	3	100	0.050	0.025
36	**Level 0:**	Photometer Level 0 Encl.	Cernox	1	10	0.002	0.002
37		Spectrometer Level 0 Encl.	Cernox	1	10	0.002	0.002
38	**300mK:**	Ph SW BDA	Cernox	0.2	5	0.001	0.001
39		Ph MW BDA	Cernox	0.2	5	0.001	0.001
40		Ph LW BDA	Cernox	0.2	5	0.001	0.001
41		Sp SW BDA	Cernox	0.2	5	0.001	0.001
42		Ph LW BDA	Cernox	0.2	5	0.001	0.001

7. PHASE B REQUIREMENTS

7.1 Instrument Power Supply

7.2 Beam Monitor

Ref:	Parameter Name
1	Date
2	Time
3	Detector Signal

7.3 Chopper

Ref:	Parameter Name
1	Date
2	Time
3	Commanded frequency
4	Measured frequency

7.4 Laser Line Selection

Ref:	Parameter Name
1	Date
2	Time
3	Selected Wavelength

7.5 Fourier Transform Spectrometer

Ref:	Parameter Name
1	Date
2	Time
	….
	….
	….