MOBIE INTERFACE CONTROL DOCUMENT

TMT.INS.ICD.08.006.DRF01

December 4, 2008

Bruce C. Bigelow, UCSC
MOBIE Project Manager

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 INTRODUCTION

This document contains a list and description of the interfaces between MOBIE, the Multi-Object Broadband Imaging Echellette, and the rest of the TMT observatory. MOBIE is the UCSC/UCO design for the TMT wide field optical spectrograph (WFOS), and is distinct from previous WFOS design concepts, including CIT-MILES, UCSC-ELVIS, and HIA-WFOS. The intended audience includes TMT project management, the systems engineering department, the instrumentation department, and members of the MOBIE project.

1.2 SCOPE

This document provides an initial overview of the anticipated interfaces between the MOBIE instrument and the TMT observatory. The details and final specifications of the interfaces will be described in individual system-to-system interface control documents to be determined in the conceptual design phase for the MOBIE instrument. The scope of this document is range of external (observatory – instrument) interfaces that will need to be defined and controlled as the MOBIE design progresses. This document does not include the interface definitions, which will be developed later. This document does not include internal interfaces, which will be defined in the conceptual design phase.

The installed MOBIE instrument hosts a typical set of spectrograph sub-systems, including:

- The instrument rotator system (IRS), which attaches to the telescope Nasmyth platform, and rotates the instrument mainframe structure, to follow the rotating field of view produced by the telescope.
- The instrument structure (STR), which is carried by the IRS, and supports most of the other instrument sub-systems.
- The instrument enclosure systems (ENC), which include an (optical) entrance hatch, maintain a clean, light-tight environment around the instrument, and attach to the STR.
- The atmospheric dispersion corrector (ADC), which mounts on the STR.
- The field correcting lens assembly (FC), which mounts on the STR.
- The instrument calibration system (CAL), which mounts on the STR.
- The instrument wavefront sensor(s) (WFS), which mounts on the STR.
- The instrument guide camera(s) (GCM), which mount on the STR.
- The long slit viewing camera (LSV), which mounts on the STR.
- The focal plane server (FPS), which delivers slit masks to the telescope focal plane, and mounts on the STR.
- The active collimator system (COLL), which carries the collimator mirror, and mounts on the STR.

- The beam-splitting dichroic (DCR), which splits the optical path into blue and red channels.
- The disperser server systems (DSS), which position gratings or imaging mirrors at the collimator exit pupil, and mount on the STR.
- The echellette prism servers (ECH), which insert cross-dispersing prisms into the optical paths to enable the echellette spectroscopy mode, and mount on the STR.
- The blue camera (BCM), which images the blue channel of the telescope focal plane on to the science detectors, and mounts on the STR.
- The red camera (RCM), which images the red channel of the telescope focal plane on to the red channel science detector system, and mounts on the STR.
- The filter server systems (FSS), which insert passband filters into the blue and red camera systems, and mount on the respective cameras.
- The shutters (SHT), which provide exposure control, and mount on the respective cameras.
- The science detector systems (DET), which convert the optical signals into electronic signals, and mount on respective cameras.
- The stray light controls (SLC), which limit stray light from reaching the science detectors, and mount in or on multiple sub-systems (e.g. inside the cameras, around the pupil optics, and on the STR).
- The instrument electrical systems (ELE), which include both on-board and remote (Nasmyth platform) sub-systems.
- The instrument control system (ICS) which manages all aspects of sensing and control of the instrument.

In addition to the instrument-mounted sub-systems, MOBIE also has sub-systems which are remote from the instrument:

- The slit mask fabrication system (MFS), a set of hardware and software systems for managing the slit mask life cycle (definition, design, fabrication, installation, tracking, transport, storage, archiving), housed in a room at the observatory.
- The instrument electrical systems (ELE), which include a rack system which mounts near the instrument on the Nasmyth platform.
- The science detector (DET) cooling systems compressor(s), which mount on the telescope, near the instrument.
- The observatory calibration system (OCL), which includes a diffuse white surface, slightly larger than 30m in diameter, on the inside of the dome, on to which calibration light sources be projected.
- The instrument servicing equipment (EQP), which includes parts, spares, tools and fixtures for servicing the instrument, and stores in a cabinet near the instrument on the Nasmyth platform.

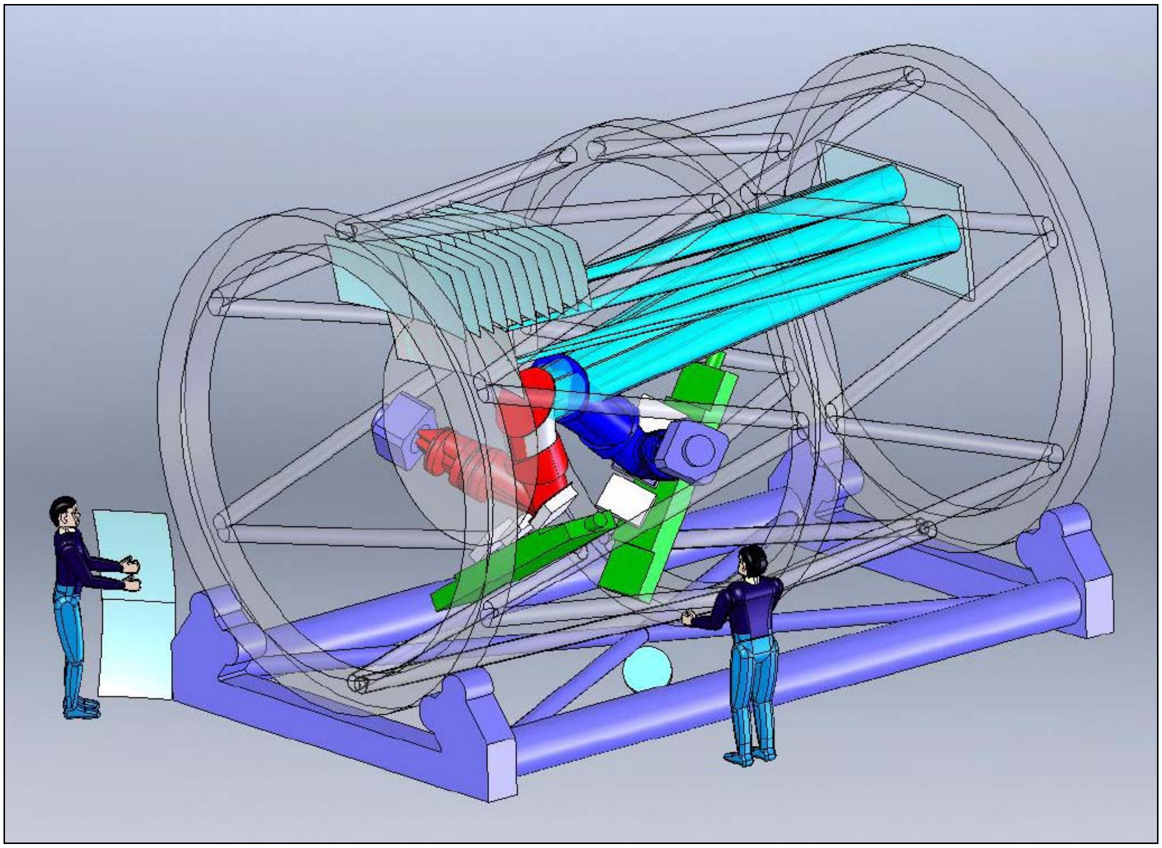

Figure 1 Schematic layout of MOBIE with a single field and reflecting collimator.

1.3 APPLICABLE DOCUMENTS

AD01 – TMT Science Req. Document (SRD) v17.0, (TMT.PSC.DRD.07.001.DRF01)

AD02 – TMT Operations Concept Document (OCD), (TMT.OPS.MGT.07.002)

AD03 – TMT Observatory Requirements Document (ORD), (TMT.SEN.DRD.05.001)

AD04 – TMT Observatory Architecture Document (OAD), (TMT.SEN.DRD.05.002)

AD05 – Observation Workflow for the TMT (TMT.AOS.TEC.07.013.DRF06)

AD06 – TMT Acronym List (TMT.SEN.COR.06.018.REL01)

AD07 – Nasmyth Instr. Support Requirements Document (TMT.SEN.DRD.06.003.DRF02)

AD08 – MOBIE Feasibility Study Statement of Work (TMT.INS.CON.08.002.DRF01)

AD09 – MOBIE Feasibility Study Report, (TMT.INS.TEC.08.003.DRF01)

AD10 – MOBIE Functional and Perf. Req. Document, (TMT.INS.DRD.08.002.DRF01)

AD11 – MOBIE Operational Concepts Def. Document, (TMT.INS.DRD.08.003.DRF01)

AD12 – MOBIE Feasibility Study Report, (TMT.INS.TEC.08.003.DRF01)

1.4 REFERENCE DOCUMENTS

RD01 – TMT Nasmyth Instrument Mass Budget, (TMT.INS.TEC.07.004.DRF01)

1.5 CHANGE RECORD

Revision	Date	Section	Modifications
DRF01	9/16/2008	All	Initial draft – B. B. Bigelow

1.6 ABBREVIATIONS

ADC – Atmospheric Dispersion Corrector
AO- Adaptive Optics
APS – Alignment and Phasing System (for TMT)
AR – Anti-reflection (coatings)
ASIC – Application-Specific Integrated Circuit
CaF2 – Calcium fluoride
CIT – California Institute of Technology
DMS – Data Management System (for TMT)
EAP – External Advisory Panel (for TMT)
EMI – Electro-Magnetic Interference
FOV – Field of View
FSR – Feasibility Study Report
FPRD – Functional and Performance Requirements Document
HIA – Hertzberg Institute for Astrophysics
HROS – High Resolution Optical Spectrograph (for TMT)
GMS – Global Metrology System (for TMT)
ICD – Interface Control Document
ICS – Instrument Control System
IDMS – Instrument Data Management System
MOBIE – Multi-Object Broadband Imaging Echellette (spectrograph)
MRF – Magneto-Rheological Finishing
OAD – Observatory Architecture Document (for TMT)
OCS – Observatory Control System (for TMT)
OCD – Operation Concepts Document (for TMT)
OCDD – Operational Concepts Definition Document
ORD – Observatory Requirements Document (for TMT)
RFI – Radio Frequency Interference
SAC – Science Advisory Committee
SOW – Statement of Work
SRD – Science Requirements Document (for TMT)
ST – Science Team (for MOBIE-WFOS)
TCS – Telescope Control System
UCSC – University of California, Santa Cruz
UCO – University of California Observatories
UPS – Uninterruptible Power Supply
WBS – Work Breakdown Structure
WFOS – Wide Field Optical Spectrograph (for TMT)

2. DESCRIPTION

2.1 PERSPECTIVE

This subsection should put the interfaces into perspective with other related systems and interfaces. This subsection should also describe how the interface operates inside various constraints and operating scenarios.

MOBIE is one of the three first-generation instruments for TMT (the others being IRIS and IRMS). MOBIE will be the only seeing-limited, visible passband instrument in the early years of TMT. MOBIE will also be the only wide-field instrument, and is the only instrument expected to permanently occupy a Nasmyth platform position coaxial with the telescope elevation axis (see Figure 2).

MOBIE will occupy a volume approximately 5m in diameter, and 8m long. The initial weight estimate for MOBIE is approximately 20,000 Kg (the maximum allowance for the WFOS instrument is 32,000 Kg). Given the instruments size and mass, MOBIE is expected to be assembled on the Nasmyth platform, and to remain there until it is decommissioned. Consequently, once finalized, the interfaces to the instrument are not expected to change substantially, or to allow for removal and re-installation of the instrument prior to decommissioning.

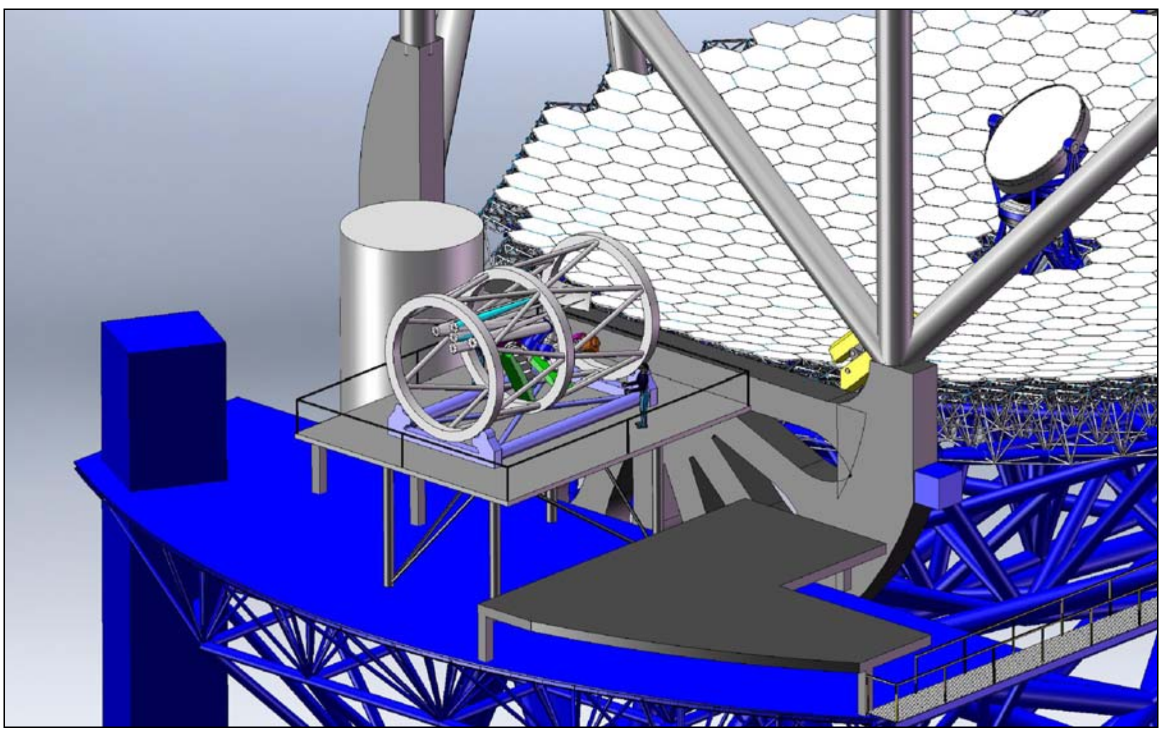

Figure 2. MOBIE on the +X Nasmyth platform.

MOBIE N2 DIAGRAM V 1.1.XLS

		IRS	STR	ENC	ADC	FC	CAL	WFS	GCM	LSV	FPS	COLL	DCR	DSS	ECH	BCM	RCM	FSS	SHT	DET	SLC	ELE	ICS	EQP	MFS
MOBIE	IRS																								
	STR	E/M/T																							
	ENC		C/M																						
	ADC		C/E/M																						
	FC		M		O																				
	CAL		C/E/M																						
	WFS		C/E/M																						
	GCM		C/E/M																						
	LSV		C/E/M																						
	FPS		C/E/M	M		O	O	O	O	O															
	COLL		C/E/M								O														
	DCR		C/E/M									O													
	DSS		C/E/M	M									O												
	ECH		C/E/M											O											
	BCM		C/E/M											O	O										
	RCM		C/E/M											O	O										
	FSS		C/E/M	M												O	O								
	SHT															M/O	M/O	M/O							
	DET															M/O	M/O								
	SLC		M/O	M/O	M/O	M/O	M/O	M/O	M/O		M/O	M/O	M/O	M/O	M/O	M/O	M/O	M/O	M/O	M/O					
	ELE	E/M/S	C/E	C/E	C/E		C/E	C/E	C/E		C/E	C/E		C/E	C/E	C/E	C/E	C/E	C/E	C/E					
	ICS	C/E	C/E	C/E	C/E		C/E	C/E	C/E		C/E	C/E		C/E	C/E	C/E	C/E	C/E	C/E	C/E		C/E			
	EQP										M							M							
	MFS	M																					C		
TELE.	TCS	C/E			C/E			C/E	C/E														C/E		
	OPT				O																				
	GMS	M	M																						
	POWR																					C/E			
	STR	M/S/T																							
OBS.	EDS				C/E			C/E	C/E											C/E			C/E		C
	SDS				C/E			C/E	C/E											C/E			C/E		C
	OSS	C/E																					C/E		C
	FAC			T			E/M/O				M			M				M				T			E/M/S/T

C	CONTR
E	ELEC
M	MECH
O	OPTICAL
S	SERVICE
T	THERMAL

Table 1 MOBIE N2 diagram with internal and external interfaces.

Table 1 shows the N2 diagram for the MOBIE instrument, with both internal and external interfaces. The abbreviations for each sub-system are listed in section 1.2. The coding in each box represents the following interfaces:

- C – controls
- E – electrical / electronic
- M – mechanical
- O – optical
- S – services
- T – thermal

2.2 INTERFACE FUNCTIONS

The interface functions are described below in section 3.

2.3 INTERFACE CONSTRAINTS

A variety of constraints are expected for the interfaces between the observatory, the telescope, and the MOBIE instrument. However, many of these must await further development before the constraints can be defined. Key examples include:

- Interfaces to the observatory safety system (OSS)
- Interfaces to the observatory software (OSW)
- Interfaces to the observatory engineering data system (EDS)
- Interfaces to the observatory science data system (SDS)
- Interfaces to the telescope Nasmyth platform structure (STR)
- Interfaces to the telescope optical system (OPT)
- Interfaces to the Observatory liquid and gaseous plumbing systems (UTIL)
- Interfaces to the Observatory electrical systems (POWR)
- Interfaces to the Observatory ethernet systems (TBD)

2.4 INTERFACE ASSUMPTIONS AND DEPENDENCIES

As with the interface constraints in the previous section, many of the assumptions and dependencies of the instrument-telescope interfaces have yet to be defined, and will be added to later versions of this document.

3. INTERFACE SPECIFICATIONS

This initial draft of the MOBIE ICD was prepared in the feasibility study for the MOBIE instrument. As such, the interfaces identified here have yet to be discussed or negotiated with the TMT project systems engineering group. The interfaces listed below will certainly change in form and quantity during the conceptual design phase. Formal numbering of the interfaces, according the TMT standard (INT-SYSA-SYSB-ZZZ) will be deferred until the conceptual design phase.

3.1 OPTICAL INTERFACES

The optical interfaces section specifies how light is passed between systems. This can include details of beam sizes, focal plane positions, pupil positions, image quality, etc.

[INT-SYSA-SYSB-ZZZZ] All interfaces shall be written using the Microsoft Word style “req”.

1. There is an optical interface between the telescope and MOBIE at the telescope focal surface. The dimensions of the focal surface include the XYZ coordinates of the focal surface vertex, the RxRy tilts of the focal surface with respect to the Z (optical) axis, the un-vignetted field diameter, the vignetted (maximum) field diameter, image quality, and the variation in image quality as a function of field radius. This interface is important for the location of the instrument slit and imaging masks. The specifications for this interface are **TBD.**
2. There is an optical interface between the telescope and MOBIE at the telescope exit pupil. The location of the telescope exit pupil determines the angles at which the rays from various field angles arrive at the telescope focal surface. This interface is important for baffling of the entrance to the instrument and the focal surface. The specifications for this interface are **TBD.**
3. There is an optical interface between the TEL and INSTR at the exit pupil of the instrument collimator. The XYZ location and RxRy rotations of the collimator exit pupil are dependent on the stability of the telescope, and especially on the alignment of the telescope optics M1, M2, and M3. The specifications for this interface are **TBD.**
4. There is an optical interface between the telescope and the instrument wavefront sensor (WFS). This interface includes the range of XYZ positions the WFS can patrol, the size of the WFS field of view, the shape of the field of view, and the number of sub-apertures across the pupil that are seen by the WFS. The specifications for this interface are **TBD.**
5. There is an optical interface between the telescope and the instrument guide camera (GCM). This interface includes the range of XYZ positions the guider can patrol, the size of the guider field of view, the location of the guider FOV, and the shape of the FOV. The specifications of this interface are **TBD.**

6. There is an optical interface between the telescope and the long slit viewer camera (LSV). This interface includes the size of the LSV field of view, the shape of the LSV field of view, and the location of the LSV on the telescope focal plane. The specifications of this interface are **TBD.**

7. There is an optical interface between the telescope (ENC) and the external calibration system (ECL). This interface includes size and location of the enclosure-mounted calibration screen, and the telescope-mounted calibration light sources. The specifications for this interface are **TBD**.

3.2 STRUCTURAL AND MECHANICAL INTERFACES

The structural and mechanical interfaces section specifies spatial characteristics, masses, connection details, load transfer details of systems. This can include mass, volume, bolt patterns, and details of force, torque, friction, dynamic characteristics, etc.

1. There is a structural interface between the telescope structure (STR.AZ.NAS) and the instrument (IRS). On the telescope side, the Nasmyth platform mounting points define the mechanical interface, including the size, type, location, force load, and moment load allowed for each mounting point in the interface. The instrument side of this interface is through the instrument rotator system (IRS). The IRS attaches to the Nasmyth instrument mounting points. The instrument rotator mounting interface is not kinematic (but the interface between the rotator and the instrument mainframe is). The specifications for this interface are **TBD.**
2. There is a structural interface between the Nasmyth platform (STR.AZ.NAS) and the instrument external electronics cabinet (ELE). The location, size, type, force loads, and moment loads for this interface are **TBD.**
3. There is a structural interface between the Nasmyth platform (STR.AZ.NAS) and the instrument tools and equipment cabinet (EQT). The location, size, type, force loads, and moment loads for this interface are **TBD**.
4. There is a mechanical interface between the telescope Global Metrology System (OPT.TINS.GMS) and the instrument rotator (IRS). The MOBIE instrument must be accurately aligned and maintained concentric with the telescope elevation axis. Corse alignment between the instrument and the Nasmyth platform will be accomplished by measuring the position of the IRS with the GMS, followed by adjustment of spacers at the IRS/Nasmyth interface. The interface to the GMS is assumed to be via corner cubes contacted to the IRS. The locations for these corner cube interfaces must be visible to the GMS. The specifications for this interface are **TBD.**
5. There is a mechanical interface between the GMS and the instrument mainframe (STR). The MOBIE instrument must be accurately aligned to the telescope elevation and optical axes. Corse adjustments will be made at the IRS/Nasmyth interface. Fine adjustments will be made between the IRS and the STR. The interface between the GMS and the IRS will be via corner cubes contacted to the STR. The locations for the corner cube interfaces on the STR must be visible to the GMS. The specifications for this interface are **TBD**.
6. There is a mechanical interface between the telescope enclosure (ENC) and the external calibration system (ECL). The mechanical interface includes the mounting arrangements for the enclosure-mounted calibration screen, and the telescope-mounted calibration light sources. The specifications for this interface are **TBD**.

3.3 ACCESS AND HANDLING INTERFACES

The access and handling interfaces section specifies how access and handling is achieved between systems. This can include how a system is removed from or replaced onto another system, or how personnel and equipment pass from one system to another.

1. There is an access/handling interface between the observatory support facilities (FAC.INF.SUPP) and the MOBIE mask fabrication system (MFS). This interface will include the specifications for the space (room) in which the MFS sits, and the utilities that are required in that room (electric power, fresh air ventilation, gas supplies for a laser cutting system, liquid coolant or a recirculating chiller for the laser).. The MFS includes a mask storage system, which may be located in the MFS room, or elsewhere. Storage space will be required for un-cut mask blanks, and used masks. The specifications for this interface are **TBD.**
2. There is an access/handling interface between the mask transport system (MFS) and the focal plane server (FPS) on the instrument. The masks may be too large and/or too heavy to be moved from the transport system to the FPS. This may require specially tooling or equipment. The specifications for this interface are **TBD.**
3. There is an access/handling interface between the observatory support facilities (FAC.INF.SUPP) and the MOBIE filters (FSS). The instrument will carry a limited number of filters on-board, and additional filters will be stored elsewhere. A transport system may be required to move (safely) the filters from the observatory storage location to the instrument. The specifications for this interface are **TBD.**
4. There is an access/handling interface between the observatory (FAC.INF.SUPP) and the MOBIE diffraction gratings (GRT). The instrument will carry a small number of gratings on-board, and additional gratings (when available) will be stored elsewhere. A transport system may be required to move (safely) the gratings from the observatory storage location to the instrument. The specifications for this interface are **TBD.**

3.4 COMMUNICATION, SOFTWARE AND CONTROL INTERFACES

The control section specifies the required communication and control signals that must pass between systems, along with details of the software interfaces. This can include details of communication standards and protocols, data rates, connector types, software data structures, etc. This section includes safety and interlock signal specifications if applicable.

The architecture of the observatory and telescope software systems has yet to be developed. The interfaces between the observatory, telescope, and instrument are identified below, but the specifications for these interfaces will be resolved in later versions of this document.

1. There is an interface between the telescope control system (TCS) and the MOBIE instrument rotator (IRS). The IRS rotates the instrument to follow the rotation of the telescope field of view. The IRS angular position will be encoded, and a motor will rotate the IRS according to commands from the TCS or the instrument control system (ICS). The control system for the IRS will need continuous updating of the telescope elevation and azimuth angles. The specifications for this interface are **TBD.**
2. There is an interface between the TCS and the MOBIE ADC. The ADC compensates atmospheric dispersion as a function of telescope elevation angle. The control system for the ADC will require continuous updating of the telescope elevation and azimuth angles, along with the position angle of the IRS. The specifications for this interface are **TBD.**
3. There is an interface between the TCS and the MOBIE instrument wavefront sensor (WFS). The WFS may be fixed with respect to the focal surface of the telescope, or it may patrol an area of the focal surface to provide a larger selection for reference objects. The WFS will provide raw images from the camera to the TCS, along with all telemetry associated with the position, operation, and status of the WFS. The specifications for this interface are **TBD.**
4. There is an interface between the TCS and the MOBIE guide camera(s). The guider(s) may be fixed with respect to the focal surface of the telescope, or may patrol an area of the focal surface to provide a larger selection for reference objects. The guider(s) will provide raw images from the camera(s) to the TCS, along with all telemetry associated with the position, operation, and status of the guider. The specifications for this interface are **TBD.**
5. There is an interface between the TCS and the MOBIE long slit viewing (LSV) camera. The LSV will be fixed with respect to the telescope focal surface. The LSV will provide raw images from the camera and related telemetry to the TCS and the ICS. The specifications for this interface are **TBD.**
6. There is an interface between the telescope TCS and the MOBIE instrument control system (ICS). The TCS will provide data to the ICS regarding telescope pointing, telemetry, observing conditions, etc., all of which will be captured in the headers of the instrument science data files. The ICS will provide similar data about instrument status to the TCS. The specifications for this interface are **TBD.**
7. There is an interface between the TCS and the ICS for coordinated telescope/instrument observing (e.g. nod and shuffle exposures). The specifications for this interface are **TBD**.

8. There is an interface between the TCS and the ICS for an audio-video link between the instrument and the telescope control room. The instrument will carry microphones and video cameras for audio-visual feedback to users and operators. The audio link will remain in operation during observations. The video link will only be used for trouble-shooting and servicing. The specifications for these interfaces are **TBD**.
9. There is an interface between the observatory engineering data system (EDS) and the instrument ADC. This interface could be unique, or could occur between the EDS and the ICS. The specifications for this interface are **TBD.**
10. There is an interface between the observatory science data system (SDS) and the instrument ADC. This interface could be unique, or could occur between the SDS and the ICS. The specifications for this interface are **TBD.**
11. There is an interface between the EDS and the instrument WFS. This interface could be unique, or could occur between the SDS or (TCS) and the ICS. The specifications for this interface are **TBD.**
12. There is an interface between the SDS and the instrument WFS. This interface could be unique, or could occur between the SDS or (TCS) and the ICS. The specifications for this interface are **TBD.**
13. There is an interface between the EDS and the instrument guider(s). This interface could be unique, or could occur between the SDS (or TCS) and the ICS. The specifications for this interface are **TBD.**
14. There is an interface between the SDS and the instrument guider(s). This interface could be unique, or could occur between the SDS (or TCS) and the ICS. The specifications for this interface are **TBD.**
15. There is an interface between the telescope EDS and the instrument science detector system (DET). This interface could be unique, or could occur between the SDS (or TCS) and the ICS. The specifications for this interface are **TBD.**
16. There is an interface between the telescope SDS and the instrument science detector system (DET). This interface could be unique, or could occur between the EDS (or TCS) and the ICS. The specifications for this interface are **TBD**.
17. There is an interface between the EDS and the mask fabrication system (MFS). Masks will be cut according to the needs of particular observers, for particular targets and observing conditions. Masks will be cut prior to the start of observing runs. The status of mask fabrication for a particular observing run will be made available through the EDS and/or SDS. The flow of information between these systems is **TBD**. The specifications for this interface are **TBD**.
18. There is an interface between the SDS and the mask fabrication system (MFS). Masks will be cut according to the needs of particular observers, for particular targets and observing conditions, and this information will need to be logged in the headers of science data files. The flow of information between these systems is **TBD**. The specifications for this interface are **TBD**.
19. There is an interface between the observatory safety system (OSS) and the MFS. The mask cutting system will use a medium power (50 – 100W) laser. The MFS will operate in a room with a fire suppression system. Parameters relevant to the safety of the laser system will be passed to the OSS. The flow of information between these systems is **TBD**. The specifications for this interface are **TBD**.

20. There is an interface between the instrument control system (ICS) and the TCS. The instrument will command external calibration light sources on the telescope to illuminate the external calibration screen on the telescope enclosure. The specifications for this interface are **TBD**.

3.5 ELECTRICAL POWER INTERFACES

The electrical interfaces section specifies how electrical power is managed between systems. This can include details of cable size, connector type, voltage, current, impedance, shielding, grounding, electromagnetic interference, circuit protection, etc.

The electrical interfaces between the telescope and the instruments have not yet been developed. The interfaces between the telescope and MOBIE are identified here, and will be specified in later versions of this document.

1. There is an electrical interface between the telescope electrical system (POWR) and the instrument electrical system(s) (ELE). There will be multiple types of power supplied through multiple interfaces, including conditioned power (free of spikes, voltage variation, and frequency variation), “dirty” power (unconditioned), and UPS power (battery back-up power). Two-phase 110 VAC and 2-3 phase 220 VAC power are expected to be provided at the instrument mounting locations. The specifications for these interfaces are **TBD.**

2. There is an electrical interface between the observatory electrical power system and the instrument mask fabrication system (MFS). The MFS will require power for the laser mask cutting system and the laser liquid cooling (chiller) system. Two-phase 110 VAC and 2-3 phase 220 VAC power are expected to be provided in the support facility. The specifications for these interfaces are **TBD.**

3. There is an electrical interface between the telescope power system and the external calibration system (calibration light sources). The specifications for this interface are **TBD**.

3.6 SERVICE AND UTILITY INTERFACES

The services and utilities section specifies how non-electrical services are managed between systems. This can include details of coolant, gas, oil, etc connections and supply between systems.

The service and utility interfaces between the observatory, telescope and instruments have not yet been developed. The interfaces between the observatory, telescope, and MOBIE are identified here, and will be specified in later versions of this document.

1. There is a service interface between the telescope liquid cooling system and the instrument liquid cooling system (ENC). This interface will occur between connections on the Nasmyth platform and instrument utility wrap. The connections are assumed to use leak-free quick-disconnect fittings. The specifications for these interfaces are **TBD**.
2. There is a service interface between the telescope liquid coolant system and the instrument electronics enclosure (ENC). This interface may occur directly between the Nasmyth platform connections and the electronics cabinet or via the interface to the instrument utility wrap. The connections are assumed to use leak-free quick-disconnect fittings. The specifications for these interfaces are **TBD**.
3. There is a service interface between the telescope compressed air system (TEL) and the instrument utility wrap (IRS). This interface will occur between connections on the Nasmyth platform, and the utility wrap on the instrument rotator. The connections are assumed to use quick-disconnect fittings. The specifications for this interface are **TBD**.
4. There is a service interface between the telescope (TEL) and the cryogenic cooling system for the instrument science detectors (DET). The location of the compressor(s) for the cooling system, either on the Nasmyth platform or elsewhere, is **TBD.** The size, mass, type, and locations of the compressor(s),.hoses and connectors for the cryogenic cooling system are **TBD**.
5. There is a service interface between the observatory dry nitrogen system (TEL) and the instrument utility wrap (IRS). Dry nitrogen will be used to purge optical areas in the instrument for dust rejection, and to prevent moisture from condensing on cold optical surfaces, such as the science detector system dewar windows. The specifications for this interface are **TBD**.
6. There is a service interface between the observatory (FAC) and the mask fabrication system (MFS). The MFS laser system will require shielding and/or feed gases (nitrogen and/or oxygen) during the cutting of slits in the masks. The specifications for these interfaces are **TBD**.
7. There is a service interface between the observatory (FAC) and the MFS. The laser mask cutting system will produce exhaust gases that will need to be ejected from the building. The smoke removal system will be independent of the observatory ventilation system. The specifications for this interface are **TBD**.

3.7 THERMAL INTERFACES

The thermal interfaces section specifies how heat flows between systems. This can include allowances for the escape of heat, the thermal conductivity between systems, etc.

1. There is a thermal interface between the telescope Nasmyth platform and the MOBIE instrument rotator system (IRS). The interface is expected to consist of a set of thermally conducting bolted connections. If necessary, these bolted connections may be insulated. The allowed heat flow between the telescope and the instrument, via these connections, is **TBD**.
2. There is a thermal interface between the telescope dome environment and the instrument enclosure (IES). A thermal gradient between the dome environment and the exterior of the instrument creates the potential for convective and radiative heat transfer. The amount of heat transfer will be controlled by the instrument cooling system and the (insulated) instrument enclosure system. The allowed heat flow between the telescope and the instrument, via these paths, is **TBD**.
3. There is a thermal interface between the telescope dome environment and the instrument electronics enclosure (ELE). The electronics enclosure will be insulated and will feature temperature control via the liquid cooling system. The allowed heat flow between the telescope and the electronics enclosure is **TBD**.

3.8 SAFETY INTERFACES

The safety interfaces section specifies how systems must interface from a safety perspective. This can include details of how personnel travel between systems, and how the interlock and emergency stop actions work between systems. Details of safety signal flow are documented in the communication, software and control sections.

The features of the observatory safety system have yet to be defined. The potential interfaces between the OSS and the instrument are identified here, and will be specified in later versions of this document.

1. There is a safety interface between the OSS and the instrument rotator (IRS). The MOBIE instrument will occupy a very large, roughly cylindrical volume, and the moving part of that volume will rotate about the elevation axis during servicing, slewing, tracking, and observations. A lock-out, tag-out system is anticipated for servicing of the instrument, such that the instrument will not be able to rotate unexpectedly during service operations (which may require **intentional** locally-controlled rotation of the instrument).
2. There is a safety interface between the OSS and the instrument rotator (IRS). Motion of the instrument by the IRS needs to be halted locally under emergency conditions. Multiple E-stop buttons will be placed near the instrument servicing ports (e.g. the mask and filter exchange ports) and strategically around the instrument servicing area. The specifications for these interfaces are **TBD**.
3. There is a safety interface between the OSS and the instrument control system (ICS). Telemetry from the instrument that shows parameters outside of normal limits (e.g. excess temperatures, malfunctioning mechanisms) will be logged by the ICS and reported to the OSS. The specifications for this interface are **TBD**.
4. There is a safety interface between the OSS and the instrument (and ICS) for servicing operations. Service operations may require that mechanisms be remotely operated by service technicians (e.g. stepping through a selection of filter positions in a filter changing mechanism). The ICS needs to selectively enable and disable instrument functions to facilitate service operations, and reports the status of the instrument to the OSS. The specifications for this interface are **TBD**.
5. There is a safety interface between the observatory and the mask fabrication system (MFS). The mask cutting laser system will operate autonomously, and will require process gases and ventilation to operate safely. Operating parameters for the room and the laser system should be logged and passed to the OSS. The specifications for this interface are **TBD**.