



Gemini WFMOS

INITIAL FUNCTIONAL & PERFORMANCE REQUIREMENTS DOCUMENT

WFMOS Feasibility Study AURA Contract No. 0084699-GEM00385

CHANGE RECORD

ISSUE	DATE	SECTION/PAGE AFFECTED	REASON/REMARKS
Rev 1	06/24/05	All	Submitted to Gemini for review as part of WFMOS Feasibility Study

Prepared jointly by

Anglo-Australian Observatory
Canadian Astronomy Data Centre
Johns Hopkins University
National Optical Astronomy Observatory
University of Durham
University of Oxford
University of Portsmouth

Released By:

Name

Date

Signature

Table of Contents

CHAPTER 1 PURPOSE.....	13
CHAPTER 2 APPLICABLE DOCUMENTATION.....	14
CHAPTER 3 GLOSSARY OF TERMS.....	15
CHAPTER 4 INTRODUCTION.....	19
CHAPTER 5 ASSUMPTIONS.....	20
5.1 SUBARU RELATED ASSUMPTIONS.....	20
CHAPTER 6 OCDD SCIENCE REQUIREMENTS.....	21
6.1 SUMMARY OF SCIENCE REQUIREMENTS.....	21
CHAPTER 7 WFMOS REQUIREMENTS.....	24
7.1 WFMOS FACILITY REQUIREMENTS.....	24
7.1.1 Facility instrument system requirements.....	24
7.1.2 Facility science requirements.....	25
7.2 TELESCOPE STRUCTURE REQUIREMENTS.....	25
7.2.1 Instrument mounting hub.....	25
7.2.2 Spider.....	26
7.2.3 Truss.....	26
7.3 PRIME FOCUS UNIT (PFU) REQUIREMENTS.....	26
7.3.1 Lower PFU.....	26
7.3.2 Upper PFU.....	27
7.4 WIDE FIELD CORRECTOR REQUIREMENTS.....	28
7.4.1 Corrector elements.....	28
7.4.2 ADC.....	30
7.5 INSTRUMENT PACKAGE REQUIREMENTS.....	30
7.5.1 Fibre positioner.....	31
7.5.2 Acquisition system.....	32
7.5.3 Guiding system.....	32
7.5.4 Wavefront sensing system.....	32
7.5.5 Calibration system.....	33
7.6 FIBRE SYSTEM REQUIREMENTS.....	33
7.6.1 Fibre probes.....	34
7.6.2 Fibre connector.....	34
7.6.3 Fibre cable.....	35
7.6.4 Slitlets.....	36
7.7 SPECTROGRAPH REQUIREMENTS.....	36
7.7.1 Low resolution mode.....	36
7.7.2 High resolution mode.....	37
7.8 DETECTOR/CONTROLLER REQUIREMENTS.....	38
7.8.1 Low resolution mode.....	38
7.8.2 High resolution mode.....	39
7.9 FACILITY SOFTWARE REQUIREMENTS.....	40

7.9.1 Observing preparation software.....	40
7.9.2 Instrument/telescope control software.....	41
7.9.3 Data pipeline software.....	42
7.9.4 Science pipeline software.....	42
7.9.5 Archive.....	42
7.10 OBSERVATORY INFRASTRUCTURE REQUIREMENTS.....	42
7.10.1 Instrument handling facilities.....	43
7.10.2 Instrument storage facilities.....	43
7.10.3 Spectrograph laboratory.....	43
7.10.4 Instrument service provision.....	43
7.10.5 Test facilities.....	43
7.10.6 Maintenance facilities.....	43
7.10.7 Observing support facilities.....	43

CHAPTER 8 REQUIREMENT DETAILS AND FLOWDOWN

REQUIREMENTS.....	44
8.1 WIDE FIELD CORRECTOR.....	45
8.1.1 Optical.....	45
8.1.1.1 Image quality and tolerances.....	45
8.1.1.2 Atmospheric Dispersion Compensator.....	45
8.1.1.3 Other.....	45
8.1.2 Mechanical.....	45
8.1.2.1 Rigidity.....	45
8.1.2.2 Mechanical and thermal tolerances.....	45
8.1.2.3 Thermal performance.....	45
8.1.2.4 Space requirements.....	45
8.1.2.5 Mass and centre of gravity requirements.....	45
8.1.2.6 Cooling system.....	45
8.1.2.7 Vacuum system.....	45
8.1.2.8 Operational requirements for mechanisms.....	45
8.1.2.9 Instrument handling.....	45
8.1.2.10 Metric dimensioning.....	45
8.1.3 Electrical & Electronics.....	45
8.1.3.1 Electronic design requirements.....	45
8.1.3.2 EMC.....	45
8.1.3.3 Other.....	45
8.1.4 Control System.....	45
8.1.4.1 Operability.....	45
8.1.4.2 Configuration time.....	45
8.1.4.3 General requirements.....	45
8.1.4.4 Temperature control.....	45
8.1.5 Software.....	46
8.1.5.1 Software design requirements.....	46
8.1.5.2 Gemini furnished software.....	46
8.1.5.3 Subaru furnished software.....	46
8.1.5.4 Engineering interface.....	46
8.2 TOP END.....	46
8.2.1 Mechanical.....	46

8.2.1.1 Rigidity.....	46
8.2.1.2 Mechanical and thermal tolerances.....	46
8.2.1.3 Thermal performance.....	46
8.2.1.4 Space requirements.....	46
8.2.1.5 Mass and centre of gravity requirements.....	46
8.2.1.6 Cooling system.....	46
8.2.1.7 Vacuum system.....	46
8.2.1.8 Operational requirements for mechanisms.....	46
8.2.1.9 Instrument handling.....	47
8.2.1.10 Metric dimensioning.....	47
8.2.2 <i>Electrical & Electronics</i>	47
8.2.2.1 Electronic design requirements.....	47
8.2.2.2 EMC.....	47
8.2.2.3 Other.....	47
8.2.3 <i>Control System</i>	47
8.2.3.1 Operability.....	47
8.2.3.2 Configuration time.....	47
8.2.3.3 General requirements.....	47
8.2.3.4 Temperature control.....	47
8.2.4 <i>Software</i>	47
8.2.4.1 Software design requirements.....	47
8.2.4.2 Gemini furnished software.....	47
8.2.4.3 Subaru furnished software.....	47
8.2.4.4 Engineering interface.....	47
8.3 FIBRE POSITIONER.....	47
8.3.1 <i>Optical</i>	47
8.3.1.1 X-Y positioning tolerance.....	47
8.3.1.2 Focus tolerance.....	47
8.3.1.3 Spine tilt.....	47
8.3.1.4 Guiding.....	47
8.3.1.5 Field rotation.....	47
8.3.1.6 Other.....	48
8.3.2 <i>Position feedback system</i>	48
8.3.2.1 Position sensor resolution.....	48
8.3.2.2 Response time.....	48
8.3.2.3 Sensitivity.....	48
8.3.2.4 Other.....	48
8.3.3 <i>Mechanical</i>	48
8.3.3.1 Rigidity.....	49
8.3.3.2 Mechanical and thermal tolerances.....	49
8.3.3.3 Thermal performance.....	49
8.3.3.4 Space requirements.....	49
8.3.3.5 Mass and centre of gravity requirements.....	49
8.3.3.6 Cooling system.....	49
8.3.3.7 Vacuum system.....	49
8.3.3.8 Operational requirements for mechanisms.....	49
8.3.3.9 Instrument handling.....	49
8.3.3.10 Rotation.....	49

8.3.3.11 Metric dimensioning.....	49
8.3.4 <i>Electrical & Electronics</i>	49
8.3.4.1 Electronic design requirements.....	49
8.3.4.2 EMC.....	49
8.3.4.3 Cooling.....	49
8.3.4.4 Other.....	49
8.3.5 <i>Control System</i>	49
8.3.5.1 Operability.....	49
8.3.5.2 Configuration time.....	49
8.3.5.3 General requirements.....	49
8.3.5.4 Temperature control.....	49
8.3.6 <i>Software</i>	49
8.3.6.1 Software design requirements.....	49
8.3.6.2 Gemini furnished software.....	49
8.3.6.3 Subaru furnished software.....	49
8.3.6.4 Engineering interface.....	50
8.4 FIBRE CABLE.....	50
8.4.1 <i>Optical</i>	50
8.4.1.1 Throughput.....	50
8.4.1.2 Beam Speeds.....	50
8.4.1.3 Focal Ratio Degradation.....	50
8.4.1.4 Modal Scrambling.....	50
8.4.1.5 Wavelength performance.....	50
8.4.1.6 Other.....	50
8.4.2 <i>Mechanical</i>	50
8.4.2.1 Rigidity.....	50
8.4.2.2 Mechanical and thermal tolerances.....	50
8.4.2.3 Thermal performance.....	50
8.4.2.4 Space requirements.....	50
8.4.2.5 Mass and centre of gravity requirements.....	50
8.4.2.6 Operational requirements for mechanisms.....	50
8.4.2.7 Instrument handling.....	50
8.4.2.8 Maintenance – spare fibres.....	50
8.4.2.9 Metric dimensioning.....	50
8.5 FIBRE CABLE CONNECTOR.....	51
8.5.1 <i>Optical</i>	51
8.5.1.1 Throughput.....	51
8.5.1.2 Beam Speeds.....	51
8.5.1.3 Focal Ratio Degradation.....	51
8.5.1.4 Modal Scrambling.....	51
8.5.1.5 Wavelength performance.....	51
8.5.1.6 Other.....	51
8.5.2 <i>Mechanical</i>	51
8.5.2.1 Rigidity.....	51
8.5.2.2 Mechanical and thermal tolerances.....	51
8.5.2.3 Thermal performance.....	51
8.5.2.4 Space requirements.....	51
8.5.2.5 Mass and centre of gravity requirements.....	51

8.5.2.6 Operational requirements for mechanisms.....	51
8.5.2.7 Instrument handling.....	51
8.5.2.8 Metric dimensioning.....	51
8.5.3 <i>Electrical & Electronics</i>	51
8.5.3.1 Electronic design requirements.....	51
8.5.3.2 EMC.....	51
8.5.3.3 Other.....	51
8.6 LOW RESOLUTION SPECTROGRAPHS.....	52
8.6.1 <i>Spectroscopic</i>	52
8.6.1.1 Resolution.....	52
8.6.1.2 Wavelength range.....	52
8.6.1.3 Number of spectra.....	52
8.6.1.4 Nod and Shuffle.....	52
8.6.1.5 System efficiency.....	52
8.6.1.6 Scattered light.....	52
8.6.1.7 Filters.....	52
8.6.1.8 Other.....	52
8.6.2 <i>Optical</i>	52
8.6.2.1 Image quality and tolerances.....	52
8.6.2.2 Focus tolerance.....	52
8.6.2.3 Cold stop.....	52
8.6.2.4 Coatings.....	52
8.6.2.5 Vacuum environment.....	52
8.6.2.6 Other.....	52
8.6.3 <i>Mechanical</i>	52
8.6.3.1 Rigidity.....	53
8.6.3.2 Mechanical and thermal tolerances.....	53
8.6.3.3 Thermal performance.....	53
8.6.3.4 Space requirements.....	53
8.6.3.5 Mass and centre of gravity requirements.....	53
8.6.3.6 Cooling system.....	53
8.6.3.7 Vacuum system.....	53
8.6.3.8 Operational requirements for mechanisms.....	53
8.6.3.9 Instrument handling.....	53
8.6.3.10 Articulation.....	53
8.6.3.11 Metric dimensioning.....	53
8.6.4 <i>Electrical & Electronics</i>	53
8.6.4.1 Electronic design requirements.....	53
8.6.4.2 EMC.....	53
8.6.4.3 Cooling.....	53
8.6.4.4 Other.....	53
8.6.5 <i>Detectors</i>	53
8.6.5.1 Science detector performance requirements.....	53
8.6.5.2 Science detector requirements.....	53
8.6.5.3 Science detector controller.....	53
8.6.5.4 Other.....	53
8.6.6 <i>Control System</i>	53
8.6.6.1 Operability.....	53

8.6.6.2 Configuration time.....	53
8.6.6.3 General requirements.....	54
8.6.6.4 Temperature control.....	54
8.6.7 <i>Software</i>	54
8.6.7.1 Software design requirements.....	54
8.6.7.2 Gemini furnished software.....	54
8.6.7.3 Subaru furnished software.....	54
8.6.7.4 Engineering interface.....	54
8.6.8 <i>Data Processing</i>	54
8.7 HIGH RESOLUTION SPECTROGRAPHS.....	54
8.7.1 <i>Spectroscopic</i>	54
8.7.1.1 Resolution.....	54
8.7.1.2 Wavelength range.....	54
8.7.1.3 Number of spectra.....	54
8.7.1.4 Nod and Shuffle.....	54
8.7.1.5 System efficiency.....	54
8.7.1.6 Scattered light.....	54
8.7.1.7 Filters.....	54
8.7.1.8 Other.....	54
8.7.2 <i>Optical</i>	54
8.7.2.1 Image quality and tolerances.....	54
8.7.2.2 Focus tolerance.....	54
8.7.2.3 Cold stop.....	54
8.7.2.4 Coatings.....	54
8.7.2.5 Vacuum environment.....	55
8.7.2.6 Other.....	55
8.7.3 <i>Mechanical</i>	55
8.7.3.1 Rigidity.....	55
8.7.3.2 Mechanical and thermal tolerances.....	55
8.7.3.3 Thermal performance.....	55
8.7.3.4 Space requirements.....	55
8.7.3.5 Mass and centre of gravity requirements.....	55
8.7.3.6 Cooling system.....	55
8.7.3.7 Vacuum system.....	55
8.7.3.8 Operational requirements for mechanisms.....	55
8.7.3.9 Instrument handling.....	55
8.7.3.10 Articulation.....	55
8.7.3.11 Metric dimensioning.....	55
8.7.4 <i>Electrical & Electronics</i>	55
8.7.4.1 Electronic design requirements.....	55
8.7.4.2 EMC.....	55
8.7.4.3 Cooling.....	55
8.7.4.4 Other.....	55
8.7.5 <i>Detectors</i>	55
8.7.5.1 Science detector performance requirements.....	55
8.7.5.2 Science detector requirements.....	55
8.7.5.3 Science detector controller.....	55
8.7.5.4 Other.....	55

8.7.6 Control System.....	55
8.7.6.1 Operability.....	56
8.7.6.2 Configuration time.....	56
8.7.6.3 General requirements.....	56
8.7.6.4 Temperature control.....	56
8.7.7 Software.....	56
8.7.7.1 Software design requirements.....	56
8.7.7.2 Gemini furnished software.....	56
8.7.7.3 Subaru furnished software.....	56
8.7.7.4 Engineering interface.....	56
8.7.8 Data Processing.....	56
8.8 CALIBRATION SYSTEM.....	56
8.8.1 Optical.....	56
8.8.1.1 Wavelengths.....	56
8.8.1.2 Photometric.....	56
8.8.1.3 Flat field parameters.....	56
8.8.1.4 Other.....	56
8.8.2 Mechanical.....	56
8.8.2.1 Rigidity.....	56
8.8.2.2 Mechanical and thermal tolerances.....	56
8.8.2.3 Thermal performance.....	56
8.8.2.4 Space requirements.....	56
8.8.2.5 Mass and centre of gravity requirements.....	56
8.8.2.6 Cooling system.....	56
8.8.2.7 Vacuum system.....	56
8.8.2.8 Operational requirements for mechanisms.....	56
8.8.2.9 Instrument handling.....	57
8.8.2.10 Metric dimensioning.....	57
8.8.3 Electrical & Electronics.....	57
8.8.3.1 Electronic design requirements.....	57
8.8.3.2 EMC.....	57
8.8.3.3 Cooling.....	57
8.8.3.4 Other.....	57
8.8.4 Control System.....	57
8.8.4.1 Operability.....	57
8.8.4.2 Configuration time.....	57
8.8.4.3 General requirements.....	57
8.8.4.4 Temperature control.....	57
8.8.5 Software.....	57
8.8.5.1 Software design requirements.....	57
8.8.5.2 Gemini furnished software.....	57
8.8.5.3 Subaru furnished software.....	57
8.8.5.4 Engineering interface.....	57
8.8.6 Data Processing.....	57
8.9 ACQUISITION AND GUIDING.....	57
8.9.1 Optical.....	57
8.9.1.1 Field acquisition time.....	57
8.9.1.2 Astrometric requirements.....	57

8.9.1.3 Acquisition target magnitude.....	57
8.9.1.4 Number of targets for acquisition.....	57
8.9.1.5 Distribution of targets for acquisition.....	57
8.9.1.6 Guide target magnitude.....	58
8.9.1.7 Number of targets for guiding.....	58
8.9.1.8 Distribution of targets for guiding.....	58
8.9.1.9 Guiding accuracy.....	58
8.9.1.10 Guiding duration.....	58
8.9.1.11 Rotation limits.....	58
8.9.1.12 Other.....	58
8.9.2 <i>Mechanical</i>	58
8.9.2.1 Rigidity.....	58
8.9.2.2 Mechanical and thermal tolerances.....	58
8.9.2.3 Thermal performance.....	58
8.9.2.4 Space requirements.....	58
8.9.2.5 Mass and centre of gravity requirements.....	58
8.9.2.6 Cooling system.....	58
8.9.2.7 Vacuum system.....	58
8.9.2.8 Operational requirements for mechanisms.....	58
8.9.2.9 Instrument handling.....	58
8.9.2.10 Metric dimensioning.....	58
8.9.3 <i>Electrical & Electronics</i>	58
8.9.3.1 Electronic design requirements.....	58
8.9.3.2 EMC.....	58
8.9.3.3 Cooling.....	58
8.9.3.4 Other.....	58
8.9.4 <i>Control System</i>	58
8.9.4.1 Operability.....	58
8.9.4.2 Configuration time.....	59
8.9.4.3 General requirements.....	59
8.9.4.4 Temperature control.....	59
8.9.5 <i>Software</i>	59
8.9.5.1 Software design requirements.....	59
8.9.5.2 Gemini furnished software.....	59
8.9.5.3 Subaru furnished software.....	59
8.9.5.4 Engineering interface.....	59
8.10 WAVEFRONT SENSING.....	60
8.10.1 <i>Optical</i>	60
8.10.1.1 Parameters monitored.....	60
8.10.1.2 Response time.....	60
8.10.1.3 Target magnitude.....	60
8.10.1.4 Number of targets for sensing.....	60
8.10.1.5 Distribution of targets for sensing.....	60
8.10.1.6 Other.....	60
8.10.2 <i>Mechanical</i>	60
8.10.2.1 Rigidity.....	60
8.10.2.2 Mechanical and thermal tolerances.....	60
8.10.2.3 Thermal performance.....	60

8.10.2.4 Space requirements.....	60
8.10.2.5 Mass and centre of gravity requirements.....	60
8.10.2.6 Cooling system.....	60
8.10.2.7 Vacuum system.....	60
8.10.2.8 Operational requirements for mechanisms.....	60
8.10.2.9 Instrument handling.....	60
8.10.2.10 Metric dimensioning.....	60
8.10.3 <i>Electrical & Electronics</i>	60
8.10.3.1 Electronic design requirements.....	60
8.10.3.2 EMC.....	60
8.10.3.3 Cooling.....	60
8.10.3.4 Other.....	60
8.10.4 <i>Control System</i>	60
8.10.4.1 Operability.....	61
8.10.4.2 Configuration time.....	61
8.10.4.3 Feedback to telescope control system.....	61
8.10.4.4 General requirements.....	61
8.10.4.5 Temperature control.....	61
8.10.5 <i>Software</i>	61
8.10.5.1 Software design requirements.....	61
8.10.5.2 Gemini furnished software.....	61
8.10.5.3 Subaru furnished software.....	61
8.10.5.4 Engineering interface.....	61
8.11 TELESCOPE SYSTEM INTEGRATION AND CONTROL.....	61
8.11.1 <i>Control System</i>	61
8.11.1.1 Operability.....	61
8.11.1.2 Configuration time.....	61
8.11.1.3 General requirements.....	61
8.11.1.4 Temperature control.....	61
8.11.2 <i>Software</i>	61
8.11.2.1 Software design requirements.....	61
8.11.2.2 Gemini furnished software.....	61
8.11.2.3 Subaru furnished software.....	61
8.11.2.4 Engineering interface.....	61
8.11.3 <i>Data Processing</i>	61
8.12 DATA REDUCTION AND HANDLING.....	62
8.12.1 <i>Software</i>	62
8.12.1.1 Software design requirements.....	62
8.12.1.2 Observation preparation support.....	62
8.12.1.3 Gemini furnished software.....	62
8.12.1.4 Subaru furnished software.....	62
8.12.1.5 Engineering interface.....	62
8.12.2 <i>Data Processing</i>	62
8.12.2.1 Data pipeline.....	62
8.12.2.2 Archiving.....	62
8.12.2.3 VO compliance.....	62
8.13 TELESCOPE INFRASTRUCTURE.....	62
8.13.1 <i>Mechanical</i>	62

8.13.1.1 Rigidity.....	62
8.13.1.2 Mechanical and thermal tolerances.....	63
8.13.1.3 Thermal performance.....	63
8.13.1.4 Space requirements.....	63
8.13.1.5 Mass and centre of gravity requirements.....	63
8.13.1.6 Cooling system.....	63
8.13.1.7 Vacuum system.....	63
8.13.1.8 Operational requirements for mechanisms.....	63
8.13.1.9 Instrument handling.....	63
8.13.1.10 Metric dimensioning.....	63
8.13.2 <i>Electrical & Electronics</i>	63
8.13.2.1 Electronic design requirements.....	63
8.13.2.2 EMC.....	63
8.13.2.3 Cooling.....	63
8.13.2.4 Other.....	63
8.13.3 <i>Control System</i>	63
8.13.3.1 Operability.....	63
8.13.3.2 Configuration time.....	63
8.13.3.3 General requirements.....	63
8.13.3.4 Temperature control.....	63
8.13.4 <i>Software</i>	63
8.13.4.1 Software design requirements.....	63
8.13.4.2 Gemini furnished software.....	63
8.13.4.3 Subaru furnished software.....	63
8.13.4.4 Engineering interface.....	63
8.13.5 <i>Data Processing</i>	63
CHAPTER 9 ENVIRONMENTAL REQUIREMENTS.....	64
9.1 ALTITUDE.....	64
9.1.1 <i>Transportation Altitudes</i>	64
9.1.2 <i>Storage Altitudes</i>	64
9.1.3 <i>Operation Altitudes</i>	64
9.2 TEMPERATURE.....	64
9.2.1 <i>Operational Environment</i>	64
9.2.2 <i>Survival Environment</i>	65
9.2.3 <i>Transport Environment</i>	65
9.3 HUMIDITY.....	65
9.3.1 <i>Operational Environment</i>	65
9.3.2 <i>Survival Environment</i>	65
9.3.3 <i>Transport Environment</i>	65
9.4 VACUUM ENVIRONMENT.....	65
9.4.1 <i>Creating the Vacuum</i>	65
9.4.2 <i>11.4.2 Vacuum Quality and Duration</i>	66
9.5 MECHANICAL ENVIRONMENT.....	66
9.5.1 <i>Telescope Slew Rates</i>	66
CHAPTER 10 OTHER REQUIREMENTS.....	67
10.1 DOCUMENTATION.....	67
10.1.1 <i>User's Manual</i>	67

10.1.2 Service and Calibration Manual.....	67
10.1.3 12.1.3 Software Maintenance Manual.....	67
10.1.4 As-Built Drawings.....	67
10.1.5 Drawing Standards.....	67
10.1.6 Drawing Numbering System.....	68
10.1.7 Drawing Filing System.....	68
10.2 TRAINING.....	68
10.3 RELIABILITY.....	68
10.3.1 Downtime.....	68
10.3.2 Spares.....	68
10.3.3 Continuous Duty.....	68
10.4 MAINTAINABILITY AND SERVICEABILITY.....	69
10.4.1 Standard Components.....	69
10.4.2 Modularity.....	69
10.4.3 Access.....	69
10.4.4 Alignment.....	69
10.4.5 Relative Equipment Arrangements.....	69
10.4.6 Subassemblies.....	69
10.4.7 Handling.....	70
10.4.8 Revisability.....	70
10.5 LIFETIME.....	70
10.6 MATERIALS.....	70
10.6.1 Toxic Products and Formulations.....	70
10.7 ELECTROMAGNETIC RADIATION.....	70
10.7.1 Electromagnetic Radiation Generation.....	70
10.7.2 Susceptibility to Electromagnetic Radiation	70
10.8 WORKMANSHIP.....	71
10.9 SAFETY.....	71
10.10 HUMAN ENGINEERING.....	71
CHAPTER 11 APPENDICES.....	72
11.1 LIST OF ACRONYMS.....	72
11.2 REQUIREMENTS TABULATION.....	72
CHAPTER 12 REFERENCES.....	73
12.1 HEADING2.....	73
12.1.1 Heading3.....	73

Chapter 1 Purpose

The Gemini Wide-Field Fiber-Fed Optical Multi-Object Spectrographs (WF MOS) Operational Concept Definition Document (OCDD) defines the scientific requirements for the WF MOS instrument and describes the operational scenarios. These requirements are translated into technical requirements for the WF MOS instrument through this Functional Performance Requirements Document (FPRD). Additional requirements derived from the interface control documents (ICD) and design reviews for WF MOS are also summarized in this FPRD. The relationships between the science and technical requirements are listed and their relationships are identified so that all functional and performance requirements can be traced from top-level science requirements.

The primary purposes of the WF MOS FPRD are to provide Gemini and Subaru with an understanding of what WF MOS will be capable of doing and to provide the design team/engineers with the requirements on which WF MOS must be designed. The design is driven by this document and this document will ultimately supersede other design and fabrication documents during the development of the WF MOS instrument. All features of WF MOS should be traceable to this document, the FPRD. Additionally, the performance and acceptance testing of the various modes of the WF MOS instrument shall be derived through this document, the FPRD.

The WF MOS FPRD is a living document that will evolve and change as the WF MOS design progresses. Feedback from design reviews and Gemini directives will need to be incorporated into this FPRD so that all requirements of the WF MOS instrument are tracked within this document.

The current WF MOS FPRD is only an initial document developed during a feasibility study of the WF MOS instrument. The current document assumes the baseline implementation for the Subaru telescope that was developed during the feasibility study and will need to undergo modification when choices for the various options are refined. Additionally, many of the specific requirements will not be well defined at this preliminary stage.

Chapter 2 Applicable Documentation

Document ID	Source	Title
Aspen report	GEMINI	Scientific Horizons at the Gemini Observatory: Exploring a Universe of Matter, Energy, and Life
GEM00385	GEMINI	WF MOS Feasibility Study Statement of Work
	AAO	WF MOS Initial Operational Concept Definition Document
ICD 1.1.1/1.9	GEMINI	Telescope Structure to Science Instruments ICD
ICD 1.1.13/1.9	GEMINI	Interlock System to Science Instruments ICD
ICD 1.5.3/1.9	GEMINI	Instrument Support Structure to Science Instruments ICD
ICD 1.6/1.9	GEMINI	A&G System to Science Instruments
ICD 1.6/1.10	GEMINI	A&G to On-Instrument Wavefront Sensors
ICD 1.9	GEMINI	Science Instruments ICD Overview and Guide
ICD 1.9/1.10	GEMINI	Science Instruments to On Instrument WFS
ICD 1.9/2.7	GEMINI	Science and Facility Instruments to Facility Handling Equipment ICD
ICD 1.9/3.6	GEMINI	Science and Facility Instruments to System Services ICD
ICD 1.9/3.7	GEMINI	Science Instrument to Facility Thermal Electronics Enclosures
ICD 1.10	GEMINI	On-Instrument WFS
ICD G0013	GEMINI	Gemini Environmental Requirements
ICD G0014	GEMINI	Gemini Observatory Optomechanical Coordinate Systems
ICD G0015	GEMINI	Gemini Facility Handling Equipment and Procedures for Instrumentation
	GEMINI	Guidelines for Designing Gemini Aspen Instrument Software
GSCG.grp.005	GEMINI	Gemini System Interfaces
GSCG.grp.006	GEMINI	Overview of Gemini System Interfaces
SPE-ASA-G0008	GEMINI	Gemini Electronic Design Specification

Chapter 3 Glossary of Terms

Acronym/term	Meaning
A&G	Acquisition and Guiding.
AAO	Anglo-Australian Observatory
ADC	Atmospheric Dispersion Compensator
AG	Auto Guider
AIT	Acceptance, Integration and Test
Aspen Process	Was an extensive effort to canvas the Gemini user community to determine which scientific avenues of research the Observatory's instrument program should support over the next 5-10 years. It is a key step in the strategic planning for the Observatory and, in collaboration with Gemini's partner National Offices, involved hundreds of astronomers worldwide during late 2002 and much of 2003.
AURA	Association of Universities for Research in Astronomy
CADC	Canadian Astronomical Data Centre
CCD	Charge Coupled Device (optical image sensor)
Components Controller	Software and hardware used to control components of an instrument.
CS	Curvature Sensor/sensing (a form of wavefront sensor)
DC	Detector Control – software, which controls a detector.
DHS	Data Handling System – the Gemini Software Scheme for moving and archiving instrument data.
EAC	Estimate at completion
EPICS	Experimental Physics and Industrial Control System . A software system used by Gemini to help implement its instrument control system.
ETC	Estimate to complete
FITS	The standard data file format used in astronomy.
FOV	Field of View
FPRD	Functional Performance and Requirements Document. Gives the requirements of the instrument.
FRD	Focal Ratio Degradation. The degradation by fiber optics that result in a loss of throughput resolution product or etendue.
FSR	Feasibility Study Report. A document detailing the technical issues addressed during the study etc. See SoW Section 4.3 Not to be confused with Free Spectral Range.

Acronym/term	Meaning
FT	Frame Transfer (CCD)
Gemini	Gemini is an international partnership managed by the Association of Universities for Research in Astronomy under a cooperative agreement with the National Science Foundation . Partner countries include the United States, United Kingdom, Canada, Chile, Australia, Argentina, and Brazil.
GIS	The Gemini Interlock System. An Alan-Bradley PLC-based safety system with components mounted on the telescope structure that monitors aspects of the system from a safety standpoint. The intent of the GIS is to provide a way of locking out systems when the reason the lockout originates from outside that system.
GWF MOS	Gemini Wide-Field Fiber-Fed Optical Multi-Object Spectrograph
HSCam	Hyper-Suprime Camera
ICD	Interface Control Document. Gemini has a set of interface control documents we are required to obey. These are listed in the statement of work.
ICS	Instrument Control System – the instrument specific software.
IFPRD	Initial Functional Performance and Requirements Document. See FPRD and SoW Section 4.2.
Instrument Sequencer	The software, which sequences operations of various parts of an instrument and its associated detector system.
IOCDD	Initial Operational Concept Definition document. See OCDD and SoW section 4.1.
IP	Intellectual Property
IR	Infrared
JHU	Johns Hopkins University
KAOS	Kilo-Aperture Optical Spectrograph. The name of the instrument concept developed for consideration in the ASPEN discussions.
Leach controller	See SDSU Controller.
LOCS	Low Order Curvature Sensor
LOWFS	Low Order Wavefront Sensor
N&S	Nod and Shuffle. A beam switch mode of observation in which the CCD charge is shuffled in coordination with a nodding of the telescope.
NIMO	Non-Inverted Mode Operation (CCD)
NOAO	National Optical Astronomy Observatory
NSF	National Science Foundation

Acronym/term	Meaning
OCDD	Operational Concept Definition document. Describes how the instrument will be used.
OCS	Observatory Control System – the software that runs the Gemini telescope. The instrument software is a component of this system.
OIWFS	On Instrument Wave Front Sensor. A high rate guider, which can correct for seeing affects.
OLDP	On-Line Data Processing – Gemini’s automated data reduction software.
OT	Observing Tool – used by observers to prepare (P2PP stage) and execute observations.
P2PP	Phase 2 Proposal Preparation. When an observer, having been allocated time on a telescope, prepares for the observation. Also see OT.
PCB	Printed Circuit Board
PCI	Peripheral Component Interface (computer interface Data Bus standard)
PIT	Gemini Phase 1 Proposal Tool. http://www.gemini.edu/sciops/P1help/p1Index.html
PMC	PCI Mezzanine Card
PWFS	Peripheral Wavefront Sensor
QE	Quantum efficiency. A measure of the sensitivity of a detector.
RC	Resistor Capacitor (electronic load)
RfP	Request for Proposal
RMS	Root Mean Square
ROM	Rough Order of Magnitude as in ROM Cost, which is a costing based upon preliminary information, guesses, and extrapolation from prior experience and is typically uncertain by up to +/-50%.
SDSU Controller	San Diego State University Controller. A CCD controller . These are the main and recommended controller used by Gemini. Also known as the “leach” controller after the prime designer.
SH	Shack-Hartmann – a commonly used type of wavefront sensor
SoW	Statement of Work
T&Cs	Terms and Conditions (of contract)
Tweaking	A process where the positions of objects on the focal surface are fine-tuned for a given observation time.
TCS	Telescope Control System – the software system used to control the telescope itself.

Acronym/term	Meaning
VME	Versa Module Europa – 19” rack data bus standard.
VPH Grating	Volume Phase Holographic Grating. A diffraction grating based upon index of refraction modulations to disperse the light.
WBS	Work Breakdown Structure – a deliverable oriented grouping of project elements that organises and defines the total scope of the project.
WFC	Wide-Field Corrector
WFMO	Wide-Field Fiber-Fed Optical Multi-Object Spectrograph.
WFS	Wavefront sensor
Work Package	A deliverable at the lowest level of the WBS.
ZEMAX	Optical design software package

Chapter 4 Introduction

This document, the WFMOS FPRD, represents the current understanding of the capabilities and performance expectations for the Gemini/Subaru WFMOS facility. The document will serve as the start of a living document that will evolve as the WFMOS facility enters into the design and fabrication phase beyond the current feasibility study.

The WFMOS facility is an instrument concept that came out of the Gemini ASPEN Future Instrumentation Workshop held in Aspen, Colorado in June 2003. The facility will be one that implements a very high multiplex factor for seeing limited, spectroscopic surveys at low and high spectral dispersion in the optical.

WFMOS will implement a very wide field of view (1.5 to 2.0 degree diameter) at the prime focus of the Subaru telescope on Mauna Kea (pending agreed upon arrangement for sharing Gemini and Subaru facilities between the Gemini partners and Subaru user community). A high density of apertures (~4500) will be implemented by using fiber optics to relay target light into an array of spectrographs. The operable wavelength regime will range from 0.39-1.0 micron. Two spectral resolution regimes are required at a minimum, $R \sim 3000$ and $R = 40000$, in order to carry out the two major surveys that arose out of the ASPEN process and as described in the WFMOS OCDD.

The feasibility study was asked to explore technical design trades, feasibility, and costing for implementation on either Gemini or Subaru. It is assumed that the baseline concept for Subaru will be the option explored further in a concept study. This document, the WFMOS FPRD, will need to be revised during the conceptual design phase in order to refine the requirements.

Chapter 5 Assumptions

The following set of assumptions is made regarding how a WFMOS facility might be implemented and perform on the Subaru telescopes.

5.1 *Subaru related assumptions*

The following assumptions apply:

1. WFMOS will be a prime focus fed instrument.
2. The spectrographs will reside on the mid-level floor on the optical side of the telescope.
3. WFMOS Field of view to be 1.5 degrees minimum diameter for spectroscopy using a common corrector that also delivers 2 degrees for imaging (HyperSuprimeCam).
4. Spectral window is 0.39 to 1.0 microns.
5. Median seeing is 0.6 arc-seconds.
6. Telescope is stiff against wind buffeting.
7. WFMOS must compensate for top end telescope flexure of TBD microns per degree of Zenith distance.
8. WFMOS must share the use of the wide field corrector with a wide field CCD imager, HyperSuprimeCam, with a 2-degree FoV.
9. Wide field corrector must compensate for atmospheric dispersion to a Zenith angle of 60 degrees.

Chapter 6 OCDD Science Requirements

6.1 Summary of Science Requirements

The following table summarizes the science requirements described in the WFMOS Operational Concept Definition Document. Numbering and ordering of the requirements will be sorted out during the concept design phase.

Requirement Identifier (to be finalized later)	Requirement Statement
WFMOS-REQ-0001	WFMOS field of view shall be at least 1.5 degrees in diameter.
WFMOS-REQ-0002	WFMOS shall have the capability of recording at least ~3000 low resolution spectra simultaneously.
WFMOS-REQ-0003	WFMOS shall have the capability of recording at least ~1500 high resolution spectra simultaneously.
WFMOS-REQ-0004	The WFMOS spectrograph(s) will have a wavelength range of operability covering from 0.39 to 1.0 microns.
WFMOS-REQ-0005	The WFMOS spectrographs shall have a minimum spectral resolving power of ~2000, sufficient to resolve the [OII] doublet, with a goal of ~3000.
WFMOS-REQ-0006	WFMOS wavelength calibration shall be sufficient to derive 20 km/s velocity measurement for the low resolution spectra. [See galactic science case that sets this requirement.]
WFMOS-REQ-0007	The WFMOS spectrographs shall have a high spectral resolution mode of ~40000.
WFMOS-REQ-0008	WFMOS wavelength calibration shall be sufficient to derive 1 km/s velocity measurement for the high resolution spectra.
WFMOS-REQ-0009	WFMOS shall sample the field with ~1 to 1.2 arc-second apertures on movable spectral probes. [Note that this requirement should probably be specified in terms of efficiency or S/N collection for target objects and seeing performance of a given range.]
WFMOS-REQ-0010	The high resolution mode shall be capable of simultaneously recording a minimum of 30 nm contiguous wavelength coverage anywhere within the spectral window defined in WFMOS-REQ-0004. [Note that the assumption in the text of 2 pixel resolution elements is unlikely. It will be more like 3 to 4 pixels per resolution element due to the speed of the camera.]

WF MOS-REQ-0011	The low resolution mode of WF MOS shall have a sensitivity that delivers a continuum SNR of 6 per resolution element in a 40 minute exposure at a magnitude of $R_{AB} < 23.6$.
WF MOS-REQ-0012	The WF MOS low resolution spectrographs shall have a Nod&Shuffle observing mode for sky subtraction.
WF MOS-REQ-0013	The WF MOS target allocation code shall not introduce significant completeness uncertainties that are correlated over large angles on the sky (> 20 arc-minute scale size).
WF MOS-REQ-0014	WF MOS shall be capable of reconfiguration for different target fields at any orientation of the telescope.
WF MOS-REQ-0015	The WF MOS spectral probes shall be capable of relative positioning to 0.1 arc-second accuracy. [This should be verified with modelling to give a definition in terms of lost S/N or efficiency due to error in alignment.]
WF MOS-REQ-0016	The WF MOS facility shall be capable of a target to target reconfiguration time of 10 minutes with a goal of 5 minutes inclusive of telescope overheads.
WF MOS-REQ-0017	The WF MOS target allocation code should allow rearrangement of a subset of fibers while retaining the same pointing center.
WF MOS-REQ-0018	The WF MOS instrument shall be stable such that daytime calibrations are sufficient to calibrate the nighttime observations. [Level of stability required TBD.]
WF MOS-REQ-0019	The WF MOS spectrographs shall have shutters.
WF MOS-REQ-0020	The WF MOS detector system shall have an exposure pause mode.
WF MOS-REQ-0021	The WF MOS quick look data reduction shall be capable of assessing the SNR of an exposure in less than 20 minutes.
WF MOS-REQ-0022	The WF MOS quick look data reduction should be capable of searching reduced, coadded spectra for determining which targets have secure redshifts in less than 30 minutes.
WF MOS-REQ-0023	WF MOS target assignment software shall allow convenient definition of acquisition, guide, and wavefront sensing stars as a function of telescope configuration and time of observation.
WF MOS-REQ-0024	WF MOS target assignment software shall allow automatic and manual adjustments to the pointing center to optimize target assignment solutions.

WF MOS-REQ-0025	WF MOS target assignment software shall allow target assignment solutions to be modified at the telescope in a reasonable period of time prior to the start of the observations.
WF MOS-REQ-0026	WF MOS target assignment software shall allow multiple configurations with the same or overlapping pointings.
WF MOS-REQ-0027	WF MOS target assignment software shall allow verification that input catalogs of target objects match the reference frame of the acquisition/guide stars.
WF MOS-REQ-0028	WF MOS data reduction (package B) shall have automated determination of radial velocity, stellar gravity, effective temperature, metallicity, and elemental abundance (for the high resolution spectra).

Chapter 7 WFMOS Requirements

The functional and performance requirements are given here. These are derived from the WFMOS OCDD and from interface requirements between WFMOS components and with respect to the Subaru environment.

The primary drivers for the instrument requirements are:

- That the system be capable to allow timely completion of the major science surveys.
- That the system be affordable by the Gemini and Subaru communities during both the construction and use phase of the instrument.
- That the system be reliable.

The overarching requirement for capability will drive the requirements for functionality and efficiency on items such as instrument operation, image quality, aperture diameters, element transmission, ease of operation, configuration overheads, and data reduction capabilities. The second overarching requirement for affordability drives the requirement that the instrument fit within the existing infrastructure and allows ease of support and operation. System reliability will drive requirements on functionality, interface, support, and maintainability. The affordability requirement will impose a constraint on the capability and reliability requirements.

For traceability, a naming convention will be adopted for requirements identified in this document, of the form 'WFMOS-RQ-XXn-YY', where 'XX' is a two-digit component identifier, 'n' a sub-component identifier and 'YY' is the requirement number, allocated sequentially.

7.1 WFMOS Facility Requirements

This category of requirements applies to the overall WFMOS facility. All requirements falling into this category will carry a component identifier of '00n'.

7.1.1 Facility instrument system requirements

WFMOS-RQ-001-01: The WFMOS facility must interface to the Subaru top end structure.

WFMOS-RQ-001-02: The WFMOS facility must interface to the f/1.83 beam of the Subaru primary mirror.

WFMOS-RQ-001-03: The WFMOS facility must interface to the Subaru facilities (operational, mechanical, electrical, and software).

WF MOS-RQ-001-04: The WF MOS facility shall image a field of at least 1.5 degree diameter at the Subaru prime focus for the WF MOS mode and be reconfigurable for use on the HyperSuprimeCam instrument with at least a 2.0 degree diameter field.

WF MOS-RQ-001-05: The WF MOS facility shall be capable of a target to target reconfiguration time of 10 minutes with a goal of 5 minutes inclusive of telescope overheads.

WF MOS-RQ-001-06: The WF MOS facility shall have a spectrographic channel for simultaneous science observation of up to 3000 targets at low-resolution and up to 1500 at high-resolution.

WF MOS-RQ-001-07: The WF MOS facility shall allow retention of existing instrumentation functionality.

WF MOS-RQ-001-08: The WF MOS-loaded top end mass must not exceed TBD kg.

7.1.2 Facility science requirements

WF MOS-RQ-002-01: The WF MOS facility shall produce data products for specific science applications as well as for archival science usage.

7.2 Telescope structure requirements

This category of requirements applies to structural modifications and additions to the Subaru telescope structure. All requirements falling into this category will carry a component identifier of '01n'.

7.2.1 Instrument mounting hub

WF MOS-RQ-011-01: The Subaru instrument mounting hub must interface to and hold the WF MOS/HyperSuprimeCam WFC assembly and WF MOS instrument packages.

WF MOS-RQ-011-02: The Subaru top end must interface to and hold existing Subaru top end instrumentation.

WF MOS-RQ-011-03: The Subaru top end shall hold instrument packages to within TBD (to be determined from existing requirements) microns linear displacement of the telescope axis.

WF MOS-RQ-011-04: The Subaru top end shall hold the instrument packages to TBD (to be determined from existing requirements) degrees angular alignment with the telescope axis.

WF MOS-RQ-011-05: The hub mass must not exceed TBD kg [this figure forms part of a mass budget to comply with requirement WF MOS-RQ-001-08].

7.2.2 Spider

WF MOS-RQ-012-01: The Subaru top end must interface to and hold the WF MOS calibration system.

7.2.3 Truss

WF MOS-RQ-013-01: The Subaru telescope truss must provide for fitting, support and removal of the WF MOS fibre cable and other service feeds.

7.3 Prime Focus Unit (PFU) requirements

This category of requirements applies to the WF MOS component support structures that mount to the Subaru telescope's instrument mounting hub in the centre of the telescope top end. All requirements falling into this category will carry a component identifier of '02n'.

7.3.1 Lower PFU

WF MOS-RQ-021-01: The WF MOS lower PFU shall interface to the lower side of the instrument mounting hub.

WF MOS-RQ-021-02: The WF MOS lower PFU shall interface to the WFC optical elements and the ADC components.

WF MOS-RQ-021-03: The WF MOS lower PFU shall hold the corrector in focus to within TBD microns axial displacement.

WF MOS-RQ-021-04: The WF MOS lower PFU shall hold the corrector in angular alignment with the optical axis with a tilt error not to exceed TBD degrees.

WF MOS-RQ-021-05: The WF MOS lower PFU shall hold the corrector in radial alignment of the optical axis to better than TBD microns.

WF MOS-RQ-021-07: The WF MOS lower PFU shall provide focus adjustment in steps of TBD microns with a total range of TBD microns.

WF MOS-RQ-021-08: The WF MOS lower PFU shall be computer controlled.

WF MOS-RQ-021-09: The WF MOS lower PFU shall have computer readable encoders to derive focus, tilt, and radial alignment to within TBD microns.

WF MOS-RQ-021-10: The WF MOS lower PFU shall maintain active mechanical alignment over the operational temperature range of TBD C.

WF MOS-RQ-021-11: The WF MOS lower PFU shall maintain active mechanical alignment over the range of 0 to 60 degrees Zenith distance.

WF MOS-RQ-021-12: The WF MOS lower PFU shall interface to the Subaru instrument exchange and storage facility.

WF MOS-RQ-021-13: The WF MOS lower PFU shall be installed or removed and stored in less than TBD hours with less than TBD staff required to carry out the task.

WF MOS-RQ-021-14: The mass of the WF MOS lower PFU shall not exceed TBD kg [this figure forms part of a mass budget for compliance with requirement WF MOS-RQ-001-08].

7.3.2 Upper PFU

WF MOS-RQ-022-01: The WF MOS upper PFU shall interface to the upper side of the instrument mounting hub.

WF MOS-RQ-022-02: The WF MOS upper PFU shall interface to the Fibre Positioner, Wave Front Sensors, Acquisition System, and Guiding system.

WF MOS-RQ-022-03: The WF MOS upper PFU shall interface to the final TBD (2) optical elements of the WFC.

WF MOS-RQ-022-04: The WF MOS upper PFU shall hold the instrument package in focus to within TBD microns axial displacement across the field.

WF MOS-RQ-022-05: The WF MOS upper PFU shall provide focus adjustment in steps of TBD microns with a range of TBD microns.

WF MOS-RQ-022-06: The WF MOS upper PFU shall hold the instrument package in angular alignment with the WFC optical axis with a tilt error not to exceed TBD degrees.

WF MOS-RQ-022-07: The WF MOS upper PFU shall hold the instrument package in radial alignment of the WFC optical axis to better than TBD microns.

WF MOS-RQ-022-08: The WF MOS upper PFU shall rotate the fibre positioner to follow the field rotation to within TBD arc-seconds of rotational error with a range of TBD degrees of motion and a speed range varying from TBD to TBD degrees per second.

WF MOS-RQ-022-09: The WF MOS upper PFU shall be computer controlled.

WF MOS-RQ-022-10: The WF MOS upper PFU shall have computer readable encoders to derive focus, tilt, and radial alignment to within TBD microns.

WF MOS-RQ-022-11: The WF MOS upper PFU shall maintain active mechanical alignment over the operational temperature range of TBD C.

WF MOS-RQ-022-12: The WF MOS upper PFU shall maintain active mechanical alignment over the range of 0 to 60 degrees Zenith distance.

WF MOS-RQ-022-13: The WF MOS upper PFU shall incorporate the necessary cable wraps.

WF MOS-RQ-022-14: The WF MOS upper PFU shall interface to the Subaru instrument exchange and storage facility.

WF MOS-RQ-022-15: The WF MOS upper PFU shall be installed or removed and stored in less than TBD hours with less than TBD staff required to carry out the task.

WF MOS-RQ-022-16: The mass of the WF MOS upper PFU shall not exceed TBD kg [this figure forms part of a mass budget for compliance with requirement WF MOS-RQ-001-08].

7.4 Wide field corrector requirements

This category of requirements applies to the optical and other components comprising the wide field corrector, carried primarily in the lower PFU. All requirements falling into this category will carry a component identifier of '03n'.

7.4.1 Corrector elements

WF MOS-RQ-031-01: The WF MOS WFC must share the same corrector as the HyperSuprimeCam instrument.

Note that it may be possible to have instrument specific components in the corrector that get swapped out when the instruments are changed, but the front elements of the corrector shall be shared in order to save cost.

WF MOS-RQ-031-02: The WF MOS WFC field of view shall be 1.5 degrees in diameter with a goal of 2.0 degrees.

WF MOS-RQ-031-03: The WF MOS WFC shall deliver chromatic image quality giving TBD (~80% EE) within a 0.6 arc-second diameter aperture across the full WF MOS field of view and across the wavelength band of 0.39-1 micron.

WF MOS-RQ-031-04: The WF MOS WFC shall deliver a focal surface that has a radius of curvature larger than TBD (possibly 6.0) meters with a goal of a flat focal surface.

WF MOS-RQ-031-05: The WF MOS WFC shall deliver an exit pupil that is concentric with the focal surface to better than TBD (possibly 0.5) degrees across the field of view.

WF MOS-RQ-031-06: The WF MOS WFC shall provide focus at a level of TBD (~0.5 to 0.1) arc-second image control.

WF MOS-RQ-031-07: The WF MOS WFC shall not introduce vignetting greater than 15% across the WF MOS field of view and shall not exceed a factor of 10% averaged across the WF MOS field. Goal is to have no vignetting due to either the corrector optics or the corrector mount.

WF MOS-RQ-031-08: The WF MOS WFC plus ADC shall have greater than 80% transmission at each wavelength across the 0.39-1 micron wavelength band.

WF MOS-RQ-031-09: The WF MOS WFC corrector shall not require refocusing across the wavelength range of 0.39-1 micron.

WF MOS-RQ-031-10: The WF MOS WFC corrector shall not require refocusing across a TBD (perhaps 10 C) degree change in temperature.

WF MOS-RQ-031-11: In imaging configuration for HyperSuprimeCam, the WFC field of view shall be 2.0 degrees in diameter.

WF MOS-RQ-031-12: In imaging configuration for HyperSuprimeCam, the WFC shall deliver chromatic image quality giving TBD (~80% EE) within a TBD arc-second diameter aperture across the full field of view and across the wavelength band of TBD-TBD micron.

WF MOS-RQ-031-13: In imaging configuration for HyperSuprimeCam, the WFC shall deliver a focal surface that has a radius of curvature larger than TBD (possibly 50) meters with a goal of a flat focal surface.

WF MOS-RQ-031-14: In imaging configuration for HyperSuprimeCam, the WFC shall provide focus at a level of TBD (~0.1) arc-second image control.

WF MOS-RQ-031-15: In imaging configuration for HyperSuprimeCam, the WFC shall not introduce vignetting greater than TBD% across the field of view and shall not exceed a factor of TBD% averaged across the field. Goal is to have no vignetting due to either the corrector optics or the corrector mount.

WF MOS-RQ-031-16: The WF MOS WFC plus ADC shall have greater than 80% transmission at each wavelength across the 0.39-1 micron wavelength band.

WF MOS-RQ-031-17: The WF MOS WFC corrector shall not require refocusing across the wavelength range of 0.39-1 micron.

WF MOS-RQ-031-18: The WF MOS WFC corrector shall not require refocusing across a TBD (perhaps 10 C) degree change in temperature.

WF MOS-RQ-031-19: The WF MOS WFC shall interface with the instrument handling and storage facilities.

WF MOS-RQ-031-20: The WF MOS WFC shall not introduce greater than TBD level of scattered light. [Need to determine how to specify this requirement.]

WF MOS-RQ-031-21: The WF MOS WFC elements shall meet the mounting and alignment tolerances specified in Table XX [Table will be generated during concept design phase].

WF MOS-RQ-031-22: The WF MOS WFC elements shall meet the surface, homogeneity, and birefringence tolerances specified in Table XX [Table will be generated during concept design phase].

WF MOS-RQ-031-23: The mass of the WF MOS WFC elements shall not exceed TBD kg [this figure forms part of a mass budget for compliance with requirement WF MOS-RQ-001-08].

7.4.2 ADC

WF MOS-RQ-032-01: The WF MOS ADC shall interface to the lower PFU and form part of the optical path of the WFC.

WF MOS-RQ-032-02: The WF MOS ADC shall correct the atmospheric dispersion across the Zenith angle range of 0 to 60 degrees.

WF MOS-RQ-032-03: The WF MOS ADC shall not introduce more than TBD arc-second image degradation.

WF MOS-RQ-032-04: The WF MOS ADC shall keep the atmospheric dispersed PSF (secondary spectrum) to within TBD arc-seconds across the full range of Zenith angles and full spectral range of 0.39-1 micron.

WF MOS-RQ-032-05: The WF MOS ADC shall be computer controlled for normal, maintenance, and test operations.

WF MOS-RQ-032-06: The WF MOS ADC shall have a mode that locks it in the null position and at any other user defined orientation.

WF MOS-RQ-032-07: The WF MOS ADC orientation shall be readable by computer (as well by a visual indicator?).

WF MOS-RQ-032-08: The WF MOS ADC shall be able to operate over the temperature range of TBD (to match the required environmental requirement temperature range).

WF MOS-RQ-032-09: The mass of the WF MOS ADC shall not exceed TBD kg [this figure forms part of a mass budget for compliance with requirement WF MOS-RQ-001-08].

WF MOS-RQ-032-10: If HyperSuprimeCam WFC imaging requirements necessitate removal of the ADC, it shall be possible to remove/refit the ADC within TBD minutes.

7.5 *Instrument package requirements*

This category of requirements applies to the WF MOS instrument components carried primarily in the upper PFU or otherwise at the top end of the Subaru telescope. All requirements falling into this category will carry a component identifier of '04n'.

WF MOS-RQ-040-01: The total mass of the WF MOS top-end mounted instrument package components shall not exceed TBD kg [this figure forms part of a mass budget for compliance with requirement WF MOS-RQ-001-08].

7.5.1 *Fibre positioner*

WF MOS-RQ-041-01: The WF MOS FP shall interface to the WF MOS upper PFU and WFC/ADC.

WF MOS-RQ-041-02: The WF MOS FP shall interface to the WF MOS Fibre Cable.

WF MOS-RQ-041-03: The WF MOS FP shall sample the field with ~1 to 1.2 arc-second apertures on movable spectral probes.

WF MOS-RQ-041-04: The WF MOS FP shall be capable of positioning a total of ~4500 probes (precise number TBD).

WF MOS-RQ-041-05: The WF MOS FP spectral probes shall be capable of relative positioning and tracking to TBD (~0.1) arc-second accuracy. [This should be verified with modelling to give a definition in terms of lost S/N or efficiency due to error in alignment.]

WF MOS-RQ-041-06: The WF MOS FP spectral probes shall be axially aligned to the focal surface to within TBD (~100?) microns.

WF MOS-RQ-041-07: The WF MOS FP spectral probes shall not have an angular deviation of greater than TBD (~2.6) degrees from the central ray for that particular target.

WF MOS-RQ-041-08: Each WF MOS FP spectral probe shall be able to be configured within an area defined by the circle centered on that probe's home position and bounded by the home position of the probe's nearest neighbour. [This may need to be redefined pending final density of fibres in the field.]

WF MOS-RQ-041-09: The WF MOS FP shall be capable of reconfiguration for different target fields at any orientation of the telescope or PFU. [A goal is to allow reconfiguration during telescope slewing.]

WF MOS-RQ-041-10: The WF MOS FP shall be capable of a reconfiguration time of less than TBD (~5) minutes.

WF MOS-RQ-041-11: The WF MOS FP shall be computer controlled.

WF MOS-RQ-041-12: The WF MOS FP shall interface with the target assignment program.

WF MOS-RQ-041-13: The WF MOS FP shall output the coordinates of the spectral probes to the data product software.

WF MOS-RQ-041-14: The WF MOS FP shall be able to configure the probes in the nominal range of environmental conditions of temperature and humidity.

WF MOS-RQ-041-15: The WF MOS FP shall have a statistical uniformity of target allocation of TBD.

7.5.2 Acquisition system

WF MOS-RQ-042-01: The WF MOS Acquisition System must be capable of aligning the telescope to within 1 arc-second of the target field coordinates, for handoff to the guiding system.

WF MOS-RQ-042-02: The WF MOS Acquisition System shall be computer controlled.

WF MOS-RQ-042-03: The WF MOS Acquisition System shall acquire the field within TBD (2) minutes with a goal of TBD (1) minutes.

7.5.3 Guiding system

WF MOS-RQ-043-01: The WF MOS Guider shall be capable of closed loop tracking in RA and Dec to better than 0.1'' across the full field of view. This requires adjusting the elevation, azimuth, and rotation angle.

WF MOS-RQ-043-02: The WF MOS Guider shall be capable of correcting telescope pointing errors in RA and Dec of up to TBD (2.0'') to maintain the spine tips on target to better than 0.1'' across the full field of view. This requires adjusting the elevation, azimuth, and rotation angle, and requires allowance for gravitational sag of the spines.

WF MOS-RQ-043-03: The WF MOS Guider shall update the telescope pointing at a rate of TBD (~1) Hz.

WF MOS-RQ-043-04: The WF MOS Guider shall measure the image focus quality to TBD (~10) microns.

WF MOS-RQ-043-05: The WF MOS Guider shall provide focus feedback at a rate of TBD (~0.03) Hz.

WF MOS-RQ-043-06: The WF MOS Guider shall not obscure more than TBD % of the science field.

WF MOS-RQ-043-07: The WF MOS Guider shall be computer controlled.

WF MOS-RQ-043-08: The WF MOS Guider shall interface to the telescope control system.

WF MOS-RQ-043-09: The WF MOS Guider shall take no more than TBD (~30?) seconds to setup and initiate guiding.

WF MOS-RQ-043-10: The WF MOS Guider shall be capable of guiding at a specific wavelength within the operable wavelength regime of WF MOS (0.39-1.0 microns).

7.5.4 Wavefront sensing system

WF MOS-RQ-044-01: The WF MOS WFS shall be capable of determining wavefront errors to a level of TBD (waves, aberration level, order of correction and bandwidth

need to be defined – these will include tip-tilt, focus, astigmatism, coma, etc.) on a star of magnitude brighter than TBD.

WF MOS-RQ-044-02: The WF MOS WFS shall be computer controlled.

WF MOS-RQ-044-03: The WF MOS WFS shall interface with the observatory primary mirror support system.

WF MOS-RQ-044-04: The WF MOS WFS shall perform a wavefront measurement within TBD (~2) minutes with a goal of TBD (~1) minute.

WF MOS-RQ-044-05: The WF MOS WFS shall interface to the PFU.

WF MOS-RQ-044-06: The WF MOS WFS shall not obscure more than TBD % of the science field.

WF MOS-RQ-044-07: The WF MOS WFS shall be able to operate at the edge of the field and at field center.

7.5.5 Calibration system

WF MOS-RQ-045-01: The WF MOS Calibration System shall illuminate the spectral probes for system calibration of the detected spectra.

WF MOS-RQ-045-02: The WF MOS Calibration System shall provide detector pixel sensitivity calibration within any wavelength window defined elsewhere.

WF MOS-RQ-045-03: The WF MOS Calibration System shall provide wavelength calibration within any wavelength window defined by elsewhere.

WF MOS-RQ-045-04: The WF MOS wavelength calibration shall be sufficient to derive 20 km/s velocity measurement for the low resolution spectra.

WF MOS-RQ-045-05: The WF MOS wavelength calibration shall be sufficient to derive 1 km/s velocity measurement for the high resolution spectra.

WF MOS-RQ-045-06: The WF MOS Calibration System shall be computer controlled.

WF MOS-RQ-045-07: The WF MOS Calibration System shall provide a full set of calibrations within TBD (~30?) minutes per target configuration.

7.6 Fibre system requirements

This category of requirements applies to the optical fibres, their organisation and protection throughout their whole length, from the focal surface to the spectrograph(s). All requirements falling into this category will carry a component identifier of '05n'.

WF MOS-RQ-050-01: The net transmission of the fibre system, including all loss mechanisms in all segments of the fibre run from the probe apertures in the focal surface to the output of the slitlets in the spectrographs, shall be greater than TBD% (80%)

across the wavelength band of 0.5-1.0 micron and greater than TBD% (50%) at a wavelength of 0.39 microns.

WF MOS-RQ-050-02: The complete fibre run, from the probe apertures in the focal surface to the output of the slitlets in the spectrographs, shall not introduce greater than TBD (~2 degree) of Focal Ratio Degradation.

WF MOS-RQ-050-03: The fibre system shall maximise radial scrambling.

WF MOS-RQ-050-04: The fibre system transmission at all WF MOS operating wavelengths (0.35 to 1.0 microns) shall be stable to TBD % throughout a temperature range of TBD°C to TBD°C, and while flexed through its operating range of movement.

7.6.1 Fibre probes

WF MOS-RQ-051-01: The WF MOS fibre probes shall interface to the fibre positioner.

WF MOS-RQ-051-02: The WF MOS fibre probes shall interface to the fibre connector.

WF MOS-RQ-051-03: The WF MOS fibre probes shall have fibre optics with a core diameter that matches the required on-sky sampling aperture of TBD (1 – 1.2”).

WF MOS-RQ-051-04: The WF MOS fibre probes shall have fibre optics that interface to the corrected focal surface with an angular deviation of up to TBD (~2.6) degrees from the central ray.

WF MOS-RQ-051-05: The WF MOS fibre probes shall not introduce greater than TBD (~2 degree) of Focal Ratio Degradation. [This forms part of an FRD budget, for compliance with WF MOS-RQ-050-02]

WF MOS-RQ-051-06: The transmission of the fibre probes inclusive of end reflection losses shall be greater than TBD% across the wavelength band of 0.5-1.0 micron and greater than TBD% at a wavelength of 0.39 microns. [This forms part of an FRD budget, for compliance with WF MOS-RQ-050-01]

WF MOS-RQ-051-07: The WF MOS fibre probes shall operate over the nominal range of environmental conditions of temperature and humidity.

7.6.2 Fibre connector

WF MOS-RQ-052-01: The WF MOS fibre connector shall provide the interface between the fibre probes and the fibre cable.

WF MOS-RQ-052-02: The WF MOS fibre connector shall relay the light from the science probes (~f/2) into the fibre cable (~f/4).

WF MOS-RQ-052-03: The WF MOS fibre connector shall have a throughput efficiency greater than 90% across all wavelengths of the operable range for an unstressed fiber.

WFMOS-RQ-052-04: The WFMOS fibre connector shall not introduce greater than TBD (~2 degree) of Focal Ratio Degradation due to stresses in the connector. [This forms part of an FRD budget, for compliance with WFMOS-RQ-050-02]

WFMOS-RQ-052-05: The WFMOS fibre connector shall allow disconnection and reconnection of the fibre cable from the fibre probes for infrequent maintenance purposes. A goal is to allow routine disconnection and reconnection.

WFMOS-RQ-052-06: The WFMOS fibre connector shall have a computer readable status indicator. [This can probably be achieved by a check of each fibre through detection of the back illumination.]

WFMOS-RQ-052-07: The WFMOS fibre connector shall operate over the nominal range of environmental conditions of temperature and humidity.

7.6.3 *Fibre cable*

WFMOS-RQ-053-01: The WFMOS fibre cable shall interface to the fibre connector.

WFMOS-RQ-053-02: The WFMOS fibre cable shall interface to the telescope structure.

WFMOS-RQ-053-03: The WFMOS fibre cable shall interface to the spectrographs via the slitlets.

WFMOS-RQ-053-04: The WFMOS fibre cable shall carry a minimum of one fibre per science probe plus a number (TBD) of spares.

WFMOS-RQ-053-05: The WFMOS fibre cable shall have fibre optics with a core that matches to the required focal ratio relay provided by the connector (~200 micron diameter) that does not degrade the etendue by more than TBD (~10?) %. [This forms part of an FRD budget, for compliance with WFMOS-RQ-050-02]

WFMOS-RQ-053-06: The WFMOS fibre cable shall not introduce greater than TBD (~2 degree) of Focal Ratio Degradation due to stresses in the cable. [This forms part of an FRD budget, for compliance with WFMOS-RQ-050-02]

WFMOS-RQ-053-07: The transmission of the unstressed fibre cable inclusive of end reflection losses shall be greater than 80% across the wavelength band of 0.5-1.0 micron and greater than 50% at a wavelength of 0.39 microns. [This forms part of an FRD budget, for compliance with WFMOS-RQ-050-01]

WFMOS-RQ-053-08: The WFMOS fibre cable shall interface to the cable wrap on the upper PFU.

WFMOS-RQ-053-09: The WFMOS fibre cable shall not be longer than TBD meters.

WFMOS-RQ-053-10: The WFMOS fibre cable shall protect the fibres from physical damage. [Not sure yet how to define the requirements, but will include crush resistance,

tensional strength, torsional strength, integrity of fibres through repeated flexing of all flexible segments, strain relief, bend radius, loads, etc..]

WF MOS-RQ-053-11: The WF MOS fibre cable shall operate over the nominal range of environmental conditions of temperature and humidity.

WF MOS-RQ-053-12: The WF MOS fibre cable shall not introduce greater than TBD of unbalanced mass loading onto the telescope for the range of 0-60 degrees Zenith angle.

WF MOS-RQ-053-13: The WF MOS fibre cable shall not interfere with motion of telescope due to static loads transmission of vibration to telescope due to wind loads, mass limit on telescope structure, mass limit on dome wall.

7.6.4 Slitlets

WF MOS-RQ-054-01: The WF MOS fibre slitlets shall interface with the fibre cable.

WF MOS-RQ-054-02: The WF MOS fibre slitlets shall interface with the spectrographs.

WF MOS-RQ-054-03: The WF MOS fibre slitlets shall not introduce greater than TBD (~2 degree) of Focal Ratio Degradation.

WF MOS-RQ-054-04: The transmission of the fibre slitlets shall be greater than TBD% (99%) across the wavelength band of 0.5-1.0 micron and greater than TBD% (95%) at a wavelength of 0.39 microns.

7.7 Spectrograph requirements

This category of requirements applies to the WF MOS spectrograph(s), excluding the detector/controller package. All requirements falling into this category will carry a component identifier of '06n'.

WF MOS-RQ-060-01: The WF MOS spectrographs shall interface to the fibre cable.

WF MOS-RQ-060-02: The WF MOS spectrographs shall have the capability of observing both high and low resolution sets simultaneously.

WF MOS-RQ-060-03: The WF MOS spectrographs shall be computer controlled.

WF MOS-RQ-060-04: The WF MOS spectrographs shall interface with the spectrograph laboratory.

7.7.1 Low resolution mode

WF MOS-RQ-061-01: The WF MOS spectrographs in low resolution mode shall have the capability of recording at least ~3000 low resolution spectra simultaneously.

WF MOS-RQ-061-02: The WF MOS spectrographs in low resolution mode shall have a resolving power of ~2000, sufficient to resolve the [OII] doublet, with a goal of ~3000.

WF MOS-RQ-061-03: The WF MOS spectrographs in low resolution mode shall be capable of simultaneously recording a minimum of 400 nm contiguous wavelength coverage anywhere within the spectral window.

WF MOS-RQ-061-04: The WF MOS spectrographs in low resolution mode shall be stable such that daytime calibrations are sufficient to calibrate the nighttime observations. [Level of stability required TBD, will include thermal, mechanical, background level.]

WF MOS-RQ-061-05: The WF MOS spectrographs in low resolution mode will have a wavelength range of operability covering from 0.39 to 1.0 microns.

WF MOS-RQ-061-06: The WF MOS spectrographs in low resolution mode shall be capable of Nod&Shuffle sky observation.

WF MOS-RQ-061-07: The WF MOS spectrographs in low resolution mode shall have a minimum system efficiency that would give a SN of 6 per resolution element in the continuum for a 40 minute observation (non-Nod&Shuffle mode) on a $R(AB) = 23.6$ galaxy. [This needs confirmation or redefinition in the concept design study, and forms a top-level efficiency requirement that flows down to testable throughput, etc. at a lower requirement level.]

WF MOS-RQ-061-08: The WF MOS spectrographs in low resolution mode shall have shutters that block all light to their detectors

WF MOS-RQ-061-09: In low resolution mode, the WF MOS spectrograph shutters shall be able to open and close with uniform illumination across the detector in less than TBD (1) second.

WF MOS-RQ-061-10: The WF MOS spectrographs in low resolution mode shall have back-illumination systems viewable by the Fibre Positioner position feedback system.

WF MOS-RQ-061-11: The WF MOS spectrographs in low resolution mode shall not allow more than TBD (~ 0.1)% leakage from other spectral orders.

WF MOS-RQ-061-12: The WF MOS spectrographs in low resolution mode shall not have greater than TBD % scattered light.

WF MOS-RQ-061-13: The WF MOS spectrographs in low resolution mode shall interface with the low resolution mode detector package.

7.7.2 High resolution mode

WF MOS-RQ-062-01: The WF MOS spectrographs in high resolution mode shall have the capability of recording at least ~ 1500 high resolution spectra simultaneously.

WF MOS-RQ-062-02: The WF MOS spectrographs in high resolution mode shall have a resolving power of ~ 40000 .

WFMOS-RQ-062-03: The WFMOS spectrographs in high resolution mode shall have a minimum system efficiency that would give a SN of TBD per resolution element in the continuum for a TBD minute observation on a TBD magnitude star.

WFMOS-RQ-062-04: The WFMOS spectrographs in high resolution mode shall be capable of simultaneously recording a minimum of 30 nm contiguous wavelength coverage anywhere within the spectral window.

WFMOS-RQ-062-05: The WFMOS spectrographs in high resolution mode will have a wavelength range of operability covering from 0.39 to 1.0 microns.

WFMOS-RQ-062-06: The WFMOS spectrographs in high resolution mode shall have shutters that block all light to their detectors

WFMOS-RQ-062-07: In high resolution mode, the WFMOS spectrograph shutters shall be able to open and close with uniform illumination across the detector in less than TBD (1) second.

WFMOS-RQ-062-08: The WFMOS spectrographs in high resolution mode shall have back-illumination systems viewable by the Fibre Positioner position feedback system.

WFMOS-RQ-062-09: The WFMOS spectrographs in high resolution mode shall not allow more than TBD (~0.1)% leakage from other spectral orders.

WFMOS-RQ-062-10: The WFMOS spectrographs in high resolution mode shall not have greater than TBD % scattered light.

WFMOS-RQ-062-11: The WFMOS spectrographs in high resolution mode shall interface with the high resolution mode detector package.

7.8 *Detector/controller requirements*

This category of requirements applies to the optical detector arrays for the spectrograph (s), and their controllers. All requirements falling into this category will carry a component identifier of '07n'.

WFMOS-RQ-070-01: The WFMOS Detector System shall interface with the spectrographs.

WFMOS-RQ-070-02: The WFMOS Detector System shall be computer controlled.

WFMOS-RQ-070-03: The WFMOS Detector System shall interface to the data pipeline system.

7.8.1 *Low resolution mode*

WFMOS-RQ-071-01: The WFMOS low resolution mode detector system shall have a format adequate to image the required number of low resolution spectra, with spectral

coverage and resolution specified by the spectrographs' low resolution mode and allowing for Nod&Shuffle observing where required.

WF MOS-RQ-071-02: The WF MOS low resolution mode detector system shall have modes for normal and for Nod&Shuffle observing.

WF MOS-RQ-071-03: The WF MOS low resolution mode detector system shall have fewer than TBD % cosmetic defects.

WF MOS-RQ-071-04: The WF MOS low resolution mode detector system shall have a science readout rate of less than TBD seconds with an rms noise level of less than TBD electrons.

WF MOS-RQ-071-05: The WF MOS low resolution mode detector system shall have a dark rate of less than TBD electrons per hour.

WF MOS-RQ-071-06: The WF MOS low resolution mode detector system, if charge coupled, shall have a charge transfer efficiency of greater than TBD %.

WF MOS-RQ-071-07: The WF MOS low resolution mode detector system shall exhibit fringing at levels less than TBD amplitude and less than TBD spatial frequency.

WF MOS-RQ-071-08: The WF MOS low resolution mode detector system shall have $QE > TBD\%$ across the useful spectral window.

WF MOS-RQ-071-09: The WF MOS low resolution mode detector system shall have an exposure mode with a range of exposures from 1 to at least 3600 seconds duration.

WF MOS-RQ-071-10: The WF MOS low resolution mode detector system shall have a dark exposure mode in which the shutter remains closed with a range of exposures equal to that of the exposure mode.

WF MOS-RQ-071-11: The WF MOS low resolution mode detector system shall have a 0 second exposure mode to determine the detector bias level.

WF MOS-RQ-071-12: The WF MOS low resolution mode detector system shall have an exposure pause mode allowing a pause range of 0 to at least 1800 seconds duration.

7.8.2 High resolution mode

WF MOS-RQ-072-01: The WF MOS high resolution mode detector system shall have a format adequate to image the required number of high resolution spectra, with spectral coverage and resolution specified by the spectrographs' high resolution mode.

WF MOS-RQ-072-02: The WF MOS high resolution mode detector system shall have fewer than TBD % cosmetic defects.

WF MOS-RQ-072-03: The WF MOS high resolution mode detector system shall have a science readout rate of less than TBD seconds with an rms noise level of less than TBD electrons.

WF MOS-RQ-072-04: The WF MOS high resolution mode detector system shall have a dark rate of less than TBD electrons per hour.

WF MOS-RQ-072-05: The WF MOS high resolution mode detector system, if charge coupled, shall have a charge transfer efficiency of greater than TBD %.

WF MOS-RQ-072-06: The WF MOS high resolution mode detector system shall exhibit fringing at levels less than TBD amplitude and less than TBD spatial frequency.

WF MOS-RQ-072-07: The WF MOS high resolution mode detector system shall have $QE > TBD\%$ across the usable spectral range.

WF MOS-RQ-072-08: The WF MOS high resolution mode detector system shall have an exposure mode with a range of exposures from 1 to at least 3600 seconds duration.

WF MOS-RQ-072-09: The WF MOS high resolution mode detector system shall have a dark exposure mode in which the shutter remains closed with a range of exposures equal to that of the exposure mode.

WF MOS-RQ-072-10: The WF MOS high resolution mode detector system shall have a 0 second exposure mode to determine the detector bias level.

WF MOS-RQ-072-11: The WF MOS high resolution mode detector system shall have an exposure pause mode allowing a pause range of 0 to at least 1800 seconds duration.

7.9 Facility software requirements

This category of requirements applies to system-wide software components. All requirements falling into this category will carry a component identifier of '08n'.

7.9.1 Observing preparation software

WF MOS-RQ-081-01: The WF MOS observing preparation software shall interface with the WF MOS fibre positioner.

WF MOS-RQ-081-02: The WF MOS observing preparation software shall translate and assign target RA and Dec values into fibre probe assignments.

WF MOS-RQ-081-03: The WF MOS observing preparation software shall allow rearrangement of a subset of fibres while retaining the same pointing center.

WF MOS-RQ-081-04: The WF MOS observing preparation software shall allow convenient definition of acquisition, guide, and wavefront sensing stars as a function of telescope configuration and time of observation.

WF MOS-RQ-081-05: The WF MOS observing preparation software shall allow automatic and manual adjustments to the pointing center to optimize target assignment solutions.

WF MOS-RQ-081-06: The WF MOS observing preparation software shall allow target assignment solutions to be modified at the telescope in a reasonable period of time prior to the start of the observations.

WF MOS-RQ-081-07: The WF MOS observing preparation software shall allow verification that input catalogs of target objects match the reference frame of the acquisition/guide stars.

WF MOS-RQ-081-08: The WF MOS observing preparation software shall allow multiple configurations with the same or overlapping pointings.

WF MOS-RQ-081-09: The WF MOS observing preparation software shall record the fibre assignments and interface to the data pipeline.

7.9.2 *Instrument/telescope control software*

WF MOS-RQ-082-01: The WF MOS control software shall interface to the Subaru telescope control system.

WF MOS-RQ-082-02: The WF MOS control software shall interface to the fibre positioner.

WF MOS-RQ-082-03: The WF MOS control software shall interface to the Target Assignment Software.

WF MOS-RQ-082-04: The WF MOS control software shall interface to the WF MOS upper and lower PFUs.

WF MOS-RQ-082-05: The WF MOS control software shall interface to the WF MOS on-instrument wavefront sensing system.

WF MOS-RQ-082-06: The WF MOS control software shall interface to the WF MOS ADC.

WF MOS-RQ-082-07: The WF MOS control software shall interface to the WF MOS calibration system.

WF MOS-RQ-082-08: The WF MOS control software shall interface to the WF MOS spectrographs.

WF MOS-RQ-082-09: The WF MOS control software shall provide an operating user interface.

WF MOS-RQ-082-10: The WF MOS control software shall provide an engineering user interface.

WF MOS-RQ-082-11: The WF MOS control software shall interface to the Data Pipeline Software, providing telescope and instrument parameters.

7.9.3 *Data pipeline software*

WF MOS-RQ-083-01: The WF MOS DP shall interface to the Target Assignment Software.

WF MOS-RQ-083-02: The WF MOS DP shall interface to the Detector System.

WF MOS-RQ-083-03: The WF MOS DP shall interface to the Telescope Control System.

WF MOS-RQ-083-04: The WF MOS DP quick look data reduction shall be capable of assessing the SNR in an exposure in less than 20 minutes.

WF MOS-RQ-083-05: The WF MOS DP quick look data reduction shall be capable of searching reduced, coadded spectra for determining which targets have secure redshifts in less than 30 minutes.

WF MOS-RQ-083-06: The WF MOS DP shall provide extracted and calibrated spectra within a TBD (~6) hour period after conclusion of the night's observations.

WF MOS-RQ-083-07: The WF MOS DP shall provide the option of normal or Nod&Shuffle sky subtraction.

WF MOS-RQ-083-08: The WF MOS DP shall interface to the Gemini Data Archive.

7.9.4 *Science pipeline software*

WF MOS-RQ-084-01: The WF MOS SP shall interface to the Gemini Data Archive.

WF MOS-RQ-084-02: The WF MOS SP shall interface to the WF MOS Data Pipeline.

WF MOS-RQ-084-03: WF MOS SP data reduction (package B) shall have automated determination of radial velocity, stellar gravity, effective temperature, metallicity, and elemental abundance (for the high resolution spectra).

7.9.5 *Archive*

WF MOS-RQ-085-01: The data archive shall allow data extraction of both raw and calibrated data.

WF MOS-RQ-085-02: The data archive shall be VO compliant.

7.10 *Observatory infrastructure requirements*

This category of requirements applies to infrastructure upgrades required to accommodate, handle and support the WF MOS facility. All requirements falling into this category will carry a component identifier of '09n'. These requirements will be defined in the Concept Design phase.

7.10.1 *Instrument handling facilities*

WFMOS-RQ-091: TBD

7.10.2 *Instrument storage facilities*

WFMOS-RQ-092 TBD

7.10.3 *Spectrograph laboratory*

WFMOS-RQ-093: TBD

7.10.4 *Instrument service provision*

WFMOS-RQ-094: TBD

7.10.5 *Test facilities*

WFMOS-RQ-095: TBD

7.10.6 *Maintenance facilities*

WFMOS-RQ-096: TBD

7.10.7 *Observing support facilities*

WFMOS-RQ-097: TBD

Chapter 8 Requirement Details and Flowdown Requirements

The following sections will give details of the requirements listed in the previous chapter and will also list lower level requirements that flow down from the higher level requirements. Details are to be derived during the design phases of the instrument. This chapter also should be reorganized to follow the system layout defined by the previous chapter as it has not yet been so organized.

8.1 *Wide Field Corrector*

8.1.1 *Optical*

- 8.1.1.1 *Image quality and tolerances*
- 8.1.1.2 *Atmospheric Dispersion Compensator*
- 8.1.1.3 *Other*

8.1.2 *Mechanical*

- 8.1.2.1 *Rigidity*
- 8.1.2.2 *Mechanical and thermal tolerances*
- 8.1.2.3 *Thermal performance*
- 8.1.2.4 *Space requirements*
- 8.1.2.5 *Mass and centre of gravity requirements*
- 8.1.2.6 *Cooling system*
- 8.1.2.7 *Vacuum system*
- 8.1.2.8 *Operational requirements for mechanisms*
- 8.1.2.9 *Instrument handling*
- 8.1.2.10 *Metric dimensioning*

8.1.3 *Electrical & Electronics*

- 8.1.3.1 *Electronic design requirements*
- 8.1.3.2 *EMC*
- 8.1.3.3 *Other*

8.1.4 *Control System*

- 8.1.4.1 *Operability*
- 8.1.4.2 *Configuration time*
- 8.1.4.3 *General requirements*
- 8.1.4.4 *Temperature control*

8.1.5 *Software*

8.1.5.1 *Software design requirements*

8.1.5.2 *Gemini furnished software*

8.1.5.3 *Subaru furnished software*

8.1.5.4 *Engineering interface*

8.2 *Top End*

8.2.1 *Mechanical*

8.2.1.1 *Rigidity*

8.2.1.2 *Mechanical and thermal tolerances*

8.2.1.3 *Thermal performance*

8.2.1.4 *Space requirements*

8.2.1.5 *Mass and centre of gravity requirements*

8.2.1.6 *Cooling system*

8.2.1.7 *Vacuum system*

8.2.1.8 *Operational requirements for mechanisms*

8.2.1.9 *Instrument handling*

8.2.1.10 *Metric dimensioning*

8.2.2 *Electrical & Electronics*

8.2.2.1 *Electronic design requirements*

8.2.2.2 *EMC*

8.2.2.3 *Other*

8.2.3 *Control System*

8.2.3.1 *Operability*

8.2.3.2 *Configuration time*

8.2.3.3 *General requirements*

8.2.3.4 *Temperature control*

8.2.4 *Software*

8.2.4.1 *Software design requirements*

8.2.4.2 *Gemini furnished software*

8.2.4.3 *Subaru furnished software*

8.2.4.4 *Engineering interface*

8.3 *Fibre Positioner*

8.3.1 *Optical*

8.3.1.1 *X-Y positioning tolerance*

8.3.1.2 *Focus tolerance*

8.3.1.3 *Spine tilt*

8.3.1.4 *Guiding*

8.3.1.5 *Field rotation*

8.3.1.6 *Other*

8.3.2 *Position feedback system*

8.3.2.1 *Position sensor resolution*

8.3.2.2 *Response time*

8.3.2.3 *Sensitivity*

8.3.2.4 *Other*

8.3.3 *Mechanical*

- 8.3.3.1 *Rigidity*
- 8.3.3.2 *Mechanical and thermal tolerances*
- 8.3.3.3 *Thermal performance*
- 8.3.3.4 *Space requirements*
- 8.3.3.5 *Mass and centre of gravity requirements*
- 8.3.3.6 *Cooling system*
- 8.3.3.7 *Vacuum system*
- 8.3.3.8 *Operational requirements for mechanisms*
- 8.3.3.9 *Instrument handling*
- 8.3.3.10 *Rotation*
- 8.3.3.11 *Metric dimensioning*

8.3.4 *Electrical & Electronics*

- 8.3.4.1 *Electronic design requirements*
- 8.3.4.2 *EMC*
- 8.3.4.3 *Cooling*
- 8.3.4.4 *Other*

8.3.5 *Control System*

- 8.3.5.1 *Operability*
- 8.3.5.2 *Configuration time*
- 8.3.5.3 *General requirements*
- 8.3.5.4 *Temperature control*

8.3.6 *Software*

- 8.3.6.1 *Software design requirements*
- 8.3.6.2 *Gemini furnished software*
- 8.3.6.3 *Subaru furnished software*

8.3.6.4 *Engineering interface*

8.4 *Fibre Cable*

8.4.1 *Optical*

8.4.1.1 *Throughput*

8.4.1.2 *Beam Speeds*

8.4.1.3 *Focal Ratio Degradation*

8.4.1.4 *Modal Scrambling*

8.4.1.5 *Wavelength performance*

8.4.1.6 *Other*

8.4.2 *Mechanical*

8.4.2.1 *Rigidity*

8.4.2.2 *Mechanical and thermal tolerances*

8.4.2.3 *Thermal performance*

8.4.2.4 *Space requirements*

8.4.2.5 *Mass and centre of gravity requirements*

8.4.2.6 *Operational requirements for mechanisms*

8.4.2.7 *Instrument handling*

8.4.2.8 *Maintenance – spare fibres*

8.4.2.9 *Metric dimensioning*

8.5 *Fibre Cable Connector*

8.5.1 *Optical*

- 8.5.1.1 *Throughput*
- 8.5.1.2 *Beam Speeds*
- 8.5.1.3 *Focal Ratio Degradation*
- 8.5.1.4 *Modal Scrambling*
- 8.5.1.5 *Wavelength performance*
- 8.5.1.6 *Other*

8.5.2 *Mechanical*

- 8.5.2.1 *Rigidity*
- 8.5.2.2 *Mechanical and thermal tolerances*
- 8.5.2.3 *Thermal performance*
- 8.5.2.4 *Space requirements*
- 8.5.2.5 *Mass and centre of gravity requirements*
- 8.5.2.6 *Operational requirements for mechanisms*
- 8.5.2.7 *Instrument handling*
- 8.5.2.8 *Metric dimensioning*

8.5.3 *Electrical & Electronics*

- 8.5.3.1 *Electronic design requirements*

This might include sensing of correct engagement.

- 8.5.3.2 *EMC*
- 8.5.3.3 *Other*

8.6 *Low Resolution Spectrographs*

8.6.1 *Spectroscopic*

- 8.6.1.1 *Resolution*
- 8.6.1.2 *Wavelength range*
- 8.6.1.3 *Number of spectra*
- 8.6.1.4 *Nod and Shuffle*
- 8.6.1.5 *System efficiency*
- 8.6.1.6 *Scattered light*
- 8.6.1.7 *Filters*
- 8.6.1.8 *Other*

8.6.2 *Optical*

- 8.6.2.1 *Image quality and tolerances*
- 8.6.2.2 *Focus tolerance*
- 8.6.2.3 *Cold stop*
- 8.6.2.4 *Coatings*
- 8.6.2.5 *Vacuum environment*
- 8.6.2.6 *Other*

8.6.3 *Mechanical*

- 8.6.3.1 *Rigidity*
- 8.6.3.2 *Mechanical and thermal tolerances*
- 8.6.3.3 *Thermal performance*
- 8.6.3.4 *Space requirements*
- 8.6.3.5 *Mass and centre of gravity requirements*
- 8.6.3.6 *Cooling system*
- 8.6.3.7 *Vacuum system*
- 8.6.3.8 *Operational requirements for mechanisms*
- 8.6.3.9 *Instrument handling*
- 8.6.3.10 *Articulation*
- 8.6.3.11 *Metric dimensioning*

8.6.4 *Electrical & Electronics*

- 8.6.4.1 *Electronic design requirements*
- 8.6.4.2 *EMC*
- 8.6.4.3 *Cooling*
- 8.6.4.4 *Other*

8.6.5 *Detectors*

- 8.6.5.1 *Science detector performance requirements*
- 8.6.5.2 *Science detector requirements*
- 8.6.5.3 *Science detector controller*
- 8.6.5.4 *Other*

8.6.6 *Control System*

- 8.6.6.1 *Operability*
- 8.6.6.2 *Configuration time*

8.6.6.3 *General requirements*

8.6.6.4 *Temperature control*

8.6.7 *Software*

8.6.7.1 *Software design requirements*

8.6.7.2 *Gemini furnished software*

8.6.7.3 *Subaru furnished software*

8.6.7.4 *Engineering interface*

8.6.8 *Data Processing*

8.7 *High Resolution Spectrographs*

8.7.1 *Spectroscopic*

8.7.1.1 *Resolution*

8.7.1.2 *Wavelength range*

8.7.1.3 *Number of spectra*

8.7.1.4 *Nod and Shuffle*

8.7.1.5 *System efficiency*

8.7.1.6 *Scattered light*

8.7.1.7 *Filters*

8.7.1.8 *Other*

8.7.2 *Optical*

8.7.2.1 *Image quality and tolerances*

8.7.2.2 *Focus tolerance*

8.7.2.3 *Cold stop*

8.7.2.4 *Coatings*

8.7.2.5 *Vacuum environment*

8.7.2.6 *Other*

8.7.3 *Mechanical*

8.7.3.1 *Rigidity*

8.7.3.2 *Mechanical and thermal tolerances*

8.7.3.3 *Thermal performance*

8.7.3.4 *Space requirements*

8.7.3.5 *Mass and centre of gravity requirements*

8.7.3.6 *Cooling system*

8.7.3.7 *Vacuum system*

8.7.3.8 *Operational requirements for mechanisms*

8.7.3.9 *Instrument handling*

8.7.3.10 *Articulation*

8.7.3.11 *Metric dimensioning*

8.7.4 *Electrical & Electronics*

8.7.4.1 *Electronic design requirements*

8.7.4.2 *EMC*

8.7.4.3 *Cooling*

8.7.4.4 *Other*

8.7.5 *Detectors*

8.7.5.1 *Science detector performance requirements*

8.7.5.2 *Science detector requirements*

8.7.5.3 *Science detector controller*

8.7.5.4 *Other*

8.7.6 *Control System*

- 8.7.6.1 *Operability*
- 8.7.6.2 *Configuration time*
- 8.7.6.3 *General requirements*
- 8.7.6.4 *Temperature control*

8.7.7 *Software*

- 8.7.7.1 *Software design requirements*
- 8.7.7.2 *Gemini furnished software*
- 8.7.7.3 *Subaru furnished software*
- 8.7.7.4 *Engineering interface*

8.7.8 *Data Processing*

8.8 *Calibration System*

8.8.1 *Optical*

- 8.8.1.1 *Wavelengths*
- 8.8.1.2 *Photometric*
- 8.8.1.3 *Flat field parameters*
- 8.8.1.4 *Other*

8.8.2 *Mechanical*

- 8.8.2.1 *Rigidity*
- 8.8.2.2 *Mechanical and thermal tolerances*
- 8.8.2.3 *Thermal performance*
- 8.8.2.4 *Space requirements*
- 8.8.2.5 *Mass and centre of gravity requirements*
- 8.8.2.6 *Cooling system*
- 8.8.2.7 *Vacuum system*
- 8.8.2.8 *Operational requirements for mechanisms*

8.8.2.9 *Instrument handling*

8.8.2.10 *Metric dimensioning*

8.8.3 *Electrical & Electronics*

8.8.3.1 *Electronic design requirements*

8.8.3.2 *EMC*

8.8.3.3 *Cooling*

8.8.3.4 *Other*

8.8.4 *Control System*

8.8.4.1 *Operability*

8.8.4.2 *Configuration time*

8.8.4.3 *General requirements*

8.8.4.4 *Temperature control*

8.8.5 *Software*

8.8.5.1 *Software design requirements*

8.8.5.2 *Gemini furnished software*

8.8.5.3 *Subaru furnished software*

8.8.5.4 *Engineering interface*

8.8.6 *Data Processing*

8.9 *Acquisition and Guiding*

8.9.1 *Optical*

8.9.1.1 *Field acquisition time*

8.9.1.2 *Astrometric requirements*

8.9.1.3 *Acquisition target magnitude*

8.9.1.4 *Number of targets for acquisition*

8.9.1.5 *Distribution of targets for acquisition*

- 8.9.1.6 *Guide target magnitude*
- 8.9.1.7 *Number of targets for guiding*
- 8.9.1.8 *Distribution of targets for guiding*
- 8.9.1.9 *Guiding accuracy*
- 8.9.1.10 *Guiding duration*
- 8.9.1.11 *Rotation limits*
- 8.9.1.12 *Other*

8.9.2 *Mechanical*

- 8.9.2.1 *Rigidity*
- 8.9.2.2 *Mechanical and thermal tolerances*
- 8.9.2.3 *Thermal performance*
- 8.9.2.4 *Space requirements*
- 8.9.2.5 *Mass and centre of gravity requirements*
- 8.9.2.6 *Cooling system*
- 8.9.2.7 *Vacuum system*
- 8.9.2.8 *Operational requirements for mechanisms*
- 8.9.2.9 *Instrument handling*
- 8.9.2.10 *Metric dimensioning*

8.9.3 *Electrical & Electronics*

- 8.9.3.1 *Electronic design requirements*
- 8.9.3.2 *EMC*
- 8.9.3.3 *Cooling*
- 8.9.3.4 *Other*

8.9.4 *Control System*

- 8.9.4.1 *Operability*

8.9.4.2 *Configuration time*

8.9.4.3 *General requirements*

8.9.4.4 *Temperature control*

8.9.5 *Software*

8.9.5.1 *Software design requirements*

8.9.5.2 *Gemini furnished software*

8.9.5.3 *Subaru furnished software*

8.9.5.4 *Engineering interface*

8.10 Wavefront Sensing

8.10.1 Optical

- 8.10.1.1 *Parameters monitored*
- 8.10.1.2 *Response time*
- 8.10.1.3 *Target magnitude*
- 8.10.1.4 *Number of targets for sensing*
- 8.10.1.5 *Distribution of targets for sensing*
- 8.10.1.6 *Other*

8.10.2 Mechanical

- 8.10.2.1 *Rigidity*
- 8.10.2.2 *Mechanical and thermal tolerances*
- 8.10.2.3 *Thermal performance*
- 8.10.2.4 *Space requirements*
- 8.10.2.5 *Mass and centre of gravity requirements*
- 8.10.2.6 *Cooling system*
- 8.10.2.7 *Vacuum system*
- 8.10.2.8 *Operational requirements for mechanisms*
- 8.10.2.9 *Instrument handling*
- 8.10.2.10 *Metric dimensioning*

8.10.3 Electrical & Electronics

- 8.10.3.1 *Electronic design requirements*
- 8.10.3.2 *EMC*
- 8.10.3.3 *Cooling*
- 8.10.3.4 *Other*

8.10.4 Control System

- 8.10.4.1 *Operability*
- 8.10.4.2 *Configuration time*
- 8.10.4.3 *Feedback to telescope control system*
- 8.10.4.4 *General requirements*
- 8.10.4.5 *Temperature control*

8.10.5 *Software*

- 8.10.5.1 *Software design requirements*
- 8.10.5.2 *Gemini furnished software*
- 8.10.5.3 *Subaru furnished software*
- 8.10.5.4 *Engineering interface*

8.11 *Telescope System Integration and Control*

8.11.1 *Control System*

- 8.11.1.1 *Operability*
- 8.11.1.2 *Configuration time*
- 8.11.1.3 *General requirements*
- 8.11.1.4 *Temperature control*

8.11.2 *Software*

- 8.11.2.1 *Software design requirements*
- 8.11.2.2 *Gemini furnished software*
- 8.11.2.3 *Subaru furnished software*
- 8.11.2.4 *Engineering interface*

8.11.3 *Data Processing*

8.12 *Data Reduction and Handling*

8.12.1 *Software*

- 8.12.1.1 *Software design requirements*
- 8.12.1.2 *Observation preparation support*
- 8.12.1.3 *Gemini furnished software*
- 8.12.1.4 *Subaru furnished software*
- 8.12.1.5 *Engineering interface*

8.12.2 *Data Processing*

- 8.12.2.1 *Data pipeline*
- 8.12.2.2 *Archiving*
- 8.12.2.3 *VO compliance*

8.13 *Telescope Infrastructure*

8.13.1 *Mechanical*

- 8.13.1.1 *Rigidity*

- 8.13.1.2 *Mechanical and thermal tolerances*
- 8.13.1.3 *Thermal performance*
- 8.13.1.4 *Space requirements*
- 8.13.1.5 *Mass and centre of gravity requirements*
- 8.13.1.6 *Cooling system*
- 8.13.1.7 *Vacuum system*
- 8.13.1.8 *Operational requirements for mechanisms*
- 8.13.1.9 *Instrument handling*
- 8.13.1.10 *Metric dimensioning*

8.13.2 *Electrical & Electronics*

- 8.13.2.1 *Electronic design requirements*
- 8.13.2.2 *EMC*
- 8.13.2.3 *Cooling*
- 8.13.2.4 *Other*

8.13.3 *Control System*

- 8.13.3.1 *Operability*
- 8.13.3.2 *Configuration time*
- 8.13.3.3 *General requirements*
- 8.13.3.4 *Temperature control*

8.13.4 *Software*

- 8.13.4.1 *Software design requirements*
- 8.13.4.2 *Gemini furnished software*
- 8.13.4.3 *Subaru furnished software*
- 8.13.4.4 *Engineering interface*

8.13.5 *Data Processing*

Chapter 9 Environmental Requirements

9.1 Altitude

All WFMOS components shall be capable of being transported, stored, and operated in a wide range of altitude environments.

9.1.1 Transportation Altitudes

WFMOS-RQ-101-01: All WFMOS components shall be capable of being transported at any altitude between -70 m and 4,200 m by any transportation mode. WFMOS shall be capable of being transported by commercial jet with pressurized cargo compartments at altitudes up to 15 km.

9.1.2 Storage Altitudes

WFMOS-RQ-101-02: All WFMOS components shall be capable of being stored in or out of their shipping containers at any altitude between -70 m and 4,200 m.

9.1.3 Operation Altitudes

WFMOS-RQ-101-03: All WFMOS components shall be capable of being operated at any altitude between -70 m and 4,200 m.

Notes and Comments

1. WFMOS must work at Subaru's Hilo integration facility, at an altitude of approximately sea level, and at the Subaru telescope on Mauna Kea.

9.2 Temperature

9.2.1 Operational Environment

WFMOS-RQ-102-01: All WFMOS components operational temperature environment shall be limited to -15 to +25°C.

9.2.2 *Survival Environment*

WFMOS-RQ-102-02: All WFMOS components shall be capable of surviving a temperature range of -20 to +50°C without damage.

9.2.3 *Transport Environment*

WFMOS-RQ-102-03: All WFMOS components shall be capable of withstanding a temperature range of -20 to +50°C during transport without damage.

9.3 *Humidity*

9.3.1 *Operational Environment*

WFMOS-RQ-103-01: All WFMOS components shall be capable of operation in a wide range of humidity environments in the range 0 to TBD% relative humidity, without condensing moisture.

9.3.2 *Survival Environment*

WFMOS-RQ-103-02: All WFMOS components shall be capable of being stored in a wide range of humidity environments in the range 0 to 100% relative humidity, with condensing moisture.

9.3.3 *Transport Environment*

WFMOS-RQ-103-03: All WFMOS components shall be capable of being transported in a wide range of humidity environments in the range 0 to 100% relative humidity, with condensing moisture.

9.4 *Vacuum Environment*

WFMOS-RQ-104-01: WFMOS shall maintain a vacuum inside its spectrograph cryostats.

9.4.1 *Creating the Vacuum*

WFMOS-RQ-104-02: WFMOS shall provide a means to evacuate its spectrograph cryostats.

9.4.2 11.4.2 Vacuum Quality and Duration

WF MOS-RQ-104-03: WF MOS shall be capable of maintaining its spectrograph cryostats cold and operated without measurable degradation of scientific performance for 3 months.

WF MOS-RQ-104-04: If needed, the WF MOS spectrographs shall be capable of being kept at room temperature without contamination of the detector or internal optics significantly affecting the scientific performance, for at least 3 months without pumping.

Notes and Comments

1. Operating vacuum may only be obtained with a cold instrument.

9.5 *Mechanical Environment*

WF MOS-RQ-105-01: WF MOS shall be capable of operating in the mechanical environment of the Subaru telescope and its base facility.

9.5.1 *Telescope Slew Rates*

WF MOS-RQ-105-02: WF MOS telescope-mounted components shall be capable of withstanding slew rates of 2° per second in azimuth and 0.75° per second in elevation, or any combination of these. All optics and mechanisms shall meet their flexure and alignment specifications at these rates.

Chapter 10 Other Requirements

10.1 Documentation

WFMOS-RQ-111-01: WFMOS shall be delivered with adequate documentation to facilitate the operation, maintenance, and repair of the instrument.

10.1.1 User's Manual

WFMOS-RQ-111-02: The Users Manual shall be written to enable a new user of WFMOS to easily get acquainted with the operation of the instrument.

10.1.2 Service and Calibration Manual

WFMOS-RQ-111-03: A manual shall be written to enable technical support personnel to maintain WFMOS. This manual shall include documentation to describe the observations required to allow spectral and spatial calibration of WFMOS data, and to calibrate the astrometric precision of the fibre positioner.

10.1.3 12.1.3 Software Maintenance Manual

WFMOS-RQ-111-04: A Software Maintenance manual shall be provided to enable software maintenance staff to maintain the WFMOS software.

10.1.4 As-Built Drawings

WFMOS-RQ-111-05: The as-built drawings shall show all dimensions in millimeters, down to TBD mm. All fasteners specified in these drawings shall be standard metric sizes. All drawings shall otherwise be to standards acceptable to Gemini and Subaru for facility instruments.

10.1.5 Drawing Standards

WFMOS-RQ-111-06: All drawings shall comply with Australian Standard AS1100 or a Gemini/Subaru approved standard.

10.1.6 *Drawing Numbering System*

WFMOS-RQ-111-07: All drawings shall be numbered in accordance with Gemini instructions.

10.1.7 *Drawing Filing System*

WFMOS-RQ-111-08: Drawings will be maintained in electronic format. Final drawings will be converted to PDF format and paper based print-outs will be produced when necessary. A database of drawings will be maintained.

10.2 *Training*

WFMOS-RQ-111-09: The WFMOS development team shall provide training documentation and a training course to Gemini/Subaru operations personnel on the operation, maintenance, and repair of WFMOS.

10.3 *Reliability*

WFMOS-RQ-111-10: WFMOS shall be designed and built to be reliable.

10.3.1 *Downtime*

WFMOS-RQ-111-11: WFMOS will have a downtime of $< 2\%$ scheduled time on the telescope and where possible, component failure shall result in gradual performance degradation.

10.3.2 *Spares*

WFMOS-RQ-111-12: Single point failures that may result in significant downtime shall be determined and, where necessary, critical spares shall be identified.

10.3.3 *Continuous Duty*

WFMOS-RQ-111-13: WFMOS shall be designed and built for continuous operation. Modules containing moving parts, e.g., cryo-cooler cold heads, shall be designed or selected to meet the WFMOS-RQ-111-11 assuming continuous operation.

10.4 *Maintainability and Serviceability*

WFMOS-RQ-111-14: WFMOS shall meet the Gemini requirements for maintainability.

10.4.1 *Standard Components*

WFMOS-RQ-111-15: Wherever possible, WFMOS shall use unmodified commercially available standard components.

10.4.2 *Modularity*

WFMOS-RQ-111-16: To the extent possible, WFMOS shall be designed to be modular.

10.4.3 *Access*

WFMOS-RQ-111-17: Access to components and subassemblies shall be considered in the WFMOS design, particularly for those elements that are accessed frequently. Tool and hand clearances shall be considered, as well as space required to remove modules, visual access to components (or a means to feel their correct position and alignment, e.g., for electronic connectors).

10.4.4 *Alignment*

WFMOS-RQ-111-18: Alignment of optical components shall be achieved to the greatest extent possible by accurate machining of locating fixtures.

10.4.5 *Relative Equipment Arrangements*

WFMOS-RQ-111-19: Equipment shall be located with due consideration of the sequence of operations involved in maintenance procedures. To the greatest extent possible, the most accessible locations shall be reserved for the items requiring most frequent access.

10.4.6 *Subassemblies*

WFMOS-RQ-111-20: Subassemblies of the equipment that require more frequent service (inspection, adjustment, repair, or replacement) shall be configured as plug-in modules or, if in racks, as drawers that can be withdrawn easily.

10.4.7 *Handling*

WFMOS-RQ-111-21: Modules greater than 20 kg in mass shall have suitable handles for use in removing, replacing, and carrying them. Handles shall be located such that the vector sum of resultant handling forces shall pass close to the center of gravity of the unit.

10.4.8 *Revisability*

WFMOS-RQ-111-22: Multilayer electronic boards shall not be used unless they are replaceable as a module. Backplane interconnections between custom boards are discouraged.

10.5 *Lifetime*

WFMOS-RQ-111-23: WFMOS shall be designed for an operational lifetime of 10 yr without a major overhaul. Components likely to affect the lifetime requirement shall be identified.

10.6 *Materials*

10.6.1 *Toxic Products and Formulations*

WFMOS-RQ-111-24: No toxic products and formulations are required for the development, construction, and maintenance of WFMOS.

10.7 *Electromagnetic Radiation*

10.7.1 *Electromagnetic Radiation Generation*

WFMOS-RQ-111-25: WFMOS shall not significantly add to the electromagnetic radiation of its operating environment.

10.7.2 *Susceptibility to Electromagnetic Radiation*

WFMOS-RQ-111-26: WFMOS performance shall not be compromised by the existing electromagnetic radiation of its operating environment.

10.8 *Workmanship*

WFMOS-RQ-111-27: Standard TBD workshop practices shall apply to workmanship in development and construction.

10.9 *Safety*

WFMOS-RQ-111-28: Normal considerations, including compliance with applicable regulations shall apply in the areas of mechanical, electrical, and electrostatic safety.

10.10 *Human Engineering*

WFMOS-RQ-111-29: Human engineering considerations shall apply especially with respect to handling of system items required in readying WFMOS for use on the telescope and its removal after use, and in the design of the user interfaces.

Chapter 11 Appendices

11.1 *List of acronyms*

11.2 *Requirements Tabulation*

End of Chapter do not delete

Chapter 12 References

12.1 *Heading2*

12.1.1 *Heading3*

End of Chapter do not delete