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INSTRUMENTATION DIVISION
ADAPTIVE OPTICS DEPARTMENT

MACAO-VLTI verification matrix.

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I. SCOPE.

This documents presents the system verification matrix of MACAO-VLTI. It can be considered as an appendix of the system design analysis (VLT-TRE-ESO-15600-2067). This matrix for the time being lists the specifications both for the different units and for the system. It will be updated when the component designs, tests or calibrations will be done. Unfortunately, no one can be told what the matrix really is: you have to see it by yourself.

II. APPLICABLE DOCUMENTS.

AD 1	Top level requirements for MACAO-VLTI	VLT-SPE-ESO-15600-2082	1.3
AD 2	MACAO-VLTI Technical specifications	VLT-SPE-ESO-15600-2056	1.0
AD 3	MACAO-VLTI System Overview	VLT-TRE-ESO-15600-2251	1.1
AD 4	MACAO-VLTI System Design Analysis	VLT-TRE-ESO-15600-2067	2.1
AD 5	Software Functional Specifications RTC	VLT-SPE-ESO-15600-2062	1.2
AD 6	MACAO-VLTI Electronics overview	VLT-TRE-ESO-15600-2268	2.0
AD 7	MACAO-VLTI wavefront sensor optics	VLT-TRE-ESO-15600-2273	2.0
AD 8	MACAO-VLTI detailed mechanical design and analysis report of the Coude AO facilities	VLT-TRE-ESO-15600-2274	2.0
AD 9	MACAO-VLTI Observation software – OS Design Description.	VLT-SPE-ESO-15600-2439	1.0
AD 10	Deformable Mirror Technical Specification	VLT-SPE-ESO-15600-2064	1.1
AD 11	MACAO-VLTI Electronics – APD	VLT-TRE-ESO-15600-2269	1.0
AD 12	Technical specification: ESO adaptive optics system: deformable mirror control.	VLT-SPE-ESO-11640-1943	1.0
AD 13	Technical specifications APD counter modules	VLT-SPE-11640-2269	1.0
AD 14	Technical specification and statement of work for the MACAO tip-tilt mount.	VLT-SPE-ESO-11640-2147	1.0
AD 15	Technical Specifications and statement of work for MACAO-VLTI WFS lenslet array.	VLT-SPE-ESO-11640-2146	2.0
AD 16	MACAO-VLTI Technical specification X-Y table	VLT-SPE-ESO-15600-2126	1.0
AD 17	MACAO-VLTI WFS unit: technical specification and statement of work	VLT-SPE-ESO-11640-2189	1.0

AD 18	Tip tilt mount final design report	VLT-TRE-ODP-15600-0002	1.0
AD19	APD log sheet.	Not archived, available STO.	
AD20	Cilas design report	DPC0-00.1630	2.0
AD21	MACAO Technical specifications and SOW for the two micro lenslet array.	VLT-SPE-11640-2460	1.0
AD22	MACAO-VLTI optical derotator specification technical specifications and SOW	VLT-SPE-ESO-15600-2413	1.0
AD23	MACAO Lenslet array unit design report.	VLT-TRE-ESO-11640-2451	1.0
AD24	MACAO Real time computer software design	VLT-SPE-ESO-11640-2353	1.0
AD25	MACAO Instrument control electronic design report	VLT-TRE-ESO-15600-2270	2.0
AD26	Technical report on Electronics DM Control	VLT-TRE-ESO-15600-2271	2.0
AD27	MACAO-VLTI Interface Control Document	VLT-TRE-ESO-15600-2057	2.0
AD28	MACAO-VLTI Assembly, integration and test plan	VLT-TRE-ESO-15600-2241	2.0
AD29	MACAO-VLTI Instrument control software design	VLT-SPE-ESO-15600-2440	1.0
AD30	UT Coude Relay Optics - Design Report	VLT-TRE-SSO-11535-0002	1.0
AD31	VLTI Coude Assemblies - Coude Trains Technical Specification (M4->M8 Mirror Assemblies)	VLT-SPE-ESO-11500-1278	3.0
AD32	UT Coude Relay Optics - Optical Design Report and Allocation Tolerance Budget	VLT-TRE-SSO-11535-0001	1.0
AD33	MACAO APD Counter Module – Design Report	VLT-TRE-SHK-11640-0001	1.0

III. ABBREVIATIONS AND ACRONYMS.

AD	Applicable Document
ADU	Analogue Digital Unit
AIT	Assembly, Integration and Tests
AO	Adaptive Optics
APD	Avalanche Photo Diode
CWFS	Curvature Wavefront Sensor
DM	Deformable Mirror
ESO	European Southern Observatory
FDR	Final Design Review
FOV	Field of View
FWHM	Full Width at Half Maximum
HF	High Frequency
HVA	High Voltage Amplifier.

ICS	Instrument Control Software
ICB	Interface control box
IR	Infrared (1.0-2.2µm)
IRTC	IR Test Camera.
LF	Low Frequency
LCU	Local Control Unit
MACAO	Multiple Applications Curvature Adaptive Optics
MAS	Milli ArcSec.
MM	Membrane Mirror.
MV	Magnitude in Visible.
NA	Not Applicable.
ND	Neutral Density
NDW	Neutral Density Wheel
NGS	Natural Guide Star (a point source < 0.2” in size)
PDR	Preliminary Design Review
PSF	Point Spread Function
PV	Peak To Valley
QE	Quantum efficiency
RTC	Real time computer
SPEC	Specification
STRAP	System for Tip-tilt Removal with Avalanche Photodiodes
TBC	To Be Confirmed
TBCL	To Be Clarified
TBD	To Be Determined
TTM	Tip-Tilt Mount
UT	Unit Telescope (8.2-m diameter)
VLT	Very Large Telescope
VLTI	VLT Interferometer (1 – 13 µm)
WFE	Wavefront error
WFS	Wavefront Sensor
WFSB	Wavefront sensor box
WS	Work Station

IV. TABLE DESCRIPTION.

Basicaly each specification is described by:

- its value and criterions.
- its origin (AO or VLTI specifications).
- the responsible (who should make sure the value meets the specification).
- the premise where the specification is verified.
- the way to check the specification: By design (D), by analysis (A), by tests (T).
- the value obtained.
- the compliance: Compliant (“C”) /Not Compliant (NC)/Partially Compliant (PC)
- the reference of the document where the specification is described.
- the final document where the obtained value is explained.
- the comments.

The system specifications of the table refers directly to the sections of the technical specifications document. The specification description can be not complete in this document because of space requirements. <u>It is then highly recommended to read the verification matrix table together with this document.</u>

V. THE MATRIX.

Specifications		Requested Value	Criterions	Origin	Responsible	Premises	Verif. by: D/A/T	Obtained Value	Compliance	Spec Doc	Final Doc	Comments
MACAO-VLTI Technical Specifications (VLT-SPE-ESO-15600-2056)												
AO module performance												
PERF1	Closed loop Strehl ratio	>50%	m_v=[0,8], T_{exp}=10min, 0.65" seeing, @ 2.2µm, 10m/s wind speed, @ Zenith	VLTI	AO	ESO	A T	59 %	C	AD1-2	AD4	
PERF2	Closed loop Strehl ratio	>25%	m_v=15.5, T_{exp}=10min, 0.65" seeing, @ 2.2µm, 10m/s wind speed, @ Zenith	VLTI	AO	ESO	A T	30%	C	AD1-2	AD4	
PERF3	Closed loop Strehl ratio	>30%	m_v=8, @1"seeing, (0.5 µm), @ 2.2µm, 10m/s wind speed, @ Zenith	VLTI	AO	ESO	A T	39%	C	AD1-2	AD4	
PERF4	Strehl on extended sources	Best effort	For a 2.5" FWHM object including seeing	VLTI	AO	ESO	D T	No value	PC	AD1-2	AD7	
PERF5	Tip-tilt residual	<0.01" rms	On the sky over 1min, m_v=8, 0.65", 10m/s wind speed, @ zenith.	VLTI	AO	ESO	A T	10 mas	PC	AD1-2	AD7	Computed for 20s, and limited by the psf sampling of the simulation (14mas)
PERF6	Piston residual	<25nm rms	over 48msec	VLTI	AO	ESO	A T	19 nm	C	AD1-2	AD4	Measures will be taken to insure the M9 tower to be protected from any vibration.
PERF7	Piston residual	<125nm rms	over 290msec	VLTI	AO	ESO	A T	28 nm	C	AD1-2	AD4	Measures will be taken to insure the M9 tower to be protected from any vibration.
PERF8	Piston residual	<2 µm PV	over 10min	VLTI	AO	ESO	A T	810 nm	C	AD1-2	AD4	Measures will be taken to insure the M9 tower to be protected from any vibration.
System requirements												
SYS1	Can be operated individually from each Coude room and VLTI laboratory.	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD3	
SYS1A	Can function without call of VLTISS and TCS.	Fulfilled	OS has its own graphical user interface	AO	AO	ESO	D	Fulfilled	C	AD2	AD9-29	
SYS1B	Installation of WS in Coude room or Interferometric laboratory	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD3-29	
SYS2	Coordination of 4 modules from a single WS through VLTISS	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD3-29	
SYS2A	VLTISS functionality	Fulfilled		AO	VLTI	ESO	D	Fulfilled	C	AD2	AD29	
SYS3	Acquisition and closed loop on NGS on axis and off axis	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD3	
SYS3A	Capability (hardware) to track the NGS in the FOV	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD3-16	
SYS3B	Capability (software) to track the NGS in the FOV	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD3-9	

SYS4	Chopping capability	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD3	
SYS4A	OS capability to open and pause the loop	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS4B	Chopping	1Hz goal 5Hz	Achievable frequency with M2 -> $m_v \le 16$	VLTI	AO	ESO	A[1] A[2] T	1.4 Hz 5Hz	PC C	AD1-2	AD4 AD4	[1] mv=16, not compliant with goal. [2] mv=10
SYS4B	Chopping	50% Goal is 80%	Duty cycle -> $m_v \le 16$	VLTI	AO	ESO	A[1] A[2] T	64% 50%	PC PC	AD1-2	AD4 AD4	Not compliant with goal Not compliant with goal
SYS5	Maximum Set up time	3 min	Time to lock on a new NGS. Once the GS is within 1.5" of the WFS	VLTI	AO	ESO	A T	3 min	C	AD1-2	AD9	In 2 phases: Preset (<120s) and acquisition (<60)
SYS5A	OS capability to provide an object and a target	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS5B	Time to close the loop on target	320 ms		AO	AO	ESO	T	320ms	C	AD2	AD9	Correspond to the bootstrap phase
SYS6	Capability to accept tip/tilt and defocus offsets	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD3	
SYS6A	Use of FOV acquisition for tip/tilt offsets	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS6B	Opto mechanical displacement that produces focus change.	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS6C	Control of WFS UVW positioning	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS7- Tip and Tilt offset	Range	>+/-1”	On sky	VLTI	AO	ESO	D T	>+/-1”	C	AD1	AD18	
	Resolution	<2 mas	On sky	VLTI	AO	ESO	D T	2 mas	C	AD1-2	AD18	
	Repeatability	<3 mas rms	On sky	VLTI	AO	ESO	D T	2 mas rms	C	AD1-2	AD18	Test will confirm that repeatability and accuracy have such values.
	Cross coupling with focus	<+/-10nm		VLTI	AO	ESO	D T	<<1nm	C	AD1-2	AD18	Given the mechanical tolerances specified to avoid piston.
	Absolute accuracy	<+/-10 mas	On sky	VLTI	AO	ESO	D T	6 mas rms	C	AD1-2	AD18	Test will confirm that repeatability and accuracy have such values.
	Time response (time/step)	<1 sec/0.1”	On sky	VLTI	AO	ESO	D T	>0.1”/s	C	AD1-2	AD18	Given the tip tilt mount transfer function
SYS7- Focus offset	Resolution	<5nm	WFE PTV	VLTI	AO	ESO	D	<<1 nm	C	AD1-2	AD25	Based on MM translation stage resolution
	Range	>+/-100nm	WFE PTV	VLTI	AO	ESO	D T	+/- 1.5 µm	C	AD1-2	AD25	Based on MM translation stage range motion
	Repeatability	<+/-10nm	WFE PTV	VLTI	AO	ESO	T	0.06 nm rms	C	AD1-2	AD25	verified by testing the membrane focus stage
	Absolute accuracy	<+/-10nm	WFE PTV	VLTI	AO	ESO	T	0.06 nm rms	C	AD1-2	AD25	verified by testing the membrane focus stage
	Cross coupling	<+/-10mas <+/-10nm <+/-10nm <+/-10nm	Tip tilt WFE PTV Decentering coma WFE PTV 3rd order spherical aberration WFE PTV 3rd order astigmatism	VLTI	AO	ESO	T T T T	TBC		AD1-2		verified by testing
	Time response (time/step)	<1 sec/20nm	WFE PTV	VLTI	AO	ESO	T	10 nm/sec	NC	AD1-2	AD25	Based on the MM translation stage speed
SYS8	Diagnostic capabilities	Fulfilled	Average seeing, coherence time, flux, Strehl, FWHM	VLTI	AO	ESO	D	Fulfilled	C	AD1-2		Based on Onera study.
SYS8A	Provision to CPU must be kept	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	

SYS8B	Sampling rate	1Hz		VLTI	AO	ESO	D	1Hz	PC	AD2	AD24	It should be noted that at this rate seeing and coherence time are meaningless.
SYS8C	Basic parameters to provide	Fulfilled	Command vector, curvature measurements vector, integration time, gain, APD count rates	AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS9	Calibration data provided during closed loop.	Fulfilled	Average and rms of piston removed, tip/tilt, defocus, and high order WFE measurements.	VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD24	
SYS9A	Provide running average of tip/tilt and defocus	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS9B	Provide running average and Std of quadratic sum of WFE higher than defocus	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS9C	Time stamp provided for each data	0.01 sec	Corresponding to [time(start)+time(stop)]/2	AO	AO	ESO	D	0.01s	C	AD2	AD24	
SYS9D	Delay to send results to VLTISS	10s	Starting from the STOP command	AO	AO	ESO	D	10s	C	AD2	AD24	
SYS10	The instrument can be operated by a trained telescope operator.	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD9	
SYS10A	MACAO controlled by a single WS	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS10B	Basic training, and minimum number of parameters to set up	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS11	High order offset modes capability	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD24	
SYS11A	Range	>50nm	WFE PTV	VLTI	AO	ESO	D T	>50nm	C	AD1-2	AD20	DM has enough stroke to provide such offsets.
SYS11A	Resolution	<5nm	WFE PTV	VLTI	AO	ESO	T	TBC		AD1-2		verified by testing
SYS11A	Absolute accuracy	<10nm	WFE PTV	VLTI	AO	ESO	T	TBC		AD1-2		verified by testing
SYS11A	Cross coupling	<+/-10mas <+/-10nm <+/-10nm <+/-10nm	Tip tilt WFE PTV Decentering coma WFE PTV 3rd order spherical aberration WFE PTV 3rd order astigmatism	VLTI	AO	ESO	T T T T	TBC		AD1-2		verified by testing
SYS11A	Time response (time/step)	<1 sec/20nm	WFE PTV	VLTI	AO	ESO	D	<1sec/20nm	C	AD1-2	AD20	@ 350Hz, response.
SYS11B	Offset must be subtracted from command space	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS11C	Provide DM control modes	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS11D	# of high order modes provided	11		AO	AO	ESO	D	>11	C	AD2	AD24	
SYS12	MACAO shall have test and maintenance	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD27-2	AD3	
SYS12A	OS can run in a stand alone config. Without VLTISS and/or TCS	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD9	
SYS13	Compatibility with VLTI beacon	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	/	Implemented protection filter in MACAO
SYS14	Internal closed loop optimization scheme	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS14A	Provision kept in term of CPU usage for calculation	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS14B	Performed without opening of the loop, and during 2 cycles max (CO frozen)	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
SYS14C	Parameters to optimise	Fulfilled	Main loop gain, mode gains, integration time	AO	AO	ESO	D	Fulfilled	C	AD2	AD24	

Optical Specifications												
OPT1	Wavelength range of corrected beam	[1.5,2.5] µm		VLTI	AO	ESO	D	[1.5,2.5] µm	C	AD2-27	AD3	
OPT2	MACAO must be located behind M9	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD2-27	AD3	
OPT2A	Focal plane position	5540 mm	Below M8	VLTI	VLTI	ESO	D T	5540 mm	C	AD2-27	AD30-31	
OPT2B	Focal ratio	F/47.6	After telecentricity lens	VLTI	VLTI	ESO	D T	F/47.6	C	AD2-27	AD30-31	
OPT2C	Beam Field of View	>+/-1’		VLTI	VLTI	ESO	D T	+/-1’	C	AD2-27	AD30-31	
OPT2D	Beam incidence angle	5 arcmin	With respect to vertical	VLTI	VLTI	ESO	D T	5 arcmin	C	AD2-27	AD30-31	
OPT2E	Global transmission at Coude Focus	35%	@ [0.4,0.7] µm, through M9	VLTI	VLTI	ESO	D T	35%	C	AD2-27	AD4-32	Tested by VLTI
OPT2E	Global transmission at Coude Focus	23%	@ [0.7,0.8] µm, through M9	VLTI	VLTI	ESO	D T	23%	C	AD2-27	AD4-32	Tested by VLTI
OPT2E	Global transmission at Coude Focus	13%	@ [0.8, 0.9] µm, through M9	VLTI	VLTI	ESO	D T	13%	C	AD2-27	AD4-32	Tested by VLTI
OPT2E	Global transmission at Coude Focus	2%	Above 2.2 µm, through M9	VLTI	VLTI	ESO	D T	2%	C	AD2-27	AD4-32	Tested by VLTI
OPT2F	WFE after M9 in transmission	<35 nm rms	In the band of [0.45, 1] µm	VLTI	VLTI	ESO	T	TBC		AD2-27	AD32	Tested by VLTI
OPT2F	Static aberrations at Coude focus	200 nm rms	For LF (active optics residuals)	VLTI	VLTI	ESO	T	TBC		AD2-27	AD31	Tested by VLTI and AO
OPT2F	Static aberrations at Coude focus	55 nm rms	HF: above mode 16^{th}	VLTI	VLTI	ESO	T	TBC		AD2-27	AD31	Tested by VLTI and AO
OPT2F	Static aberrations at Coude focus	500 nm PTV	LF : below mode 40^{th}	VLTI	VLTI	ESO	T	TBC		AD2-27	AD31	Tested by VLTI and AO
OPT2F	Static aberrations at Coude focus	70 nm rms	HF above mode 40^{th}	VLTI	VLTI	ESO	T	TBC		AD2-27	AD31	Tested by VLTI and AO
OPT3	M8 must be coated with protected silver	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD1-2	AD20	
OPT4	Diff. Phase retardation of polar. States between two DM .	<2 deg	for 13>λ>1.5 µm @ 13.26 deg	VLTI	AO	SUP	D T	<1.8 deg	C	AD1-2	AD20	Assuming maximum +/-5% thickness difference between DMs
OPT5	DM flatness capability	Fulfilled		VLTI	AO	SUP	D	Fulfilled	C	AD1-2	AD20	
OPT5A	Provide mean of measuring offset voltage	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD24	
OPT5B	DM Flatness including creep.	<120nm rms	over 5min @ best flat	VLTI	AO	ESO	A T	36 nm rms	C	AD1	AD20	The mirror must be driven for a few sample before setting to flat so as to avoid creep effect
OPT6- Acquisition accuracy	Resolution	<2 mas	On sky, (i.e <160 mas on TTM)	VLTI	AO	ESO	D	0.5 mas	C	AD1	AD25	
OPT6A	Repeatability on 2” central FOV	<3 mas rms	On sky, over a night. (i.e <240mas on TTM)	VLTI	AO	ESO	D T	3 mas rms	C	AD1	AD8	Directly linked to XY table performances
OPT6B	Repeatability on the whole FOV	<10 mas rms	On sky, over 2h, (i.e <800 mas on TTM)	VLTI	AO	ESO	D T	10 mas rms	C	AD1	AD8	Directly linked to XY table performances
OPT6C	Absolute accuracy	<+/-100 mas	On sky (i.e < 8arcsec on TTM)	VLTI	AO	ESO	D T	<+/-100 mas	C	AD1	AD8	Directly linked to XY table performances
OPT6D	Telescope pointing accuracy at Coude	1.5” rms	On sky (i.e 120 ArcSec on TTM)	VLTI	VLTI	ESO	T	TBC		AD27		Tested by VLTI
OPT6E	Telescope related tilt error @ Coude	100 mas	On sky, Over 10 min	VLTI	VLTI	ESO	T	TBC		AD27		Tested by VLTI
OPT6F	Telescope related tilt error @ Coude	5mas rms	On sky, over 10 ms	VLTI	VLTI	ESO	T	TBC		AD27		Tested by VLTI
OPT7-Opto mechanical Interface	Opto-mechanical interface shall re-direct the beam in the WFS	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD3	See beam exchanger unit.

OPT7A	Closed loop adaptive correction	Fulfilled	All light to WFS with mirror system	AO	AO	ESO	D	Fulfilled	C	AD2	AD3	See beam exchanger unit.
OPT7B	Acquisition/ Field selection	Fulfilled	All light to TCCD with mirror system, including objective and manual filter	AO	AO	ESO	D	Fulfilled	C	AD2	AD3	See beam exchanger unit.
OPT7C	Tip/Tilt correction only	Fulfilled	All light to Strap with mirror system	AO	AO	ESO	D	Fulfilled	C	AD2	AD3	See beam exchanger unit.
OPT7D	Close loop adaptive correction diagnosis	Fulfilled	Split light between WFS and TCCD with BS (50/50) and manual filter in front of TCCD	AO	AO	ESO	D	Fulfilled	C	AD2	AD3	See beam exchanger unit.
OPT7E	Tip tilt correction diagnosis	Fulfilled	Split light between STRAP and TCCD with BS (50/50) and manual filter in front of TCCD	AO	AO	ESO	D	Fulfilled	C	AD2	AD3	See beam exchanger unit.
OPT8- TCCD objective quality	Encircled energy of image	80%	Within 0.2 ArcSec diameter	VLTI	AO	ESO	D	TBC		AD2-27		
	Strehl ratio	TBC		VLTI	AO	ESO	D	TBC		AD2-27		
	Wavelength range	[450,900]nm		VLTI	AO	ESO	D	[450,900]nm		AD2-27		
Mechanical Specifications												
MEC1- DM specification	DM should replace M8	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD2-27	AD3	
MEC1A	DM optical surface size	>99.71mm		AO	AO	ESO	D	110 mm	C	AD2	AD20	
MEC1B	Beam incidence angle	13.26 deg		AO	AO	ESO	D	13.26 deg	C	AD2	AD3-20	
MEC1C	Position centring	<1mm		AO	AO	ESO	D	<1mm	C	AD2	AD28	
MEC1D	Mismatching tolerance between DM and lenslet array	<140µm		AO	AO	ESO	T	TBC	C	AD2	/	Alignment tool have the required precision to fulfilled the specification
MEC1E	Adjustments on Tip/tilt mount	20”		AO	AO	ESO	D	15” sensitivity	C	AD2	/	Of the reosc mount
MEC2		Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	/	
Electronic Specifications												
ELE1- M8 Power dissipation	Power dissipation by M8	[-10,10W]	In Coude room	VLTI	AO	ESO	A T	<<1 mW	C	AD1	AD20	
	Temperature difference	[-1,+2] deg	Between ambient air and M8 surface	VLTI	AO	ESO	A T	<<1 deg	C	AD1	AD20	
ELE2 - MACAO power dissip.	Power dissipation by MACAO	[-20,10W]	In Coude room	VLTI	AO	ESO	A T	18 Watts	NC	AD1	AD6	Note that most of the dissipated power will be sunk into the mechanical structure and platform. Requested for waiver have been asked for power dissipation. Temperature will verified by testing.
	Temperature difference	[-5,+1] deg	Between ambient air and MACAO	VLTI	AO	ESO	T T	TBC	C	AD1	/	
Software Specifications												
SOF1	Commands from VLTI will go through the VLTI backbone Network and processed by VLTISS	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD2	AD29-27	
SOF2	Commands between MACAO and TCS will be processed by VLTISS	Fulfilled		VLTI	AO	ESO	D	Fulfilled	C	AD2	AD29-27	
SOF3	Reflective memory	Fulfilled	Use of VMIVME-5576 board	AO	AO	ESO	D	Fulfilled	C	AD2	AD29	
SOF4	Reflective memory shall receive WFE at each sampling time	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD29	

SOF5	Commands to VLTI instruments are routed through VLTISS	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD29	
SOF6	List of command (see document)	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD29	
Maintenance &AIT												
AIT1	MACAO shall work in daytime on the Nasmyth artificial source	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD28	This requires the telescope enclosure to be closed to avoid background emission.
AIT2	MACAO will have tools for alignment check of the pupil and focus	Fulfilled		AO	AO	ESO	D	Fulfilled	C	AD2	AD28	Proper tools have been ordered.
Deformable mirror (VLT-SPE-ESO-15600-2064)												
Geometry	Averaged pupil diameter	99.7 mm		AO	SUP	SUP	D	99.7 mm	C	AD10	AD3	
	Mirror diameter	<150 mm		AO	SUP	SUP	D	150 mm	C	AD10	AD20	
	Clear aperture	105 mm		AO	SUP	SUP	D	110 mm	C	AD10	AD20	
	Pupil stretching	1.02808	Ratio between X and Y elliptic pupil	AO	SUP	SUP	D	1.02808	C	AD10	AD20	
Surface Quality:	DM Flatness	<30nm rms	@ best flat	AO	SUP	ESO SUP	T D	~ 10 nm rms	C	AD10	AD20	
	Max WFE	<5nm rms	within 5mm @ any position in pupil	AO	SUP	ESO SUP	T D	<5nm	C	AD10	AD20	
	DIN (surface quality)	3140/7-5/3*0.63; K1*0.025		AO	SUP	SUP	D	Yes	C	AD10	AD20	
	Surface finish/roughness	<3nm rms		AO	SUP	SUP	D	<1.5 nm rms	C	AD10	AD20	
Actuator:	Actuator number	60		AO	SUP	SUP	D	60	C	AD10	AD20	
	Stroke	No Value	Should be sufficient to compensate 1" seeing. piston removal, and 235nm static WFE	AO	SUP	SUP ESO	A T	Sufficient	C	AD10	AD20	
	Useful range	<10%	of actuator stroke @ best flat	AO	SUP	SUP ESO	D T	<10%	C	AD10	AD20	
	Drive voltage range	+/- 400 V		AO	SUP	SUP	D	+/- 400 V	C	AD10	AD20	
	Pattern accuracy	<+-0.1mm	Goal is +-0.05mm	AO	SUP	SUP	D	<+/- 0.1 mm	C	AD10	AD20	Based on supplier manufacturing precision.
Optical properties:	Reflectivity	R>97%	@[450,1000] nm @ 13.26 deg	AO	SUP	ESO SUP	T D	>97%	C	AD10	AD20	On witness piece
	Reflectivity	R>98%	@[1000,13000] nm @ 13.26 deg	AO	SUP	ESO SUP	T D	>98%	C	AD10	AD20	On witness piece up to 4µm
	Coating quality	Mil-C-13508		AO	SUP	SUP	D	Mil-C-13508	C	AD10	AD20	
	Coating quality	DIN 58197		AO	SUP	SUP	T	DIN 58197	C	AD10	AD20	
	Polarisation states	<2 deg	for 13>λ>1.5 µm @ 13.26 deg	VLTI	AO	SUP	A	<1.8 deg	C	AD1	AD20	Assuming maximum +/-5% thickness difference.
Non linear effects:	Hysteresis	7%	Goal is 5%	AO	SUP	ESO SUP	T D	5 to 6%	C	AD10	AD20	
	Creep effect	<100nm rms	drift over 10min for DM flat vector	AO	SUP	ESO SUP	T D	30 nm rms WFE	C	AD10	AD20	Need the mirror to be driven in closed loop for a few sample, on flat WF.
Transfer function	Phase lag	<15 deg	@ 350Hz (goal is 500Hz)	AO	SUP	SUP	A T	<15 deg at 560Hz	C	AD10	AD20	

	Lowest Resonance Frequency	>500Hz	Goal is >700Hz	AO	SUP	SUP SUP	A T	691 Hz	C	AD10	AD20	
Mechanical Spec	Diameter of DM + support	<180mm	Goal is 170mm	AO	SUP	SUP	D	180 mm	C	AD10	AD20	
	Gravity center tolerances	+/- 1mm	Distance centre of gravity DM optical surface					+/- 1mm	C	AD10	AD20	
	Reference mark	+/- 0.1mm	Positioning accuracy	AO	SUP	SUP	D	+/- 0.1mm	C	AD10	AD20	Based on supplier manufacturing precision.
	DM forefront interface	Fulfilled	Interface with DM mask	AO	SUP	SUP	D	Fulfilled	C	AD10	AD20	
	DM + mount weight	<750g	Goal is 500g	AO	SUP	ESO SUP	T D	813g	NC	AD10	AD20	Close to specification.
	Interface with TTM	Fulfilled	Compatible with TTM	AO	SUP	SUP ESO	D T	Yes	C	AD10	AD	
Temperature sensor	Temperature monitoring accuracy	+/- 0.1 C	DM temperature	AO	SUP	SUP	D	+/- 0.1 C	C	AD10	AD26	
	Analogue input voltage	+/- 10V		AO	SUP	SUP	D	+/- 10V	C	AD12	AD26	
	Connector type	Mil 8-4		AO	SUP	SUP	D	Mil 8-4	C	AD10	AD26	
	Sensor type	PT100		AO	SUP	SUP	D	PT100	C	AD10	AD26	
Piston Sensor	accuracy	5nm rms	Displacement of the mirror centre	AO	SUP	SUP SUP	D T	2 nm rms	C	AD10	AD26	
	Analogue input voltage	+/- 10V		AO	SUP	SUP	D	+/- 10V	C	AD12	AD26	
	Sampling frequency	500Hz		AO	SUP	SUP	D	Several KHz	C	AD10	AD26	
Electrical interface	Connector type	MIL		AO	SUP	SUP	D	MIL-C 26482 male	C	AD10	AD20	
	Interlock system	Fulfilled		AO	SUP	SUP	D	Yes	C	AD10	AD20	
	Minimum rate	>1200V		AO	SUP	SUP	D	1500V/mm	C	AD10	AD20	
Deformable mirror control electronics (VLT-SPE-ESO-11640-1943)												
HVA channel	Output voltage	+/- 400V	60 channels	AO	SUP	SUP	D	+/- 400V	C	AD12	AD26	
	System overall latency	150 µs		AO	SUP	SUP	D	150 µs	PC	AD12	AD26	Only for small to medium stroke amplitudes
	Electrode Capacity	<10nF		AO	SUP	SUP	A	4.5 to 10.4 nF	C	AD12	AD20	From inner to outer ring electrodes
	Output current	+/- 6mA		AO	SUP	SUP	D	+/- 6mA	C	AD12	AD26	
	Amplifier bandwidth	>2 KHz	@-3dB	AO	SUP	SUP ESO	T T	TBC		AD12		Needs testing
	Output linearity	<0.1%	Over +/- 400V	AO	SUP	SUP ESO	T T	TBC		AD12		Needs testing
	Noise on HV outputs	<100mV PV		AO	SUP	SUP ESO	T T	TBC		AD12		Needs testing
	D/A resolution	14 bit		AO	SUP	SUP	D	14 bit	C	AD12	AD26	
	D/A update rate	>1.5 KHz		AO	SUP	SUP	D	>1.5 KHz	C	AD12	AD26	
Miscellaneous	Integrated high volt. power supply	Fulfilled		AO	SUP	SUP	D	Yes	C	AD12	AD26	
	Telemetry and trouble shooting	RS232link		AO	SUP	SUP	D	Yes	C	AD12	AD6	
	Output characteristic	Output relay	For each output	AO	SUP	SUP	D	Yes	C	AD12	AD6	

APD module (VLT-TRE-ESO-15600-2269)												
Performances	Quantum efficiency	>51%	@550 nm, connectorized (FC connector).	AO	SUP	ESO SUP	T T	63%	C	AD11	AD19	Average over 300 APD, all are above spec.
	Dark current	<250 cts/s		AO	SUP	ESO SUP	T T	<80cts/s 53 cts/s	C C	AD11	AD19	Maximum value measured on few APD. Averaged over 300 APD
	Dead time	50 ns		AO	SUP	SUP	T	44 ns	C	AD11	AD19	Averaged over 300 APD
	Peak power (heat)	<10 watts		AO	SUP	ESO	T	6 Watts	C	AD11	AD11	Maximum of 1.27A @ 5V.
	Linearity correction factor	<1.67		AO	SUP	SUP	T	1.37	C	AD11	AD19	Averaged over 300 APD
	Pulse width	25ns		AO	SUP	SUP	T	27.3 ns	C	AD11	AD19	Averaged over 300 APD
	Supply voltage	5V		AO	SUP	SUP	D	5V	C	AD11	AD11	Also verified in the lab.
	Output count rate before saturation	>10M cts/s		AO	SUP	SUP	T	15Mcts/s counts	C	AD11	AD19	Mean correction factor at 10Mcts/s is 2.11
APD counter module	Minimum number of counter	2×60		AO	SUP	SUP	D	2×60	C	AD13	AD33	
	Input	Single ended or different.	TTL RS 422	AO	SUP	SUP	D	RS 422	C	AD13	AD33	
	Count rate	From DC to 15MHz		AO	SUP	SUP	D	From DC to 40 MHz	C	AD13	AD33	
	Frequency range of sine generator	[1.5,3] kHz		AO	SUP	SUP	D	[1.5,3] kHz	C	AD13	AD33	
	Resolution of sine wave amplitude	>=12bits		AO	SUP	SUP	D	12bits	C	AD13	AD33	
	Resolution of sine wave frequency	<=1Hz		AO	SUP	SUP	D	<=1Hz	C	AD13	AD33	
	Power amplifier bandwidth	500 to 9kHz	@ -3dB	AO	SUP	SUP	D	500 to 9kHz	C	AD13	AD33	
	Maximum output power	=>4W	Into 4 Ohms	AO	SUP	SUP	D	=>4W / 40 ohms	C	AD13	AD33	
	Distortion of power amplifier	<=5%	At max power	AO	SUP	SUP	D	<=5%	C	AD13	AD33	
Tip-tilt mount (VLT-SPE-ESO-11640-2147)												
Transfer function	Bandwidth	[100,400] Hz	@ -3db in local closed loop	AO	SUP	SUP	D T	>100Hz	C	AD14	AD18	
	Phase lag	<-20 degrees	up to 15Hz	AO	SUP	SUP	A T	16 deg at 15Hz	C	AD14	AD18	
Cross talk	Cross talk	<0.5%	up to 15Hz	AO	SUP	SUP	T	TBC	C	AD14	/	
Angular performance	Range	240" PV	(6" on sky)	AO	SUP	SUP	D T	18' PV	C	AD14	AD18	1mm is the actuator stroke range
	Resolution	<40 mas rms	(noise equivalent angle)	AO	SUP	SUP	D T	<40 mas rms	C	AD14	AD18	Given the resolution of the capacitive sensor
	Positioning accuracy for each axis	<+/-40 mas	+/- 1mas on the sky	AO	SUP	SUP	T	<+/-40 mas	C	AD 14	AD18	
Rotation axis	lateral misalignment	<+-0.2mm goal 0.05mm	Between crossing point and surface centre	AO	SUP	SUP	D	+/- 0.1mm	C	AD14	AD18	(goal is +-0.05mm), based on mechanical precision.
	longitudinal misalignment	<+-1mm	Between crossing point and surface centre	AO	SUP	SUP	D	+/- 0.1mm	C	AD14	AD18	based on mechanical precision.
	Maximum tilt acceptable	+/- 0.1 deg	Between DM axis and plane defined by the tip	AO	SUP	SUP	D	+/- 0.1 deg	C	AD14	/	See interface drawing between DM and TTM

			and tilt rotation axis									
Electrical sub-assembly	Input signal (analogue)	+/-10 Volts		AO	SUP	SUP	D T	+/-10 Volts	C	AD14	AD18	
	Inter channel cross talk	<0.1%		AO	SUP	SUP	T	TBC	C	AD14		Will be minimised during integration
	Maximum power dissipation	5W		AO	SUP	SUP	D T	<2mW	C	AD14	AD18	
	Cable length	18m		AO	SUP	SUP	D	18 m	C	AD14	AD18	
TTM + DM dimension	Maximum size	290mm		AO	SUP	SUP	D	287 mm	C	AD14	AD18	
Local closed loop	Functionality	Tuneable		AO	SUP	SUP	D	Yes	C	AD14	AD18	
Position sensor	output voltage	10 Volts		AO	SUP	SUP	D	10 Volts	C	AD14	AD18	
Lenslet Array (VLT-SPE-ESO-11640-2146)												
Global specifications												
Geometry	Spot position	+/- 10µm	Of pupil image on the fiber	AO	SUP	SUP	A	+/- 3µm	C	AD15	AD23	See AD15 for the exact lenslet geometry pattern
	Pupil dimension	14mm		AO	SUP	ESO	D	14mm	C	AD15	AD23	
Fibres	Length	3m		AO	SUP	SUP	D	3m	C	AD15	AD23	
	Core	100 µm		AO	SUP	SUP	D	100 µm	C	AD15	AD23	
	Quantity	60		AO	SUP	SUP	D	60	C	AD15	AD23	
	Cross coupling between 2 fibres	1%		AO	SUP	SUP	T	0%	C	AD15	AD23	Given the tolerances on the spot position
	Type	Silica	multi mode	AO	SUP	SUP	D	Silica	C	AD15	AD23	
	Connector type	FC		AO	SUP	SUP	D	FC	C	AD15	AD23	
Reference mark	Precision positioning	0.1mm	Shall be 0.5 * 0.1 mm	AO	SUP	SUP	D	<0.1mm	C	AD15	AD23	Given the manufacturing precision of supplier
Labelling		Each lenslet		AO	SUP	SUP	D	Yes	C	AD15	AD23	
Temperature		[-10,30]		AO	SUP	SUP	D	[-10,30]	C	AD15	AD23	
Optical properties	FOV	3" on sky		AO	SUP	SUP	D	4.4"	C	AD15	AD7	When membrane mirror is flat
	Overall transmission	T>85%	in [450,950] nm, including fibres	AO	SUP	SUP	A T	86%	C	AD15	AD23	
First lenslet array												
Optical specifications	Radius of curvature	29 mm +/- 0.3 mm		AO	SUP	SUP	D	29 mm	C	AD21	AD7	Given the manufacturing precision of the supplier
	Encircled energy	90%	In 100 micrometer aperture	AO	SUP	SUP	D	TBC	C	AD21		
	Transmission of the lenslet	T>95%	Goal is 97%,, in [450,950] nm	AO	SUP	SUP	D T	T>95%	C	AD21	AD23	
	Reflection	R<1%		AO	SUP	SUP	D T	R<1%	C	AD21	AD23	With Anti reflection coating
	Bottom flatness	< λ/2 nm rms	in [450,950] nm	AO	SUP	SUP	D	< λ/2 nm rms	C	AD21	AD23	Given the manufacturing precision of supplier
	Internal ring flatness	< λ/2 nm rms	R=0.5mm, in [450,950] nm	AO	SUP	SUP	D	< λ/2 nm rms	C	AD21	AD23	Given the manufacturing precision of supplier

	External ring flatness	< λ/2 nm rms	8.75<R,10.5 mm ring, in [450,950] nm	AO	SUP	SUP	D	< λ/2 nm rms	C	AD21	AD23	Given the manufacturing precision of supplier
Geometry	External diameter	21 mm +/- 0.04 mm		AO	SUP	SUP	D T	21 mm	C	AD21	AD7	Given the manufacturing precision of supplier
	Angular tolerance	+/- 0.3 deg	For each lenslet	AO	SUP	SUP	D T	+/- 0.3 deg	C	AD21	AD7	Given the manufacturing precision of supplier
	Radius tolerance	+/- 0.01mm	For each lenslet	AO	SUP	SUP	D T	+/- 0.01mm	C	AD21	AD7	Given the manufacturing precision of supplier
	Vertex position error	<+/-10µm	From the theoretical position given in AD15	AO	SUP	SUP	D T	<+/-10µm	C	AD21	AD7	Given the manufacturing precision of supplier and alignment tolerances
Second lenslet array												
Optical specifications	Radius of curvature	0.75 mm +/-0.02 mm		AO	SUP	SUP	D	0.75 mm	C	AD21	AD7	Given the manufacturing precision of supplier
	Encircled energy	90%	In 20 micrometer aperture	AO	SUP	SUP	D	TBC	C	AD21		
	Transmission of the lenslet	T>93%	Goal is 95%,, in [450,950] nm	AO	SUP	SUP	D T	T>95%	C	AD21	AD7	
	Reflection	R<1%	On both sides	AO	SUP	SUP	D T	R<1%	C	AD21	AD23	Anti reflection coating
Geometry	Lenslet array external diameter	23 mm +/- 0.04 mm		AO	SUP	SUP	D T	23 mm	C	AD21	AD7	Given the manufacturing precision of supplier
	Thickness of the support	1.85 mm +/- 0.01 mm		AO	SUP	SUP	D T	1.85 mm	C	AD21	AD7	Given the manufacturing precision of supplier
	Lenslet diameter	0.7 mm + 0.1 mm		AO	SUP	SUP	D T	0.7 mm	C	AD21	AD7	Given the manufacturing precision of supplier
	Vertex position	<3µm		AO	SUP	SUP	D T	<3µm	C	AD21	AD23	Given the manufacturing precision of supplier and alignment tolerances
Mechanical	Bottom flatness	< λ/2 nm rms	in [450,950] nm	AO	SUP	SUP	D	< λ/2 nm rms	C	AD21	AD23	Given the manufacturing precision of supplier
	Wedge	<5 arcmin		AO	SUP	SUP	D	<5 arcmin	C	AD21	AD23	Given the manufacturing precision of supplier
X-Y Table (VLT-SPE-ESO-15600-2126)												
Positioning	Range	250mm		AO	ESO	ESO	D	250 mm	C	AD16	AD25	
	Absolute accuracy	<+/-100µm	On Central en surrounding areas (1 and 2)	AO	ESO	ESO ESO	D T	<+/-100µm	C	AD16	AD8	Will be tested by ESO
At ESO	Relative accuracy	<+/-12µm	within any 10 mm in surrounding area	AO	ESO	ESO ESO	D T	<+/-12µm	C	AD16	AD8	Will be tested by ESO
	Relative accuracy	<+/-8µm	within any 5 mm in central area	AO	ESO	ESO ESO	D T	<+/-8µm	C	AD16	AD8	Will be tested by ESO
	Bi-directional repeatability	+/- 30µm	Central and surrounding areas	AO	ESO	ESO ESO	D T	+/- 30µm	C	AD16	AD8	Will be tested by ESO
	Bi-directional repeatability	+/- 10 µm	Within 4 mm in central and surrounding areas	AO	ESO	ESO ESO	D T	+/- 10 µm	C	AD16	AD8	Will be tested by ESO
	Max relative tilt of the WFSB axis	+/-15" goal is 10"	Central and surrounding areas	AO	ESO	ESO ESO	D T	+/-15"	C	AD16	AD8	Will be tested by ESO
	Maximum tilt of the WFSB	+/-5"	over any 10mm (differential) in central and surrounding areas	AO	ESO	ESO ESO	D T	+/-5"	C	AD16	AD8	Will be tested by ESO
	Resolution	50 nm		AO	ESO	ESO	D	50 nm	C	AD16	AD25	4 ELECT HH + 10 elect ESO

	home repeatability	<40µm		AO	ESO	ESO ESO	D T	+/- 2µm	C	AD16	AD8	Tested at ESO
Speed	Maximum speed	>2mm/sec		AO	ESO	ESO ESO	D	>2mm/sec	C	AD16	AD25	
	acceleration	$1mm/s^2$		AO	ESO	ESO ESO	D T	$<1mm/s^2$	C	AD16	AD25	
	Tracking speed	Up to 0.025 mm/sec		AO	ESO	ESO ESO	D T	Up to 0.025 mm/sec	C	AD16	AD8	
	Output signal	TTL pulses		AO	ESO	ESO	D	TTL pulses	C	AD16	AD25	After EXE box
Surface temperature	Maximum deviation from ambient air	[-5,1] deg C.		AO	ESO	ESO	T	TBC	C	AD16	/	Compliant with similar motor measured on Coude platform (see analysis doc)
Stiffness	Torsional	$\geq 4.10^6$ Nm/rad	In pitch, yaw and roll	AO	ESO	ESO	D	$2*10^7$ Nm/rad	C	AD16	AD8	
	Axial	$\geq 1.10^6$ N/m		AO	ESO	ESO	D	1.10^7 N/m	C	AD16	AD8	
Interfaces	Mechanical interface	Fulfilled	Compatibility with WFSB	AO	ESO	ESO	D	Fulfilled	C	AD16	AD8	See mechanical interface drawing
	Controller	Fulfilled	Compatibility with ESO motion control sys.	AO	ESO	ESO	D	Fulfilled	C	AD16	AD25	
Motors	Type	DC motor		AO	ESO	ESO	D	DC	C	AD16	AD25	
Wavefront sensor optics (VLT-SPE-ESO-15600-2273)												
General specifications	Effective focal length	654 mm		AO	SUP	ESO	D	654 mm	C	AD7	AD7	
	Exit pupil diameter	14 mm		AO	ESO	ESO	D	14 mm	C	AD7	AD7	
	Global WFS transmission	73%		AO	ESO	ESO	D T	73%	C	/	AD7-23	
	WFE in pupil plane	130 nm rms	Tip, tilt, focus removed	AO	ESO	ESO	D T	130nm rms	C	/	AD7	
Membrane mirror	Cavity frequency	2.1 KHz +/- 0.1 KHz		AO	SUP	ESO	D	2.1 KHz	C	AD2	AD7	
	Minimum radius of curvature	+/- 500 mm		AO	SUP	ESO	D	+/- 500 mm	C	AD2	AD7	
	Clear aperture	10 mm		AO	SUP	ESO	D	10mm	C	AD2	/	