Appendix 8. Optical design – criteria and merit function

	Requirement / characteristic	Weight (1-5)	Remarks
	Diffraction-limited FOV	5	Min. 1 arc minute in the visible.
	Total field of view	5	Min. 8 arc minutes.
	Optical quality at edge of field of view	3	Must be seeing-limited.
	Field curvature	3	Convex in the direction of light propagation preferred.
	Focal ratio	3	Optimal range f/6-f/7.
	Maximum monolithic mirror diameter	5	Maximum allowable is 8.3-m.
	Emissivity (number of surfaces)	5	May be alleviated by high performance coatings.
	Sensitivity to M1-M2 decenters	5	Includes image motion and decentering aberrations.
	Sensitivity to M1-M2 axial despace	5	
	Sensitivity to decenters of M3, M4, …	3	Lower weight than for M1-M2 decenters because of (presumed) higher local stiffness.
	Sensitivity to axial despace of M3, M4, …	3	Idem.
	Central obscuration	3	
	Vignetting in the science field	5	
	Vignetting outside the science field	2	Relevant for wavefront sensing; generous tolerances if several references & wavefront sensors available.
	M1-M2 separation	5	Ideally ≤ aperture diameter
	Structure aspect ratio	4	Ideal structure is (presumably) a cone with 60 degrees angle.
	Built-in IR adaptive optics (SCAO & GLAO)	5	
	Built-in IR MCAO	5	
	Separation of active and adaptive functions in different units (correctors)	5	Large amplitude, low temporal frequency (Active Optics) would over-constrain the adaptive mirror technology.
	SCAO / GLAO mirror dimensions	5	Assumed optimum ~2-3m.
	MCAO mirror(s) dimensions	5	Assumed optimum ~2-3m.
	Intermediate focus for AO calibration	2	On-sky calibration is an alternative, albeit an undesirable one.
	Number of segmented mirrors	4	
	Feasibility of secondary mirror	5	Includes test set-up feasibility.
	Difficulty of fabricating most aspheric mirror(s)	4	
	Compatibility with serial production & maintenance of segments	5	
	Segments optical testing	4	Ideally against one unique reference.
	Compatibility with lightweight segments	3	
	Baffling options	2	
	Allowable design volume for active/adaptive units	2	
	Allowable design volume for instruments	3	

	Requirement / characteristic	Weight (1-5)	Remarks
	Access to gravity-stable platform(s)	3	For critical instrumentation.
	Rapid switch between permanently mounted instruments possible	2	For minimum overheads and maximum operational flexibility.

Table A- 4. Function of merit, criteria and relative weights.

	Objective / guideline
1.	Diffraction-limited (Strehl Ratio ≥ 0.80, λ=0.5µm) over at least 1 arc minute FOV.
2.	Field aberrations over the science field (3 arc minutes diameter) shall be axisymmetrical or negligible.
3.	The field of view (diameter) available for adaptive optics wavefront sensing shall be 6 arc minutes.
4.	The design shall provide suitable surfaces for active optics, including deformable mirror(s), active centring, focusing, and field stabilization
5.	Monolithic mirrors shall be less than 8.3m in diameter (useful area).
6.	Field stabilization shall be done in a pupil image
7.	The design shall provide a suitably located surface for single-conjugate IR SCAO and GLAO.

Table A- 5. Mandatory requirements.

	Requirement / characteristic	Ratings
1	Diffraction-limited FOV	0: fails to meet requirements 1: 60 arc seconds diameter 2: 90 arc seconds diameter 3: 120 arc seconds diameter 4: 150 arc seconds diameter 5: 180 arc seconds diameter or more.
2	Total field of view (0.1 arc seconds RMS image quality or unacceptable vignetting, whichever comes first)	0: Less than 6 arc minutes 1: Up to 7 arc minutes 2: Up to 8 arc minutes 3: Up to 9 arc minutes 4: Up to 10 arc minutes 5: Up to 11 arc minutes or more.
3	Optical quality at edge of field of view	0: Larger than 0.2 arc second RMS diameter 1: Up to 0.15 arc second RMS diameter 2: Up to 0.10 arc second RMS diameter 3: Up to 0.08 arc second RMS diameter 4: Up to 0.06 arc second RMS diameter 5: Up to 0.04 arc second RMS diameter
4	Field curvature	0: Up to 1.5-m 1: Up to 2-m 2: Up to 3-m 3: Up to 4-m 4: Up to 6-m 5: 10-m or more NB: subtract one point if concave in the direction of light propagation.
5	Focal ratio	0: Less than f/3 or more than f/10 1: Less than f/4 or more than f/9 2: Less than f/5 or more than f/8 3: Less than f/5.5 or more than f/7.5 4: Less than f/6 or more than f/7 5: Between f/6 and f/7
6	Maximum monolithic mirror diameter	0: Larger than 8.3-m 1: Up to 8.3-m 2: Up to 7.0-m 3: Up to 6.0-m 4: Up to 5.0-m 5: Up to 4.0-m
7	Emissivity (number of surfaces)	0: 9 surfaces or more 1: 8 surfaces

	Requirement / characteristic	Ratings
		2: 7 surfaces 3: 6 surfaces 4: 5 surfaces 5: 4 surfaces
8	Sensitivity to M1-M2 decenters	Qualitative; representative of image motion and decentering aberration induced by gravity load z=0 to z=60 degrees
9	Sensitivity to M1-M2 axial despace	Qualitative; representative of defocus induced by gravity load z=0 to z=60 degrees.
10	Sensitivity to decenters of M3, M4, …	Qualitative; representative of the effect of gravity load from z=0 to z=60 degrees, taking into account combined motion of mirrors.
11	Sensitivity to axial despace of M3, M4, …	Qualitative; representative of defocus induced by gravity load z=0 to z=60 degrees.
12	Central obscuration	0: More than 50% (linear) 1: 40% or more 2: 30% or more 3: 20% or more 4: 10% or more 5: Less than 10%
13	Vignetting in the science field	0: More than 10% (linear) 1: More than 8% 2: More than 6% 3: More than 4% 4: More than 2% 5: Less than 2%
14	Vignetting outside the science field	0: 50% of more 1: More than 40% 2: More than 30% 3: More than 20% 4: More than 10% 5: Up to 10% Add one score point if 3 wavefront sensors, 2 points if 5 or more.
15	M1-M2 separation	0: More than 1.4 x D 1: Up to 1.3 x D 2: Up to 1.2 x D 3: Up to 1.1 x D 4: Up to 1.0 x D 5: Up to 0.9 x D
16	Structure aspect ratio	Qualitative; ideal structure is (presumably) a cone with 60 degrees angle.
17	Built-in IR adaptive optics (SCAO & GLAO)	0 : none or SCAO only (inappropriate conjugate for GLAO) 3: SCAO & some (non-optimal) GLAO capability 5: SCAO & GLAO
18	Built-in IR MCAO	0: No MCAO 3: Two-layers with optimal (~7-9 km) 2nd conjugate 5: Three-layers with optimal conjugates
19	Separation of active and adaptive functions in different units (correctors)	0: No separation 3: Active and adaptive functions with different subsystems 5: Field stabilization, active and adaptive functions with different subsystems.
20	SCAO / GLAO mirror dimensions	0: Less than 1-m or more than 4-m 1: Less than 1.2-m or more than 3.8-m 2: Less than 1.4-m or more than 3.6-m 3: Less than 1.6-m or more than 3.4-m 4: Less than 1.8-m or more than 3.2-m 5: Between 2 and 3-m
21	MCAO mirrors dimensions	0: Less than 1-m or more than 4-m 1: Less than 1.2-m or more than 3.8-m 2: Less than 1.4-m or more than 3.6-m 3: Less than 1.6-m or more than 3.4-m 4: Less than 1.8-m or more than 3.2-m 5: Between 2 and 3-m
22	Intermediate focus for AO calibration	0: None 3: Yes, requires aberrations compensation 5: Yes, does not require aberration compensation
23	Number of segmented mirrors	0: More than two

	Requirement / characteristic	Ratings
		3: Two 5: One
24	Feasibility of secondary mirror	Qualitative; includes test set-up feasibility.
25	Difficulty of fabricating most aspheric mirror(s)	Qualitative; includes test set-up feasibility.
26	Compatibility with serial production & maintenance of segments	Qualitative.
27	Segments optical testing	Qualitative.
28	Compatibility with lightweight segments	0: No; 5: Yes.
29	Baffling options	From 0 (none) to 5 (excellent baffling options)
30	Allowable design volume for active/adaptive units	Qualitative
31	Allowable design volume for instruments	Qualitative
32	Access to gravity-stable platform(s)	5: Coude focus 4: Nasmyth-type focus (foci) 0: None of the above.
33	Rapid switch between permanently mounted instruments possible (without additional relay optics).	5: Yes, 6 instruments or more. 4: Yes, 5 instruments 3: Yes, 4 instruments 2: Yes, 3 instruments 1: Yes, 2 instruments 0: No, only one instrument permanently mounted.

Table A- 6. Merit function; guidelines for ratings.