Top Level requirements

(Presented by R. Gilmozzi)

Science cases requirements

	FOV	Spatial Resolution (arcsec)	Spectral (R)	Wavelength (microns)	Dynamic Range	Target density
Planets and Stars						
Exoplanets						
HIGHLIGHT CASE: Terrestrial planets in habitable zones	~1"x1"	diff. lim. S=0.7-0.9	500-1000	0.6-1.4	10^{10} at 0.03"	~1000 in sky
Giant planets	~1"x1"	0.001-0.002	10-100	0.5-2.5	10^7-10^8	Few x 1000 in sky
Mature Gas-giant planets	few arcsec	diff. lim. high S		1.0-10.0	10^7-10^8	Few x100 in sky
Earth-like moons						
- Reflex velocity			few x10,000			
- Astrometric wobble	very small	diff. lim.		~1.0		
- Spectral detection			>10	1.0 - 5		
- Transits & eclipses				1.0 - 5		
Rings around extra-solar planets	single sources	0.01	100-1000	0.5 - 4	10^7-10^9	
Planets around young stars in the solar neighborhood	few arcsec	0.002	10-100	0.6 -10	10^8	Few x100 in sky
Free-floating planetary-mass objects	1-few arcsec	0.01	10-100	1.0 - 10		100s to 1000s in sky
Our Solar system	up to ~1'x1'	diff. lim.	TBD	Opt - therm-IR		
Stars & circumstellar disks						
Probing birthplaces	up to ~1'x1'	0.002-0.01	up to 100,000	1.0 - 5		Up to 300/sq "
"	"	0.02-0.04	"	10 to 20		"
Structure in inner disks	few arcsec	diff. lim.		2, 10 and 17	10^5 at 0.1"	
Embedded young stellar objects	few arcsec	diff. lim.	~100,000	5.0 - 20		
Jets and outflows		diff. lim.	~100 (NB imaging)	0.5 - 2		
Debris around other stars	3'x3'	diff. lim. (~1", no AO)	350-850		10^2 within 0.5"	All stars within 100pc

(Courtesy Isobel Hook)

	FOV	Spatial Resolution (arcsec)	Spectral (R)	Wavelength (microns)	Dynamic Range	Target density
The lives of massive stars						
Early Phases		as high as possible		NIR & MIR		
Mature phase outflows		diff. lim.		NIR & MIR		
Normal and Peculiar stars	~1"x1"	diff. lim. S~0.9	up to 100,000	0.6 (Ha)		
Asteroseismology	30'	no AO needed	80,000		> few x 10^5	500 per field
Chemical composition : chronometry	30"x30"		30,000-150,000	0.3 - 0.7		
The Death of Stars						
Mass fn of black holes and neutron stars			~1000	NIR		
Isolated neutron stars	single sources		~100	Op		
Black holes in globular clusters	5"	~0.001	~5 and 20,000	Opt and NIR		Crowded fields
Microlenses			~100	1 - 2.5		
Stars and Galaxies						
The Interstellar medium						
Temperature and density probes			10,000 to 10^6	7 to 25		
Fine structure in the ISM						
High redshift	single sources			NIR		
Dust properties via polarimetry						
Heavily extinguished regions						
HIGHLIGHT CASE : Resolved Stellar Populations						
Imaging	5"x5" or larger	diff. lim. (S TBD)	~5	V to K	TBD	Very crowded fields.
Spectroscopy	few arcmin	0.002-0.02	3-8,000 & 20-40,000	V to K		in specific galaxies
Resolved stars in stellar clusters	~2"x2"	0.003	~25	0.4 - 0.6	TBD	Very crowded fields.
Spectral observations of star clusters		few mas	30,000			
The stellar IMF				1.0 - 10		
Extragalactic massive stars beyond the LG	~1'x1'	0.02-0.1	1000 - 10,000	V+R (+IJHK)		few tens / field
Stellar kinematic archaeology	few arcsec	diff. lim.	10,000 -100,000	V to K		many nearby galaxies
The intracluster stellar population	few tens of ″	diff. lim. (S TBD)	~5	NIR (J & K)		few tens / sq"
The cosmic SFR from supernovae	2'x2'	diff. lim. (S=0.5)	~ 5 and ~2,000	NIR (JHK)		4-8 per field per year
Young, massive star clusters	~2'x2'	0.03 - 0.04	> 40,000	>0.8		many nearby galaxies
Black Holes - monsters in Galactic Nuclei	5"x5"	few mas	few x 1000	Opt & NIR		

Science cases requirements

	FOV	Spatial Resolution (arcsec)	Spectral (R)	Wavelength (microns)	Dynamic Range	Target density
Galaxies and Cosmology						
Cosmological Parameters						
Dark Energy						
Type Ia SNe as distance indicators	2'x2'	diff. lim. (S=0.5)	~5 and ~2,000	NIR (JHK)		4-8 / field / year
GRBs as distance indicators	5'x5'		8,000 to 10,000	0.8 - 2.4		single targets
Expansion History						
From primary distance indicators						
CODEX: Cosmic Differential Expansion	single sources	0.2	>100,000 (400,000)	0.4 - 0.7		

HIGHLIGHT CASE: First Light - The First Galaxies and the Ionisation State of the Early Universe						
Galaxies and AGN at the end of reionisation	> 5' x 5'	0.01 - 0.02 50% EED	5,000-10,000			0.2 - 5 / sq'
- most distant sources	> 5' x 5'	0.1 - 0.2 50% EED	few x 100	1.0 - 2.4		"?
Probing the reionisation history	single sources	diff. lim.	1000 - 10,000	JHK		
Early chemical evolution of the IGM	single sources	Any (if imaged sliced)	10,000	0.4 - 0.9		
Evolution of galaxies						
Physics of high redshift galaxies - Req	2' diam.	0.05	5,000	0.5 - 2.5		0.1 to 10 /sq'
" - Goal	10' diam.	0.01 - 0.02	10,000	0.3 - 2.5		"
Assembly of galaxy haloes - Req	2' diam.	0.1	5,000	1 - 2.5		0.1 to 10 /sq'
" - Goal	10' diam.	0.05	10,000	0.7 - 2.5		"
The SFR over the history of Universe a)	3' x 3'	0.1	~5	0.5 - 2.2		few tens /sq'
b)	10' x 10'	0.05	~5	0.3 - 2.2 + FIR		few per unit z / sq'
Fundamental Constants	single sources	< 0.01	300,000	Opt		

Requirements from Science case

- The requirements can be distilled in a small number of broad categories
- Some tradeoffs unavoidable (e.g. FoV)

Specification	Requirement	Minimum	Goal
Telescope size	Maximize > 60m	60m	100m
Wavelength coverage	0.5 – 25 μm	0.7 – 10 μm	0.3 – 850 μm
Field of view	Maximize	> 0.5 arcmin > 1 arcmin	Opt: 2 arcmin IR: 6 arcmin
Image quality	Diffraction limit	S >0.8 (K, SCAO) S >0.4 (V, ExAO) S >0.3 (K, MCAO, 2′×2′)	Highest contrast over FoV & spectral range
Spectral resolution	$100 - 10^5$	$100 - 10^5$	$10 - 10^6$
Throughput	Maximize	m_K > 29.5 in 1 hour	m_K > 30.5 in 1 hour
Emissivity	Minimize	< 10%	< 6%
Site	AO friendly mid and far IR	<seeing> ≤ 0.6″ τ_0 > 3 ms low PVW, > 2500m	<seeing> ≤ 0.5″ τ_0 > 5 ms low PVW, > 4000m

OWL top level requirements

Parameter	Requirement	Goal	Comments
Telescope area	> 6500 m^2	> 7000 m^2	
Wavelength coverage	0.4 to 25 µm	0.30 to > 850 µm	
Image quality (AO)			
SCAO	0.65 Strehl @ K	0.75 Strehl @ K	By telescope in
MCAO	0.40 Strehl @ K	0.50 Strehl @ K	<seeing> = 0.6“
GLAO	3.5× EE gain	5× EE gain	
ExAO	0.90 Strehl @ K	0.96 Strehl @ K	0.40 Strehl @ V
Emissivity	< 15%	< 8%	Protected Ag in Phase A
Field of view	> 6 arcmin	> 10 arcmin	
Throughput (0.55 Š 25 µm)	> 90%	> 92%	Protected Ag in Phase A
Focal stations	> 4	> 6	At least one should be gravity invariant
Sky coverage	1 – 60 degree (ZD)	0.5 – 70	
Operational lifetime	> 30 years	> 40 years	
Technical downtime	< 3%	2%	3 years after start of operations
Operating cost	< 3% per year	2%	Of capital cost. Does not include new instruments
ADC: residual dispersion	0.2 pixel	0.1 pixel	Over any one Johnson band

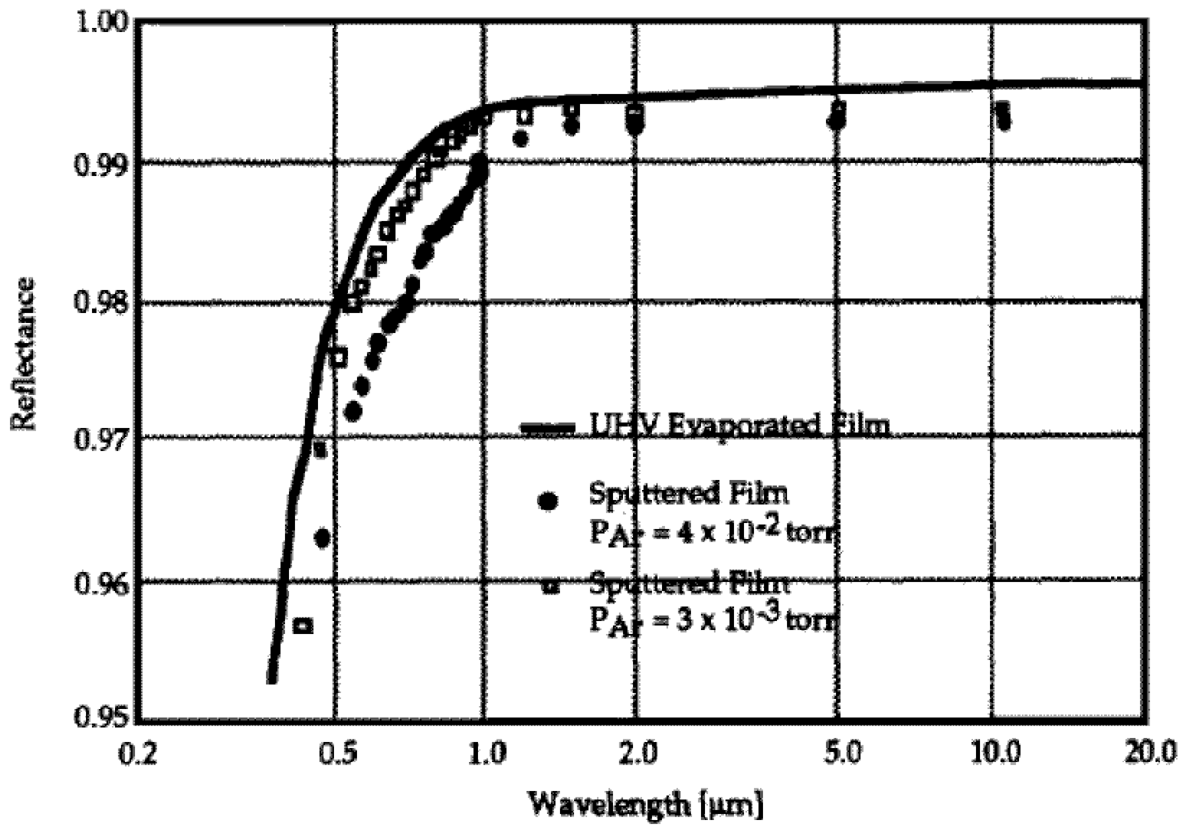
Wavelength range: 0.4-25 (850) μm

- Most science cases require near to mid IR
- Shorter wavelengths required by
  - Spectroscopy of exo-planets, stellar populations (≥ V)
  - Codex (blue, but can work without AO)
- Strong case for synergy with ALMA extends range to sub-mm
  - Sets requirements on site (low PVW, high site?)

	SCOWL (100m)		ALMA	
	850μ m	450μ m	850μ m	450μ m
Flux sensitivity (mJy/Ćsec)	0.3	0.6	1.9	11
Dust mass sensitivity (cf SCUBA-2)	70	170	11	9
Resolution (arcsec)	2.1	1.1	0.02	0.01
Confusion limit (mJy)	0.01	0.005	4e-4	2e-4
Mapping speed (time per square degree to 0.01mJy)	2 days	10 days	7yr	900yr

Coatings: goal 99% per surface @1µm

- Highest possible reflectivity needed
  - To offset large number of reflections
  - To reduce emissivity
- R&D planned in design phase



(Gemini study)

Adaptive Optics

- Image quality a driver requiring most demanding developments
- Many science cases require diffraction limit
- Several cosmology science cases require seeing improvement over a “wide” FoV
- Unlikely to meet TLR at the start
  - Gradual implementation. Great science can be done with limited AO
  - Simulations based on “mild” extrapolations
    - i.e. no assumption that we will have 10^6 actuators any time soon
  - Ample R&D time and resources
  - Roadmap including breadboards, demonstrators, test benches
- However:
  - If at the end of the design phase and of the FP6 studies it does not appear that AO is likely to deliver the performance needed by a 100m telescope, a thorough reassessment of the telescope size and capabilities should be made, quite independently of budget or other considerations

AO requirements

SCAO

Star mag	Seeing	Strehl (J)	Strehl (K)
13.5	0.4	0.45	0.75
	0.6	0.35	0.65
	0.8	0.25	0.55
	1.2	0.10	0.40
15.5	0.4	0.15	0.45
	0.6	0.10	0.35
	0.8	0.05	0.25

MCAO, 2'

Star mag	Seeing (arc secs)	Strehl		
		J	H	K
13.5	0.4	0.20	0.35	0.45
	0.6	0.15	0.30	0.40
	0.8	0.10	0.25	0.35

GLAO, 3'

Star mag	Seeing (arc secs)	EE gain		
		J	H	K
13.5	0.6	2.5	3.0	3.5
	1.2	2.0	2.5	3.0

MOAO, >3'

Star mag	Seeing (arc secs)	EE gain		
		J	H	K
13.5	0.6	40	60	80
	1.2	10	15	20

ExAO

Star mag	Seeing (arc secs)	Strehl Ratio			
		V	J	H	K
< 10	< 0.6	0.40	0.87	0.92	0.96

Ultimate goal: Optical AO

Star mag	Seeing (arc secs)	Strehl Ratio		
		V	R	I
< 10	0.4	0.4	0.5	0.6
	0.6	0.3	0.4	0.5
	0.8	0.2	0.3	0.4

Needs developments in
- Adaptive mirrors (large & micro)
- Laser Guide Stars
- RTCs
- Algorithms

Sky coverage

- Astronomical: depends on latitude of site
  - Accessible fraction of sky larger at lower latitudes
  - Differential displacement due to refraction smaller at higher latitudes (not a problem at poles…)
  - Parameter to be included in site tradeoff analysis

- Operational: $1 \leq ZD \leq 60$
  - Zenith avoidance area may be increased if relaxation of telescope requirements (e.g. kinematics) is desirable

Site selection

- Characterization of sites
  - Multi parameter tradeoffs
    - Atmosphere
    - Meteorology
    - Ground properties
    - Logistics
    - Earthquakes
    - …
  - Same instrumentations
    - To guarantee proper comparisons
- Selection to be made 2-3 years into design phase
  - Optical design (e.g. conjugation of adaptive mirrors)
  - Mechanics (e.g. stiffness to withstand earthquakes)
  - Logistics (e.g. foundations, roads)

Instrumentation

- Fixed, semi-permanently mounted instruments.
  - To achieve the stated scientific goals
  - Some instruments will be general-use observatory facilities; others might be specialized experiments with a well-defined finite life program
- Instruments will be modified, upgraded or replaced at well announced times after an approved program to do so has been executed and documented
- Concept designs will continue to be developed
- Synergy with FP6 studies
- Choice of those to enter Preliminary and Final design to be taken during the telescope Phase B
  - Ample time to develop innovative (e.g. active) approaches
- Iteration with optical design within first 1.5 years of Phase B