KT Matrix Update

Keith Warfield

Jet Propulsion Laboratory, California Institute of Technology

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HabEx

Option B Architecture

- Revisited the Kepner-Tregoe process to help with the Option B decision
- Looked at the Option A architectures with a 48m starshade
- Added three 6.5m and three 3.2m telescope architectures
  - A 48m starshade was included with options requiring a starshade
- Used the original musts, wants, risks and opportunities
  - Kept the original weighting for the wants
- Also looked at weighting more for cost and less in favor of science
  - Used a Science/Schedule/Cost weighting of 50%/10%/40%

Option Descriptions

3	9	10	12	13	14	15	16	17
4.0m w/ SS (UV to NIR) & Coronagraph (Vis/NIR)	4.0m Coronagraph Only Vis/ NIR	4.0m SS Only UV to NIR	6.5m JWST w/ SS	6.0m Active w/ SS	6.5m w/ SS and Coronagraph	3.2m w/ SS	3.2m Coronagraph Only	3.2m Starshade Only
Off-axis; single SLS launch; 300-1800nm Starshade is 48m diameter and does 300-850nm at 80Mm with 62mas IWA, and 1000-1800nm at 40Mm with 124 mas IWA Coronagraph is used primarily for visible detection and starshade for Near UV/VIS/NIR characterization. Coronagraph will enable multiple revisits for verification and possibly orbit determination	Off axis; 450-1800nm only; SLS launch EMCCD and HgCdTe detectors. Multiple bands covered with filters.	On-axis; 300-1800nm , no coronagraph; 2 Falcon H launches; Starshade is 48m diameter and does 300-850nm at 80Mm with 60mas IWA, and 1000-1800nm at 40Mm with 124 mas IWA	on-axis segemented telescope; two Falcon H launches; 300-1800nm Starshade is 48m diameter and does 300-850nm at 80Mm with 62mas IWA, and 1000-1800nm at 40Mm with 124 mas IWA	on-axis actively controlled segmented telescope; two Falcon H launches; 300-1800nm Starshade is 48m diameter and does 300-850nm at 80Mm with 62mas IWA, and 1000-1800nm at 40Mm with 124 mas IWA Primary mirror surface cigure is actively controlled	Off-axis segmented telescope; two SHLLV launches; 300-1800nm Starshade is 48m diameter and does 300-850nm at 80Mm with 62mas IWA, and 1000-1800nm at 40Mm with 124 mas IWA Coronagraph is used primarily for visible detection and starshade for Near UV/VIS/NIR characterization. Coronagraph will enable multiple revisits for verification and possibly orbit determination	Off-axis; single SLS launch but also might be able to launch with two SHLLVs; 300-1800nm Starshade is 48m diameter and does 300-850nm at 80Mm with 62mas IWA, and 1000-1800nm at 40Mm with 124 mas IWA Coronagraph is used primarily for visible detection and starshade for Near UV/VIS/NIR characterization. Coronagraph will enable multiple revisits for verification and possibly orbit	Off-axis; single SLS launch; 300-1800nm Coronagraph is used for both detection and characterization.	on-axis telescope; two Falcon H launches; 300-1800nm Starshade is 48m diameter and does 300-850nm at 80Mm with 62mas IWA, and 1000-1800nm at 40Mm with 124 mas IWA

Musts

		3		9		10		12		13		14		15		16		17	
		4.0m w/ SS (UV to NIR) & Coronagraph (Vis/NIR)		4.0m Coronagraph Only Vis/ NIR		4.0m SS Only UV to NIR		6.5m JWST w/ SS		6.0m Active w/ SS		6.5m w/ SS and Coronagraph		3.2m w/ SS		3.2m Coronagraph Only		3.2m Starshade Only	
MUSTS																			
Science/Technical																			
M1a	Can search for exo-Earths in the HZ of enough nearby single stars to reach a total HZ cumulative completeness greater than 40	66 to 88	Yes	66 to 88 (1 Pol)	Yes	65	Yes												
M3	Can spectrally characterize HZ earth-like planets to R 140 resolution and SNR 10 around at least 10 stellar systems (no orbits)	36	Yes	25	Yes	33	Yes												
M4.1	Can determine the orbits of the best 10 habitable zone planet candidate systems (no spectra)	58	Yes	58	Yes	16	Yes												
M4.3	Can characterize both orbits and spectral properties of HZ planets around at least 1 stellar target	5.0 to 39	Yes	2.7 to 23	Yes	2.2 to 16	Yes												
M7	No more than 3 enabling new technologies (TRL 3 or less)	1	yes	0	Yes	1	Yes	2	yes	2-3	yes	2-3	yes	1	Yes	0	Yes		
Schedule																			
M8	Ready for KDP-A by 2025		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes
Cost																			
M9	Total estimated cost will be less than $7B		Yes		Yes		Yes		No		No		No		Yes		Yes		

Wants – Original Weighting

			3		9		10		12		13		14		15		16		17	
			4.0m w/ SS (UV to NIR) & Coronagraph (Vis/NIR)		4.0m Coronagraph Only Vis/ NIR		4.0m SS Only UV to NIR		6.5m JWST w/ SS		6.0m Active w/ SS		6.5m w/ SS and Coronagraph		3.2m w/ SS and Coronagraph		3.2m Coronagraph Only		3.2m Starshade Only	
WANTS (DISCRIMINATORS)		**100**		**761**		**686**		**720**		**589**		**586**		**678**		**803**		**721**		**#VALUE!**
	Technical	***70***		***653***		***518***		***552***		***544***		***544***		***656***		***635***		***511***		***0***
W0	Measure orbits of all detected planets	4		10		10		5		5		5		10		10		10		
W0b	Maximize the number of orbits measured	5		10	5.8	10		5		5		5		10		10		10		
W4	Maximize spectral characterization of all	4		10		5		10		10		10		10		10		5		
W5	Can spectrally characterize and measure	5		8		5		5		5		5		10		8		5		
W1	Spectrally characterize up to 1800 nm in	3		10		8		10		10		10		10		10		8		
W5i	Planet search capability for binary stars	3		10		5								10		10		5		
W2	Spectrally characterize to 250 nm or	2		10				10		10		10		10		10				
W2a	Spectrally characterize as many planets	2		8				8		8		8		8		8				
W3	Minimize number of new technologies	2	1	8	0	10	1	8		5		5		5		8		10		
W7	Spectrally characterize measure orbits	2		8		5		8		8		8		8		8		5		
W5f	Maximize the outer working angle	2		10		5		10		10		10		10		10		5		
W5g	Maximize the magnitude at which we can	2		8		5		8		10		10		10		5		2		
W5h	Measure the spectrum of the host star in	2		10		10		10		10		10		10		10		10		
W8	*Telescope design allows for more than*	5		10		10		10		10		10		10		8		10		
W9	*Maximize the 5 year mission time*	2		5		5		10		10		10		5		5		5		
W6	Minimize number of launch vehicles	1	1 SLS	10	1 SLS	10	1SLS	10	2 FH	5	2 FH	5		5		10		10		
W16	Graceful descopes	3		8		5		5		5		5		8		8		5		
	Schedule			***80***		***80***		***80***		***50***		***20***		***20***		***80***		***100***		***#VALUE!***
W6b	Reach TRL 5 at earliest possible date	10		8		8		8		5		2		2		8		10		
	Cost			***100***		***160***		***160***		***40***		***40***		***20***		***160***		***200***		***#VALUE!***
W7	Minimize cost	20		5		8		8		2		2		1		8		10		

Wants – Weighting to More Favor Cost

			3		9		10		12		13		14		15		16		17	
			4.0m w/ SS (UV to NIR) & Coronagraph (Vis/NIR)		4.0m Coronagraph Only Vis/ NIR		4.0m SS Only UV to NIR		6.5m JWST w/ SS		6.0m Active w/ SS		6.5m w/ SS and Coronagraph		3.2m w/ SS and Coronagraph		3.2m Coronagraph Only		3.2m Starshade Only	
WANTS (DISCRIMINATORS)		**100**		**761**		**686**		**720**		**589**		**586**		**678**		**803**		**721**		**#VALUE!**
	Technical	***70***		***653***		***518***		***552***		***544***		***544***		***656***		***635***		***511***		***0***
W0	Measure orbits of all detected planets	4		10		10		5		5		5		10		10		10		
W0b	Maximize the number of orbits measured	5		10	5.8	10		5		5		5		10		10		10		
W4	Maximize spectral characterization of all	4		10		5		10		10		10		10		10		5		
W5	Can spectrally characterize and measure	5		8		5		5		5		5		10		8		5		
W1	Spectrally characterize up to 1800 nm in	3		10		8		10		10		10		10		10		8		
W5i	Planet search capability for binary stars	3		10		5								10		10		5		
W2	Spectrally characterize to 250 nm or	2		10				10		10		10		10		10				
W2a	Spectrally characterize as many planets	2		8				8		8		8		8		8				
W3	Minimize number of new technologies	2	1	8	0	10	1	8		5		5		5		8		10		
W7	Spectrally characterize measure orbits	2		8		5		8		8		8		8		8		5		
W5f	Maximize the outer working angle	2		10		5		10		10		10		10		10		5		
W5g	Maximize the magnitude at which we can	2		8		5		8		10		10		10		5		2		
W5h	Measure the spectrum of the host star in	2		10		10		10		10		10		10		10		10		
W8	*Telescope design allows for more than*	5		10		10		10		10		10		10		8		10		
W9	*Maximize the 5 year mission time*	2		5		5		10		10		10		5		5		5		
W6	Minimize number of launch vehicles	1	1 SLS	10	1 SLS	10	1SLS	10	2 FH	5	2 FH	5		5		10		10		
W16	Graceful descopes	3		8		5		5		5		5		8		8		5		
	Schedule			***80***		***80***		***80***		***50***		***20***		***20***		***80***		***100***		***#VALUE!***
W6b	Reach TRL 5 at earliest possible date	10		8		8		8		5		2		2		8		10		
	Cost			***100***		***160***		***160***		***40***		***40***		***20***		***160***		***200***		***#VALUE!***
W7	Minimize cost	20		5		8		8		2		2		1		8		10		

Risks/Opportunities

		3		9		10		12	13	14	15	16	17
		4.0m w/ SS (UV to NIR) & Coronagraph (Vis/NIR)		4.0m Coronagraph Only Vis/ NIR		4.0m SS Only UV to NIR		6.5m JWST w/ SS	6.0m Active w/ SS	6.5m w/ SS and Coronagraph	3.2m w/ SS and Coronagraph	3.2m Coronagraph Only	3.2m Starshade Only
RISKS													
R2	WFIRST starshade captures significant fraction of exoplanet science	Low L	**High C**	Med L	**High C**	Med L	**High C**						
R3	Low eta_earth value (<0.1)	Low L?		Low L?	High C	Low L?							
R5	Confusing planets with one another when measuring orbits	Low L	**High C**	Low L	**High C**	Low L	**High C**						
OPPORTUNITIES													
O2	Precursor / contemporaneous observations with astrometry or radial velocity that is sensitive to potential habitable planet		high		Med C		Best						
O6	Higher performance (better IWA and bandwidth) NIR coronagraph for point sources	L=H	B=M	L=H	B=H	N/A							
O7	Permits faster telescope and better UV instrument design (General astrophysics FOV and throughput)						B=H						
O8	High eta_earth value (>> 0.1)												
O9	Mission lifetime significantly exceeds 5 years	L=H	B=Highest	L=H	B=Highest	L=H	B=low						