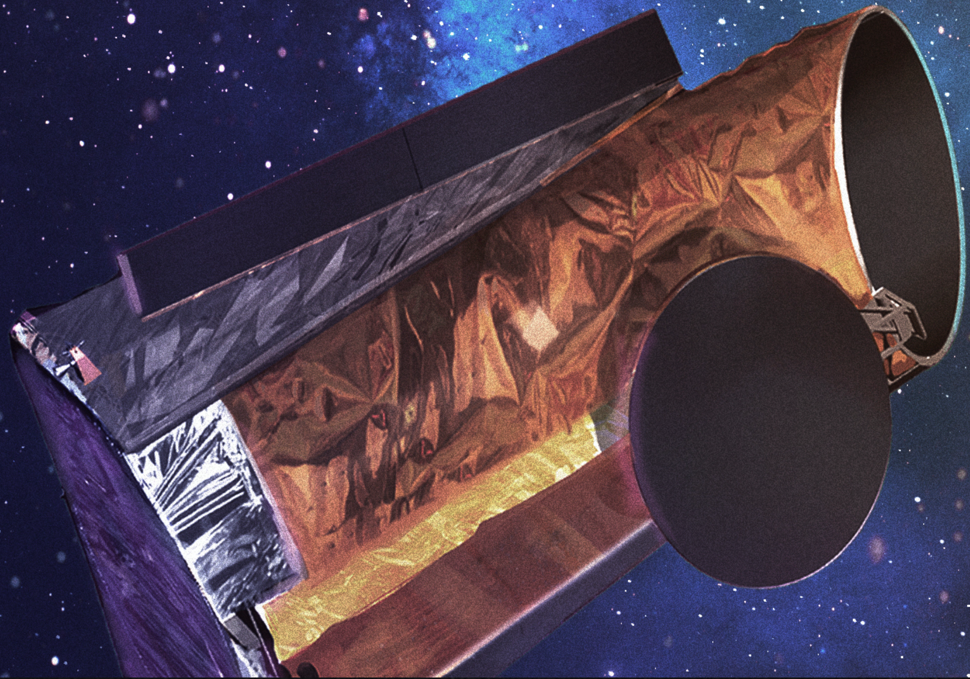
The Habitable Exoplanet Observatory



The Architecture Section

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The Architectures

- The HabEx Final Report will center on a discussion of the possible HabEx architectures
  - We will emphasize the adaptability of HabEx to uncertain future budgets, technology development difficulties and unexpected programmatic changes such as the availability of the SLS
  - All nine options will be discussed at a high level in the Architecture section on the report
- The baseline option and the two selected additional options will be discussed in more technical detail
  - The level of detail is intended to be sufficient to support CATE estimates which will give the Decadal multiple cost and risk reference points within the tradespace and allow them to consider the entire tradespace should they need to do so to find an architecture that fits the available funding.
- This briefing is intended to remind everyone of the 9 architecture options and not to reopen the “Option B” trade decision
  - The descriptions and data have been updated to reflect our current understanding of the option designs
  - Subsequent presentations will review the Exoplanet and GO science estimates

HabEx

Summary

Starlight Suppression System / Telescope Diameter	H (Hybrid)	C (Coronagraph only)	S (Starshade only)
4m	Cost ($B): >5 #TRL3: 1 LV: SLS and SHLLV	Cost ($B): >5 #TRL3: 0 LV: SLS	Cost ($B): >5 #TRL3: 1 LV: 2 SHLLVs
3.2m	Cost ($B): >5 #TRL3: 1 LV: 2 SHLLVs	Cost ($B): < 5 #TRL3: 0 LV: 1 SHLLV	Cost ($B): <5 #TRL3: 1 LV: 2 SHLLVs
2.4m	Cost ($B): <5 #TRL3: 1 LV: 2 SHLLVs	Cost ($B): <5 #TRL3: 0 LV: 1 SHLLV	Cost ($B): <5 #TRL3: 1 LV: 2 SHLLVs

Summary

Starlight Suppression System / Telescope Diameter	H (Hybrid)	C (Coronagraph only)	S (Starshade only)
4m	Cost ($B): >5 #TRL3: 1 LV: SLS and SHLLV **Baseline**	Cost ($B): >5 #TRL3: 0 LV: SLS Other Designs	Cost ($B): >5 #TRL3: 1 LV: 2 SHLLVs
3.2m	Cost ($B): >5 #TRL3: 1 LV: 2 SHLLVs	Cost ($B): < 5 #TRL3: 0 LV: 1 SHLLV	Cost ($B): <5 #TRL3: 1 LV: 2 SHLLVs Other Designs
2.4m	Cost ($B): <5 #TRL3: 1 LV: 2 SHLLVs	Cost ($B): <5 #TRL3: 0 LV: 1 SHLLV	Cost ($B): <5 #TRL3: 1 LV: 2 SHLLVs

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The Baseline

Architecture 4m-H: Hybrid

Metric	Value
Resolution @ 0.4 micron (^{2})	0.025" (6.3×10^{-4} sq. arcsec.)
Effective Area at 200nm	~10^4 cm^2
Starshade Size (tip to tip) and nominal distance	52m @ 77 Mm (300-1000nm spectra); IWA = 70 mas
Cost	>$5B
Number of TRL 3 Enabling Technologies	1
Number of TRL 4 Enabling Technologies	7
Launch Vehicle	SLS and Falcon H

Description

- 4m off-axis F# 2.5 telescope with HST coatings
- SS Camera, coronagraph, HWC, UVS
- 52m starshade
- Microthrusters for pointing control

Cons

- Cost well over $5B target.
- Many low TRL (<TRL 5) technologies.
- Requires SLS Launch Vehicle which may bring some programmatic risk.

Pros

- Some redundancy in exoplanet spectral instruments.
- Hybrid allows orbits, larger OWA, and better spectral characterization.
- Can allow starshade delayed launch for lower funding profile

Architecture 4m-C: Coronagraph Only

Metric	Value
Resolution @ 0.4 micron ([2])	0.025” (1.9x10^{-4} sq. arcsec.)
Effective Area at 200nm	~10^{4} cm^{2}
Starshade Size (tip to tip) and nominal distance	N/A
Cost	>$5B
Number of TRL 3 Enabling Technologies	0
Number of TRL 4 Enabling Technologies	5
Launch Vehicle	SLS

Description

- 4m off-axis F# 2.5 telescope with HST coatings
- Coronagraph, HWC, UVS
- Microthrusters for pointing control

Cons

- Only one exoplanet spectral measurement instrument.
- SLS required
- Many low TRL (<TRL 5) technologies required
- No exoplanet UV spectral characterization.

Pros

- Can make orbit measurements efficiently.

Architecture 4m-S: Starshade Only

Metric	Value
Resolution @ 0.4 micron (2)	0.025” (1.9x10^{-4} sq. arcsec.)
Effective Area at 200nm	~10^{4} cm^{2} (ignoring central obs.)
Starshade Size	52m @ 77 Mm (300-1000nm spectra); IWA = 70 mas 52m @ 115Mm (300-670nm detection); IWA = 47 mas
Cost	>$5B
Number of TRL 3 Enabling Technologies	1
Number of TRL 4 Enabling Technologies	3
Launch Vehicle	2 – SHLLVs

Description

- 4m on-axis F# 1.0 telescope with HST coatings
- SS Camera, HWC, UVS
- 52m starshade
- Microthrusters for pointing control

Cons

- Only one exoplanet spectral instrument.
- Limited orbits information but disambiguation achieved by taking spectra

Pros

- Improves with precursor knowledge and/or serviceability.
- Larger OWA and better spectral characterization.
- Simpler telescope (on-axis, looser stability requirements).

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Architecture 3.2m-H: Hybrid

Metric	Value
Resolution @ 0.4 micron (^{2})	0.031" (1.9x10^{-4} sq. arcsec.)
Effective Area at 200nm	~8 x 10^3 cm^2
Starshade Size (tip to tip) and nominal distance	52m @ 70 Mm (for 300-1000nm spectra) ; IWA = 77 mas
Cost	>$5B
Number of TRL 3 Enabling Technologies	1
Number of TRL 4 Enabling Technologies	7
Launch Vehicle	2 - SHLLVs

Description

- 3.2m off-axis F# 2.5 telescope with HST coatings
- SS Camera, coronagraph, HWC, UVS
- 52m starshade
- Microthrusters for pointing control

Cons

- Cost over $5B target.
- Many low TRL (<TRL 5) technologies.

Pros

- Some redundancy in exoplanet spectral instruments.
- Hybrid allows orbits, larger OWA, and better spectral characterization.
- Can allow starshade delayed launch for lower funding profile

HabEx

Architecture 3.2m-C: Coronagraph Only

Metric	Value
Resolution @ 0.4 micron (^{2})	0.031” (1.9×10^{-4} sq. arcsec.)
Effective Area at 200nm	~8×10^3 cm^2
Starshade Size (tip to tip) and nominal distance	N/A
Cost	<$5B
Number of TRL 3 Enabling Technologies	0
Number of TRL 4 Enabling Technologies	5
Launch Vehicle	1 - SHLLV

Description

- 3.2m off-axis F# 2.5 telescope with HST coatings
- Coronagraph, HWC, UVS
- Microthrusters for pointing control

Cons

- Only one exoplanet spectral instrument
- Many low TRL (<TRL 5) technologies required
- No exoplanet UV spectral characterization.

Pros

- Can make orbit measurements efficiently.

Architecture 3.2m-S: Starshade Only

Metric	Value
Resolution @ 0.4 micron ([2])	0.031” (1.9×10^{-4} sq. arcsec.)
Effective Area at 200nm	$\sim 8 \times 10^{3}$ cm^{2} (ignoring central obs.)
Starshade Size (tip to tip) and nominal distance	52m @ 70 Mm (for 300-1000nm spectra) ; IWA = 77 mas 52m @ 104 Mm (for 300-670 nm detection); IWA = 52 mas
Cost	<$5B
Number of TRL 3 Enabling Technologies	1
Number of TRL 4 Enabling Technologies	3
Launch Vehicle	2 – Vulcan and Falcon H

Description

- 3.2m on-axis F# 1.0 telescope with a segmented primary and HST coatings
- SS Camera, HWC, UVS
- 52m starshade
- Microthrusters for pointing control

Cons

- Only one exoplanet spectral instrument.
- Limited orbits information but disambiguation can be achieved by taking spectra

Pros

- Improves with precursor knowledge and/or serviceability.
- Larger OWA and better spectral characterization.

Architecture 2.4m-H: Hybrid

Metric	Value
Resolution @ 0.4 micron (^{2})	0.04" (1.8x10^{-3} sq. arcsec.)
Effective Area at 200nm	~3.6 x 10^3 cm^2
Starshade Size (tip to tip) and nominal distance	36m @ 36 Mm (spectra); IWA = 104 mas
Cost	<$5B
Number of TRL 3 Enabling Technologies	1
Number of TRL 4 Enabling Technologies	5
Launch Vehicle	2 SHLLVs

Description

- 2.4m off-axis F# 2.5 telescope with a monolithic primary and HST coatings
- SS Camera, coronagraph, HWC, UVS
- 52m starshade
- Microthrusters for pointing control

Cons

- Image problem (2.4m = Hubble = WFIRST).
- Many low TRL (<TRL 5) technologies.

Pros

- Some redundancy in exoplanet spectral instruments.
- Hybrid allows orbits, larger OWA, and better spectral characterization.
- Can allow starshade delayed launch for lower funding profile

Architecture 2.4m-C: Coronagraph Only

Metric	Value
Resolution @ 0.4 micron (^{2})	0.04" ($1.8x10^{-3}$ sq. arcsec.)
Effective Area at 200nm	~$3.6 x 10^3$ cm^2
Starshade Size (tip to tip) and nominal distance	N/A
Cost	<$5B
Number of TRL 3 Enabling Technologies	0
Number of TRL 4 Enabling Technologies	3
Launch Vehicle	SHLLV

Description

- 2.4m off-axis F# 2.5 telescope with HST coatings
- Coronagraph, HWC, UVS
- Microthrusters for pointing control

Cons

- Image problem (2.4m = Hubble = WFIRST).
- Only one exoplanet spectral instrument
- No exoplanet UV spectral characterization.

Pros

- Fewer low TRL (<TRL 5) technologies needed
- Can make orbit measurements efficiently.

Architecture 2.4m-S: Starshade Only

Metric	Value
Resolution @ 0.4 micron (^{2})	0.04” (1.8x10^{-3} sq. arcsec.)
Effective Area at 200nm	~3.6 x 10^{3} cm^{2} (ignoring central obs.)
Starshade Size (tip to tip) and nominal distance	36m @ 36 Mm (0.3-1 mum spectra) IWA = 105 mas 36m @ 54 Mm (0.3-0.67 mum detection); IWA = 70 mas
Cost	<$5B
Number of TRL 3 Enabling Technologies	1
Number of TRL 4 Enabling Technologies	2
Launch Vehicle	2 – SHLLVs

Description

- 2.4m on-axis F# 1.0 telescope with a monolithic primary and HST coatings
- SS Camera, HWC, UVS
- 52m starshade
- Likely could use just reaction wheels without microthrusters

Cons

- Image problem (2.4m = Hubble = WFIRST).
- Only one exoplanet spectral instrument.
- Many low TRL (< TRL5) technologies.
- Limited orbits information but disambiguation can be achieved by taking spectra

Pros

- Improves with precursor knowledge and/or serviceability.
- Larger OWA and better spectral characterization.
- Fewer low TRL (<TRL 5) technologies needed
- Simpler telescope (on-axis, looser stability requirements).