HabEx Concept Architecture and Technology Maturity

Dr. Rhonda Morgan

and the HabEx Design Team

Jet Propulsion Laboratory, California Institute of Technology

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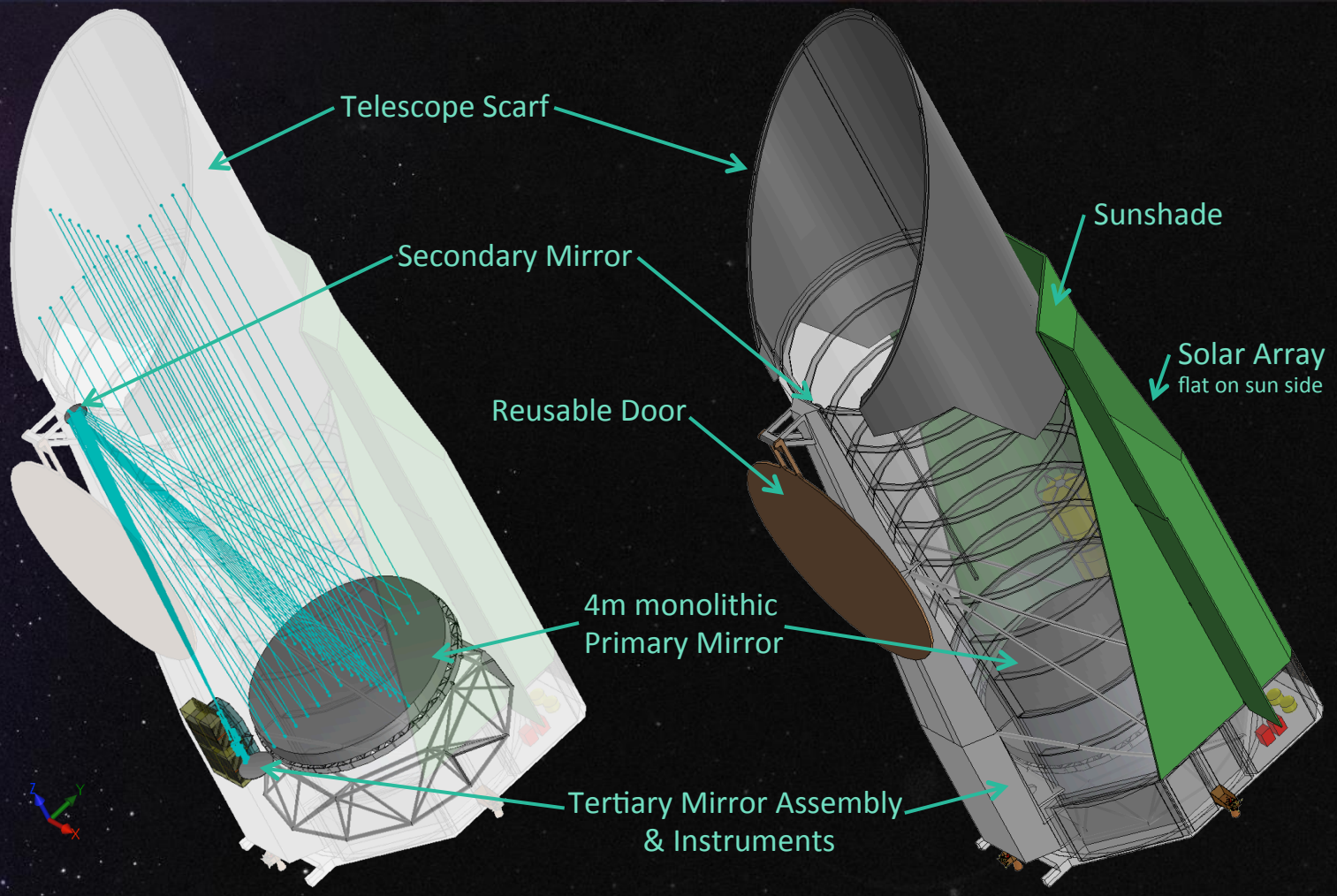
Pre-decisional information -- for planning and discussion purposes only.

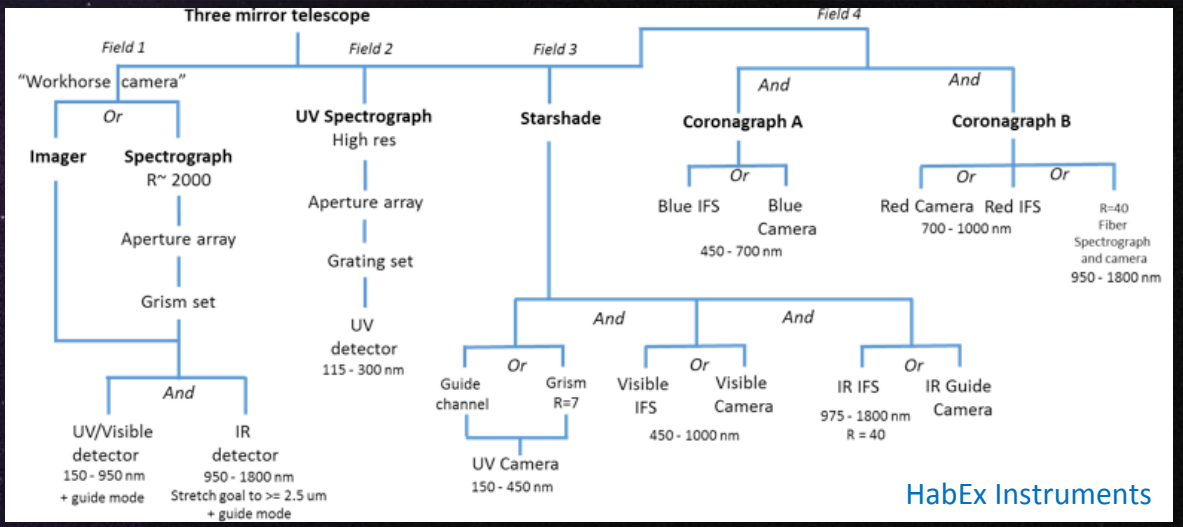
HabEx Baseline Architecture



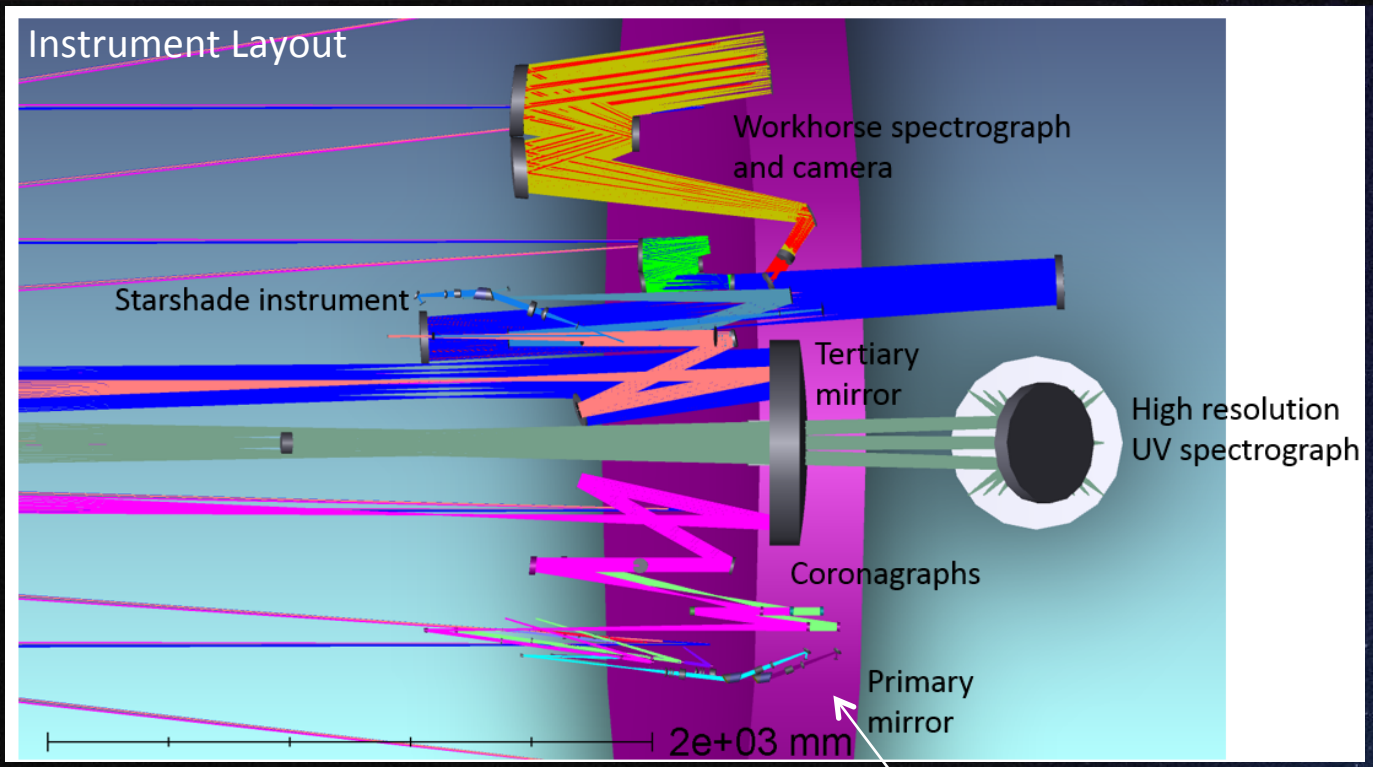
Habitable Exoplanet Imaging Mission	
Mission Duration:	5 years
Orbit:	Earth-Sun L2 Halo orbit
Aperture:	4-meter unobscured
Telescope Architecture:	off-axis, Three Mirror Anastigmat (TMA)
Primary Mirror:	f-number: f/2.5 construction: monolith reflective coating: Al+MgF2
Wavelengths:	115nm – 2500nm (UV, Vis, NIR)
Instruments:	- Coronagraph - Starshade Camera + Starshade Occulter - High-Resolution UV Spectrograph - Multi-purpose, Wide-field Camera & Spectrograph
Starshade	72-meter diameter starshade occulter
Attitude Control System (ACS):	- Fine-Guiding Sensor Instrument - biprop thrusters (slewing) - microthrusters (pointing)
Formation Flying Control System:	- position sensor - local communications
Communications:	phased-array antenna
Serviceability:	- instruments (4) - thrusters - avionics - communications - refueling: telescope + starshade

The 4m monolithic primary TRL of 4 is enabled by microthrusters and the SLS lift capacity.

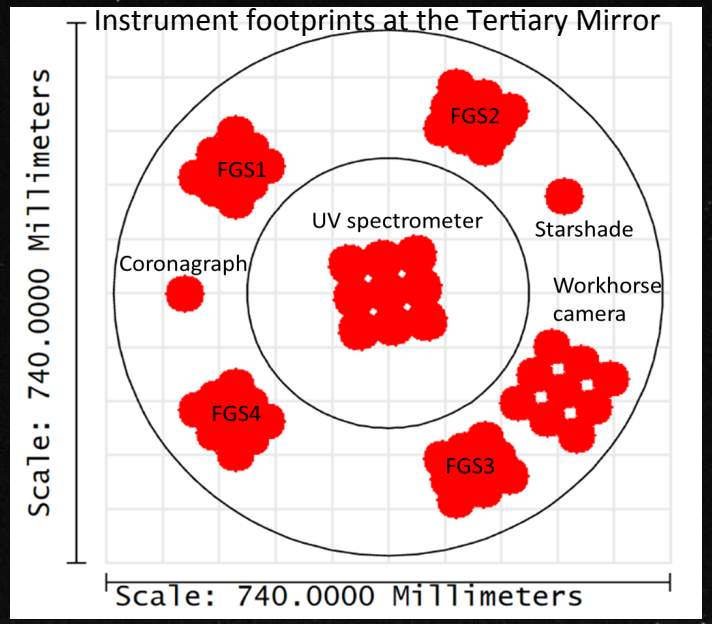
Baseline Instruments



HabEx Instruments



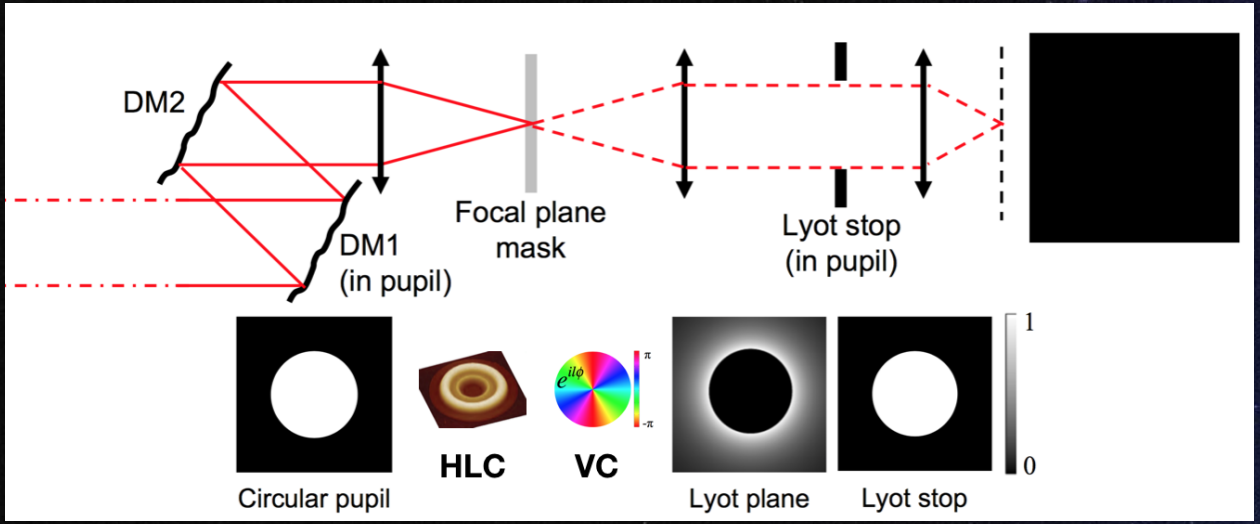
Primary Mirror



Coronagraph

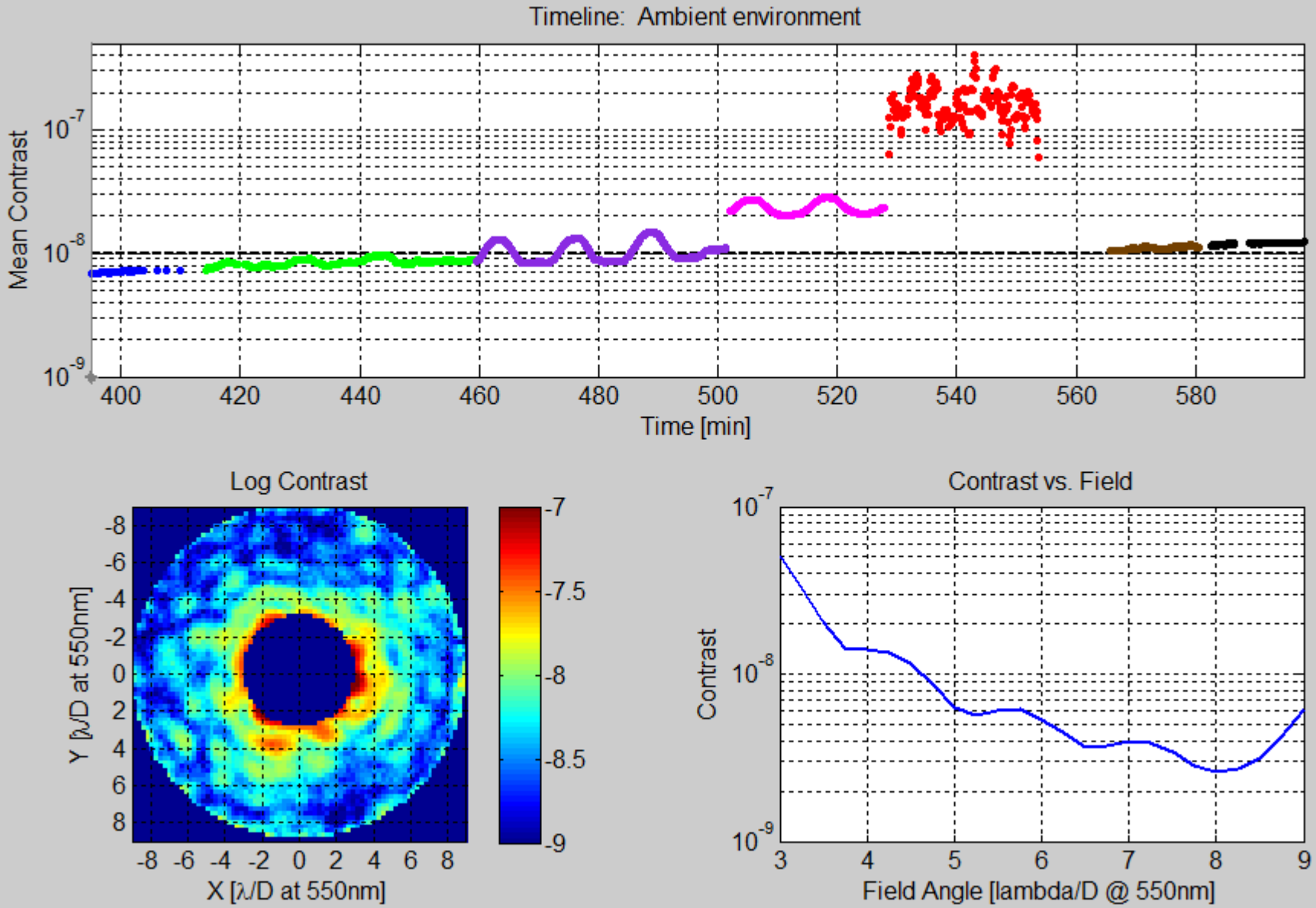
- Requires 10^{-10} raw contrast from 2.4 to 32 λ/D for 20% bandwidth

Coronagraph Instrument	
Purpose:	Exoplanet Search & Characterization
Wavebands:	Blue: 400nm - 672nm Red: 672nm - 1000nm NIR: 950nm - 1800nm
Coronagraph "A"	Blue Channel: - Camera, 2k x 2k EMCCD - IFS, R = 140
Coronagraph "B"	Red Channel: - Camera, 2k x 2k EMCCD - IFS, R = 140 NIR Channel: - Camera, 256x320 LMAPD - Spectrograph (TBD)
Coronagraph Type:	Vector Vortex and/or Hybrid-Lyot (TBD)
Inner Working Angle (IWA):	2.4 λ/D (56mas, 83mas, 117mas)
Outer Working Angle (OWA):	0.74asec, 1.11asec, 1.57asec
Starlight Suppressioin Raw Contrast:	$\leq 10^{-10}$
Deformable Mirror:	64x64 0.4-mm pitch
Wavefront Control subsystem:	Low-Order Wavefront Sensor (LOWFS) Fine Steering Mirror (FSM)



The ExEP Decadal Studies Testbed (DST) strives to achieve 10^{-10} raw contrast for an unobscured aperture.

LOWFS/C



- Low Order Wavefront Sensing and Control (LOWFS/C) demonstrated in testbed for WFIRST with jitter and focus input disturbance.
- The HabEx jitter environment is much more benign due to microthrusters.

HabEx DMs and visible detectors

- Boston Micromachines Corp (BMC) Deformable Mirrors (DMs)
  - 0.5 mm pitch
  - Micro Electrical Mechanical System (MEMS)
  - 64 x 64 actuators (4096 actuators)
- Under test in the DST
- Environmental testing in progress (TDEM)
- Phase 2 SBIR to improve residual WFE

Image courtesy BMC

- Visible detectors are EM-CCDs
  - CCD201: 1024 pixels for cameras
  - CCD282: 2048 pixels for coro. IFS
  - CCD282: 4096 pixels for Starshade IFS
- WFIRST-CGI lab results for dark current meet HabEx requirements
- WFIRST-CGI EMCCD requirements meet HabEx needs

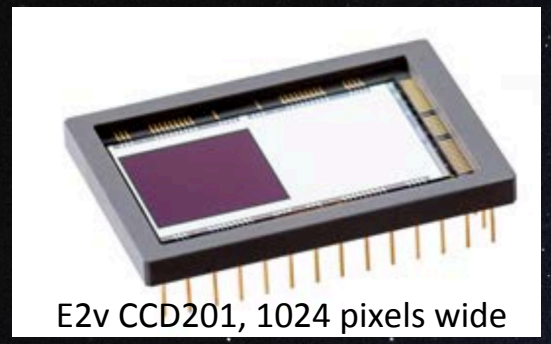
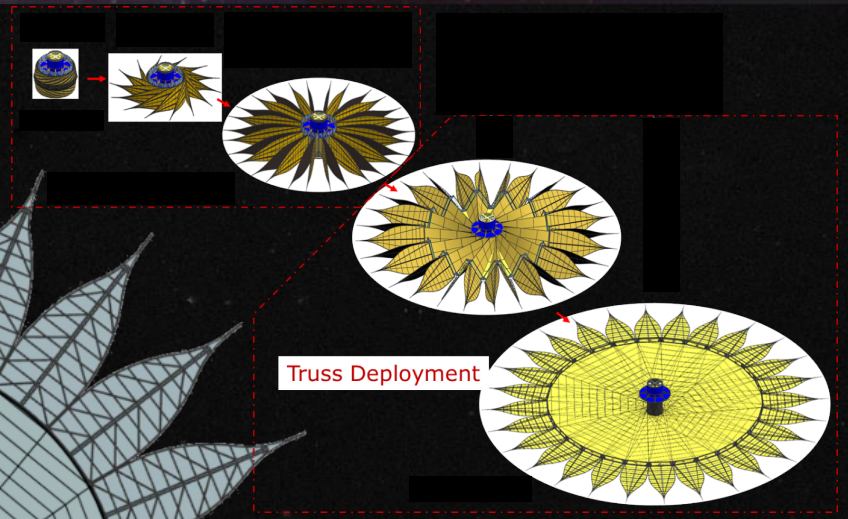
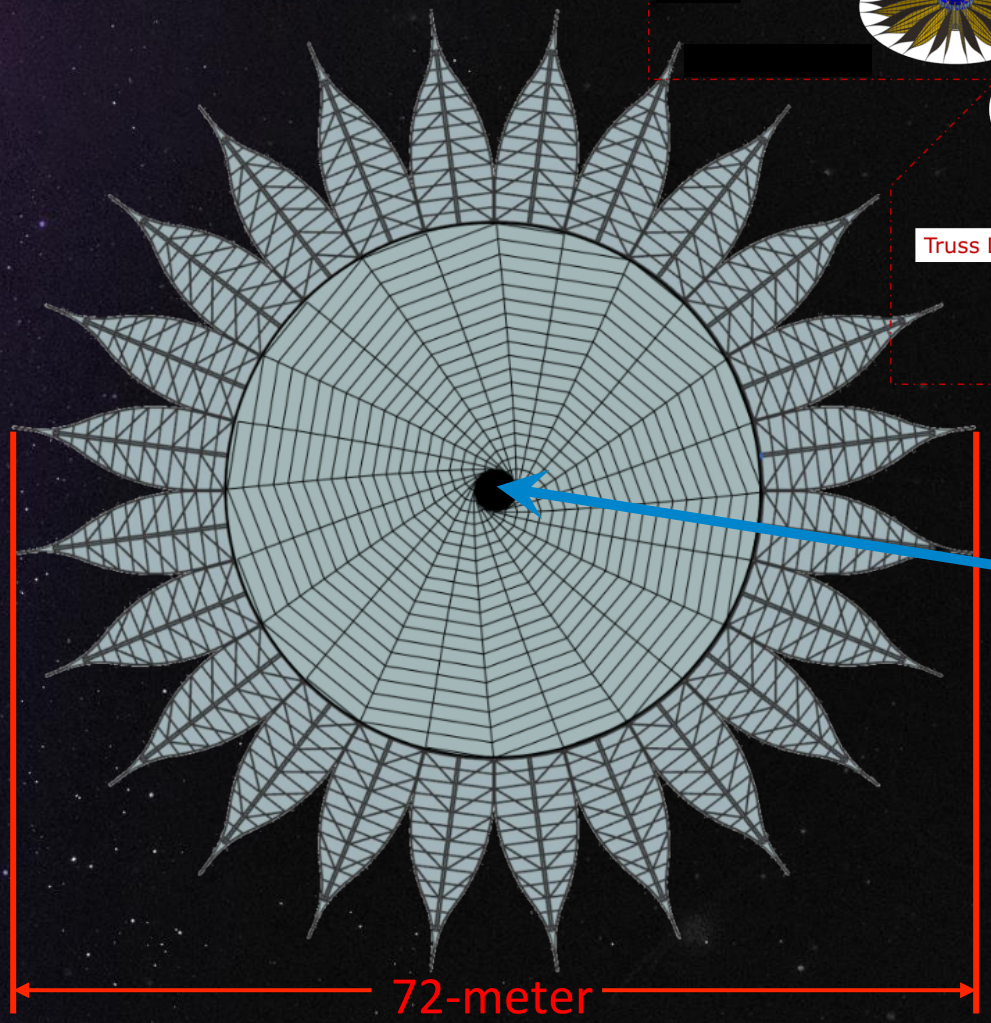


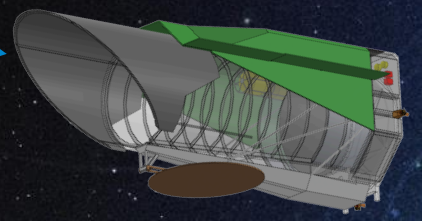
Image courtesy e2v

HabEx Starshade





124,000km



- **Propulsion (Occulter)**
  - Solar Electric Propulsion (SEP) with Hermes Hall effect thrusters for slewing (repositioning)
  - Biprop thrusters for attitude control
  - >100 targets / 5yrs
- **Observing**
  - $\leq 10^{-10}$ Suppression
  - 40 – 83 degree sun-angles
  - 450 – 1000nm wavelengths at **nominal** separation
    - IWA = 62 mas
    - IFS, R = 140
  - 150– 300nm wavelengths at farther distance
    - IWA = 28 mas
    - Grism, R = 7
  - 1000 – 1800nm at closer distance
    - IWA = 111 mas
    - Slit spectrograph, R = 140
  - OWA = 1.9 arcsec

- **Technology Maturity**
  - The Starshade to TRL 5 (S-5) project is maturing 5 starshade technology gaps to TRL 5: 3 by the end of 2019 and 2 by 2021
  - S-5 demonstration on a 26 m starshade achieves HabEx requirements on HabEx 72 m starshade because requirements scale by angle to starshade.

Workhorse camera, UVS

Workhorse Camera Instrument	
Purpose:	Multi-purpose, wide-field imaging camera and spectrograph for general astrophysics
Waveband: • UV: • Vis: • NIR:	 • 150nm – 400nm • 400nm – 950nm • 950nm - 1800nm (2500nm goal)
Telescope Diffraction Limit:	400nm
Field-of-view:	3 arcmin x 3 arcmin
Spectral Resolution:	R = 2000
Detector: • UV/Vis: • NIR:	 • 3x3 CCD203 12288x12288 pixels • 2x2 H4RG10 8192x8192 pixels
Multi-Object Spectroscopy (MOS) capable	Micro-shutter array, 2x2 array 200x100 um 171x365 apertures

UV Spectrograph Instrument	
Purpose:	High resolution, UV spectroscopy for general astrophysics
Waveband: • Spectroscopy:	 115nm – 360nm (20 bands)
Telescope Diffraction Limit:	400nm
Field-of-view:	3 arcmin x 3 arcmin
Spectral Resolution:	R = 500 – 60,000 (band dependent)
Detector	• 6x6 MCP array, 100mm sq each • 60000x60000 pixels
Multi-Object Spectroscopy (MOS) capable	Micro-shutter array, 2x2 array 200x100 um 171x365 apertures

- UV requirements are met by the state of the art.
- UV Performance can be enhanced by advancements in UV coatings and detectors