	ID	Title	Description	Current Capabilities	Needed Capabilities
Contrast	CG-2	Coronagraph Optics and Architecture	Coronagraph optics and architecture that suppress diffracted starlight by a factor of ≤ 10^{-9} at visible and infrared wavelengths.	$6x10^{-10}$ raw contrast at 10% bandwidth across angles of 3-16 λ/D demonstrated with a linear mask and an unobscured pupil in a static vac lab env't (Hybrid Lyot) < $8.8x10^{-9}$ raw contrast at 10% bandwidth across angles of 3-9 λ/D demonstrated with a circularly-symmetric mask and obscured pupil in a static vacuum lab env't (WFIRST)	Coronagraph masks and optics capable of creating circularly symmetric dark regions in the focal plane enabling raw contrasts ≤ 10^{-9}, IWA ≤ 3 λ/D, throughput ≥ 10%, and bandwidth ≥ 10% on obscured/segmented pupils in a simulated dynamic vacuum lab environment.
Angular Resolution (plus sensitivity, integration time, and planet yield)	CG-1	Large Aperture Primary Mirrors	Large monolith and multi-segmented mirrors that meet tight surface figure error and thermal control requirements at visible wavelengths.	Monolith: 3.5m sintered SiC with < 3 um SFE (Herschel) 2.4m ULE with ~ 10 nm SFE (HST) Depth: Waterjet cutting is TRL 9 to 14", but TRL 3 to >18". Fused core is TRL 3; slumped fused core is TRL 1. Segmented: 6.5m Be with 25 nm SFE (JWST) Non-NASA: 6 dof, 1-m class SiC and ULE, < 20 nm SFE, and < 5 nm wavefront stability over 4 hr with thermal control	Aperture: 4m - 12m; SFE < 10 nm rms (wavelength coverage 400 nm - 2500 nm) Wavefront stability better than 10 pm rms per wavefront control time step. Segmented apertures leverage 6 DOF or higher control authority meter-class segments for wavefront control. Environmentally tested.
Detection Sensitivity	CG-8	Ultra-Low Noise, Large Format Visible Detectors	Low-noise visible detectors for faint exoplanet characterization with an Integral Field Spectrograph	1kx1k silicon EMCCD detectors provide dark current of $8x10^{-4}$ e-/px/sec; effective read noise < 0.2 e- rms (in EM mode) after irradiation when cooled to 165.15K (WFIRST). 4kx4k EMCCD fabricated but still under development.	Effective read noise < 0.1e- rms; CIC < $3x10^{-3}$ e-/px/fram; dark current < 10^{-4} e-/px/sec tolerant to a space radiation environment over mission lifetime. ≥ 2kx2k format
Detection Sensitivity	CG-9	Ultra-Low Noise, Large Format Near Infrared Detectors	Near infrared wavelength (900 nm to 2.5 μm), extremely low noise detectors for exo-earth spectral characterization with Integral Field Spectrographs.	HgCdTe photodiode arrays have read noise <~ 2 e- rms with multiple non-destructive reads; dark current < 0.001 e-/s/pix; very radiation tolerant (JWST). HgCdTe APDs have dark current ~ 10-20 e-/s/pix, RN << 1 e- rms, and < 1kx1k format Cryogenic (superconducting) detectors have essentially no read noise nor dark current; radiation tolerance is unknown.	Read noise << 1 e- rms, dark current < 0.001 e-/pix/s, in a space radiation environment over mission lifetime. ≥ 2kx2k format
Contrast Stability	CG-6	Segment Phasing Sensing and Control	Multi-segment large aperture mirrors require phasing and rigid-body sensing and control of the segments to achieve tight static and dynamic wavefront errors.	6 nm rms rigid body positioning error and 49 nm rms stability (JWST error budget) SIM and non-NASA: nm accuracy and stability using laser metrology	Systems-level considerations to be evaluated but expect will require less than 10 pm rms accuracy and stability.

	ID	Title	Description	Current Capabilities	Needed Capabilities
Contrast Stability	CG-7	Telescope Vibration Control	Isolation and damping of spacecraft and payload vibrational disturbances	80 dB attenuation at frequencies > 40 Hz (JWST passive isolation) Disturbance Free Payload demonstrated at TRL 5 with 70 dB attenuation at "high frequencies" with 6-DOF low-order active pointing.	Monolith: 120 dB end-to-end attenuation at frequencies > 20 Hz. Segmented: 140 dB end-to-end attenuation at frequencies > 40 Hz. End-to-end implies isolation between disturbance source and the telescope.
Contrast	CG-3	Deformable Mirrors	Environment-tested, flight-qualified large format deformable mirrors	Electrostrictive 64x64 DMs have been demonstrated to meet $\leq 10^{-9}$ contrasts and $< 10^{-10}$ stability in a vacuum environment and 10% bandwidth; 48x48 DM passed random vibe testing.	4 m primary: ≥ 96x96 actuators 10 m primary: ≥ 128x128 actuators Enable raw contrasts of $\leq 10^{-9}$ at ~20% bandwidth and IWA ≤ 3 λ/D Flight-qualified device and drive electronics (radiation hardened,environmentally tested, life-cycled including connectors and cables) Large segment DM needs possible for segmented telescopes.
Contrast Stability	CG-5	Low-Order Wavefront Sensing and Control	Sensing and control of line of sight jitter and low-order wavefront drift	< 0.5 mas rms per axis LOS residual error demonstrated in lab with a fast-steering mirror attenuating a 14 mas LOS jitter and reaction wheel inputs; ~ 100 pm rms sensitivity of focus (WFIRST). Higher low-order modes sensed to 10-100 nm WFE rms on ground-based telescopes.	Sufficient fast line of sight jitter (< 0.5 mas rms residual) and slow thermally-induced (≤ 10 pm rms sensitivity) WFE sensing and control to maintain closed-loop $< 10^{-9}$ raw contrast with an obscured/segmented pupil and simulated dynamic environment.
Contrast	CG-4	Post-Data Processing	Post-data processing techniques to uncover faint exoplanet signals from residual speckle noise at the focal-plane detector.	Few 100x speckle suppression has been achieved by HST and by ground-based AO telescopes in the NIR and in contrast regimes of 10^{-4} to 10^{-5}, dominated by phase errors.	A 10-fold contrast improvement in the visible from 10^{-9} raw contrast where amplitude errors are expected to be important (or a demonstration of the fundamental limits of post-processing)