P/C/E	Gap Name	Tier	Description	Current State-of-the-Art	TRL	Performance Goals and Objectives	Scientific, Engineering, and/or Programmatic Benefits	Applications and Potential Relevant Astrophysics Missions	Urgency
E	Coronagraph Contrast and Efficiency in the Near Infrared	1	The capability to suppress starlight and receive planet light with a coronagraph to the level needed to detect and spectrally characterize Earth-like exoplanets in the habitable zones of Sun-like stars across the wavelength range 1-2 microns.	[illegible]	3	[illegible]	[illegible]	HWO, or any other coronagraph-based exoplanet direct-imaging mission.	Demonstration of feasibility and as much risk reduction as possible prior to mission formulation. TRL 6 in the mid-to-late 2020's.
E	Coronagraph Contrast and Efficiency in the Near Ultraviolet	1	The capability to suppress starlight and receive planet light with a coronagraph to the level needed to detect and spectrally characterize Earth-like exoplanets in the habitable zones of Sun-like stars across the wavelength range 200-400 nm.	[illegible]	2	[illegible]	[illegible]	HWO, or any other coronagraph-based exoplanet direct-imaging mission.	Demonstration of feasibility and as much risk reduction as possible prior to mission formulation. TRL 6 in the mid-to-late 2020's.
E	Coronagraph Stability	1	The capability to maintain the deep starlight suppression provided by a coronagraph for a time period long enough to detect light from an exo-Earth.	[illegible]	3	[illegible]	[illegible]	HWO, or any other coronagraph-based exoplanet direct-imaging mission.	Demonstration of feasibility and as much risk reduction as possible prior to mission formulation. TRL 6 in the mid-to-late 2020's.
C	Cryogenic Readouts for Large-format Far-IR Detectors	1	Readout schemes including cryogenic multiplexing for arrays of large-format Far-IR detectors need to be developed.	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]
P	Fast, Low-noise, Megapixel X-ray Imaging Arrays with Moderate Spectral Resolution	1	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]
P	High-Bandwidth Cryogenic Readout Technologies for Compact and Large-Format Calorimeter Arrays	1	[illegible]	[illegible]	3-5	[illegible]	[illegible]	[illegible]	[illegible]
P	High-Efficiency X-ray Grating Arrays for High-Resolution Spectroscopy	1	[illegible]	[illegible]	3-4	[illegible]	[illegible]	[illegible]	[illegible]
C	High-Efficiency, Low-Scatter, High- and Low-Ruling-Density, High- and Low-Blazed-Angle UV Gratings (from HWO START/TAG)	1	[illegible]	[illegible]	3-5	[illegible]	[illegible]	[illegible]	[illegible]
C	High-Performance, Sub-Kelvin Coolers	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	High-Reflectivity Broadband FUV-to-NIR Mirror Coatings (from HWO START/TAG)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	High-Resolution, Lightweight X-ray Optics	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	High-Throughput, Large-Format Object-Selection Technologies for Multi-Object and Integral Field Spectroscopy (from HWO START/TAG)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Integrated Modeling for HWO: Multi-Physics Systems Modeling, Uncertainty Quantification and Model Validation	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Large-Format, High-Resolution Far-UV (100-200 nm) Detectors (from HWO START/TAG)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Large-Format, High-Resolution Near-UV (200 - 400 nm) Detectors (from HWO START/TAG)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Low-Stress, Low-Roughness, High-Stability X-ray Reflective Coatings	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Mirror Technologies for High Angular Resolution (UV/Vis/Near IR)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Optical Blocking Filters for X-ray Instruments	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Scaling and Metrology for Advanced Broadband Mirror Coatings for HWO (from HWO START/TAG)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Segmented-Pupil Coronagraph Contrast and Efficiency in Visible Band	1	The capability to suppress starlight and receive planet light with a coronagraph to the level needed to detect and spectrally characterize Earth-like exoplanets in the habitable zones of Sun-like stars across the wavelength range 400-1000 nm.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	UV Multi-Object Spectrograph Calibration Technologies (from HWO START/TAG)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	UV Single-Photon Detection Sensitivity	1	The sensitivity to perform imaging spectroscopy of exoplanets in the ultraviolet.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Vis/NIR Single-Photon Detection Sensitivity	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Advanced Cryocoolers	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Broadband X-Ray Detectors	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Compact, Integrated Spectrometers for 100 to 1000 μm	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Cryogenic Far-IR to mm-Wave Focal Plane Detectors	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Far-IR Imaging Interferometer for High-Resolution Spectroscopy	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Far-IR Spatio-Spectral Interferometry	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Heterodyne Far-IR Detector Systems	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	High-Performance Computing for Event Reconstruction	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	High-Resolution, Direct-Detection Spectrometers for Far-IR Wavelengths	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	High-Throughput Focusing Optics for 0.1-1 MeV Photons	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	High-Throughput UV Bandpass Standalone and Detector-Integrated Filters and Bandpass Selection (from HWO START/TAG)	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Improving the Calibration of Far-IR Heterodyne Measurements	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Large-Format, High-Spectral-Resolution, Small-Pixel X-ray Focal Plane Arrays	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Large-Format, Low-Noise and Ultralow-Noise Far-IR Direct Detectors	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Low-Power Readout and Multiplexing for CMB Detectors	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Millimeter-Wave Focal-Plane Arrays for CMB Polarimetry	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Optical Elements for a CMB Space Mission	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Starshade Deployment and Shape Stability	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Starshade Starlight Suppression and Model Validation	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Stellar Reflex Motion Sensitivity: Astrometry	2	Capability to measure exoplanet masses down to Earth-mass.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Stellar Reflex Motion Sensitivity: Extreme Precision Radial Velocity	2	Capability to measure exoplanet masses down to Earth-mass.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Warm Readout Electronics for Large-Format Far-IR Detectors	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Broadband X-ray Polarimeter	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Charged-Particle-Discriminating X-ray/Gamma-ray Detectors	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Dynamic Switching for Ultra-Low-Power, High-Resolution Charge Readout	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	High-Energy-Resolution Gamma-ray Detectors	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Large Cryogenic Optics for the Mid IR to Far IR	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Large Field-of-View and Effective Area Gamma-ray Detectors	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Large-Aperture Deployable Antennas for Far-IR/THz/sub-mm Astronomy for Frequencies Above 100 GHz	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Low-Power Readout for Silicon Photomultipliers	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Low-Power, Low-Cost Semiconductor Detectors	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Photometric and Spectro-Photometric Precision of Time-Domain and Time-Series Measurements	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Precision Timing Measurement Technology	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Radiation-Tolerant, Photon-Counting Light Detectors	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Sensitive Spectrometer for CMB Spectrum Measurement	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	UV/Opt/Near-IR Tunable Narrowband Imaging Capability	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	Advancement of X-ray Polarimeter Sensitivity	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Detection Stability in Mid-IR	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]