

Optical design of the *Origins* space telescope

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Introduction

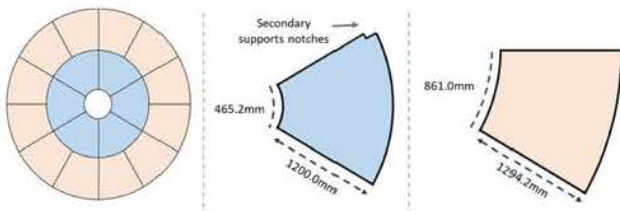
Origins is one of four large missions currently under study for the 2020 Decadal Survey in Astronomy and Astrophysics. Sensitive in the mid- and far-infrared spectrum (between 2.8 and 588 μm), *Origins* main science themes are:

- 1) How do galaxies form stars, build up metals, and grow their supermassive black holes from reionization to today?
- 2) How do the conditions for habitability develop during the process of planet formation?
- 3) Do planets orbiting M-dwarf stars support life?

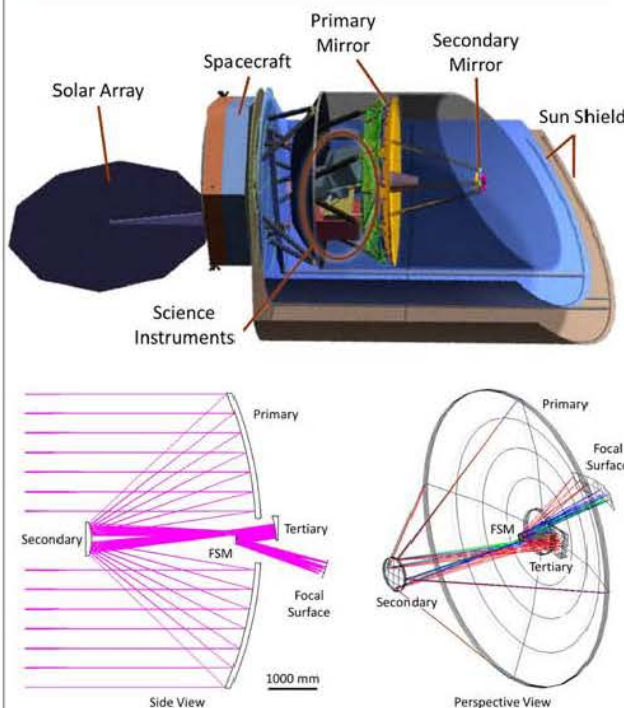
Telescope Overview

Origins is a three-mirror anastigmat (TMA) like the James Webb Space Telescope (JWST), that includes three powered optics (the primary, secondary, and tertiary mirrors) as well as a flat field-steering mirror (FSM). The telescope image surface is concave, with its center of curvature located at the FSM surface which is also the location of the telescope's exit pupil. By constraining the design in this way, defocus does not result when scanning the FSM.

The TMA architecture enables the required wavefront performance (diffraction-limited at $\lambda = 30 \mu\text{m}$) over a relatively large field of view. *Origins* is designed to fit within its launch vehicle without requiring deployments (including the primary and secondary) which helps to reduce telescope complexity and cost. The primary size (5.9 m diameter) and on-axis configuration are based on this requirement, maximizing collecting area while meeting packaging constraints. *Origins* utilizes 18 'keystone' shaped segments arranged in two annuli to form its primary mirror. Such a segmentation scheme is desirable over hexagons as it maximizes the collecting area of the mirror in a given fairing size while also reducing the effects of diffraction. Only two optical prescriptions are required for the segments (those of the inner and outer annuli). Because of its high stiffness, low density, low CTE, and high thermal conductivity, Be O-30 is baselined for the optical components and instrument structure.



Optical Design



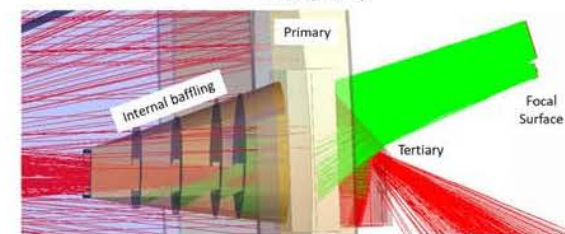
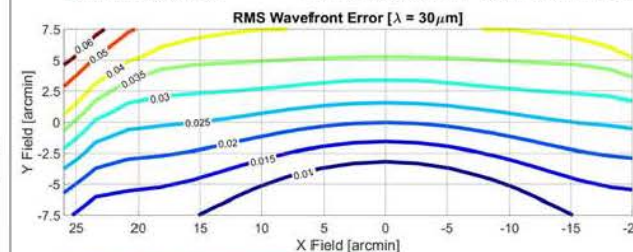
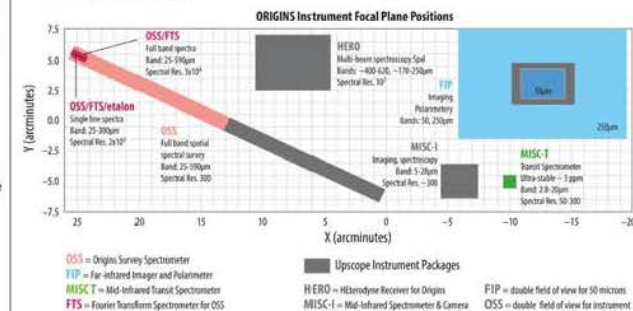
Parameter	Origins Baseline	Units
Primary Size	Circular, 5.9	Meters
f-number	f/14.0 (telescope) f/0.63 (primary)	--
Effective Focal Length	82.6	Meters
Field of View	46 x 15	Arcmin
Waveband	2.8 - 588	Microns
Operating Temp.	4.5	Kelvin
Optical Performance	Diffraction limited at $\lambda = 30 \mu\text{m}$	
Design Form	Three Mirror Anastigmat Obstructed (on-axis pupil)	
Mirror Coatings	Protected Gold	
Optical and Structural Material	Beryllium O-30	

Science Instruments

The baseline *Origins* design includes three instruments:

- 1) Origins Survey Spectrometer (OSS) with Fourier Transform Spectrometer (FTS) and etalon
- 2) Mid-infrared Spectrometer Camera Transit Spectrometer (MISC-T)
- 3) Far-Infrared Imager Polarimeter (FIP)

Upscope options for *Origins* include a fourth instrument, Heterodyne Receiver for *Origins* (HERO), imaging camera module (MISC I), and increased fields of view for the OSS and FIP instruments.



REFERENCES:

1. *Origins* Final Report. NASA GSFC, August 2019