Optical Design of a Large Segmented Space Telescope

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Mission Overview

• Approximately 1,000 identical, mass-produced spacecraft
• Spacecraft travel via solar sail to L2
• Each spacecraft combines to form one large telescope via autonomous in-space assembly
• Each flat mirror modulated to control shape
• Completed structure combines with instrument spacecraft and secondary mirrors.

Segmentation of Primary

• Finds the correct location for each mirror
• Center mirrors removed based on geometry
• Segments excluded if >40% of the hexagonal area is outside the 31 m diameter.
• Gaps between mirrors determined by relative angle and assumed thickness

Ideal Optical System

Ritchey-Chrétien Cassegrain Telescope

• Aperture: $d = 31$ m
• Primary Focal Length: $f_p = f/2$
• Secondary Diameter: 3 m
• Effective focal length $F = f/5.6$
• Mirror Size: 1 m (flat-to-flat)
• Gap Size: 0.006 m

Shape Reconstruction

• Each mirror begins identical and flat
• Must be adjusted to the ideal shape at that location
• Least-squares fit the shape to Zernike polynomials
• Uses a hexagonal domain
• Leverage JWST technology to modulate to the first 4 modes.

Modelling and Simulation

Example segment with complex shape

Zernike polynomials used

Point Spread Functions

Gaps, ideal shape:

Gaps, reconstructed shape:

Acknowledgements

This work was supported by NASA Grant NNX03CC82G.

References


Parameters selected from comparisons to TMT¹, GMT², Hubble³, and JWST⁴

Deformation is dominated first by angular rotation, then by a curvature mode

Example of residuals on a specific segment using only piston, tip, tilt and defocus modes

Root Mean Square residuals for every segment in the primary mirror

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