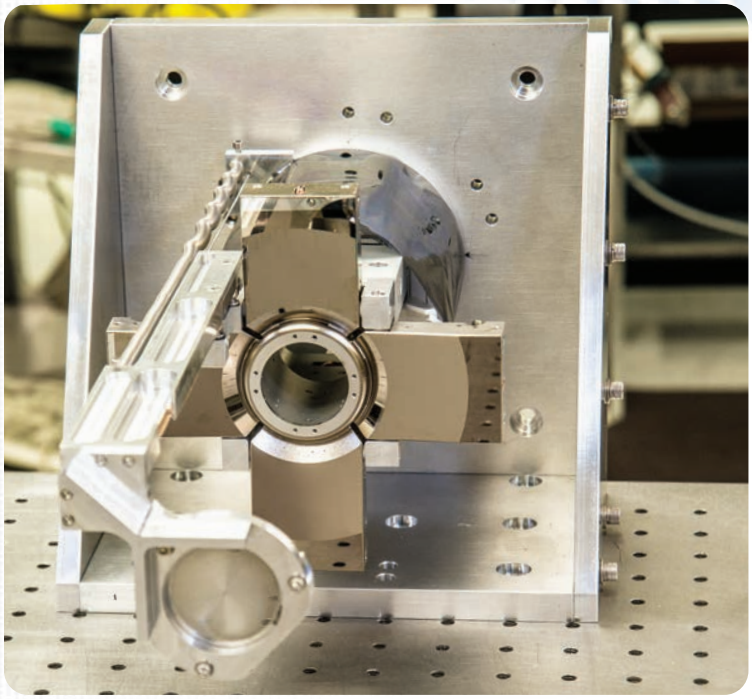
SDL/14-608A

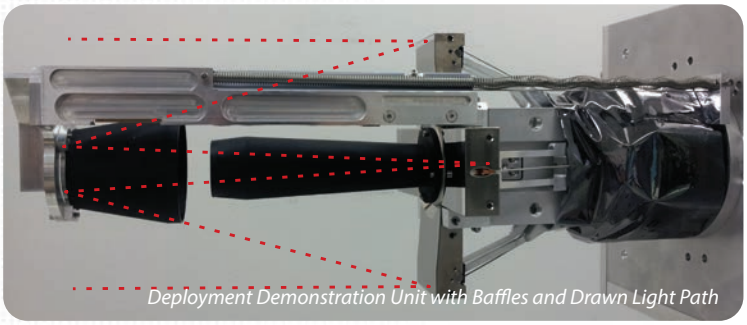
DEPLOYABLE PETAL TELESCOPE

The Space Dynamics Laboratory (SDL) has designed and built the Deployable Petal Telescope (DPT) to enable a larger optical aperture than would be normally possible within restricted volume constraints. The DPT is simple and robust. Its larger aperture enables higher signal-to-noise and increased ground spatial imagery. It is built using modern precision fabrication techniques that permit simple passive deployment and alignment mechanisms, resulting in lower costs than other actively-aligned deployable telescopes.

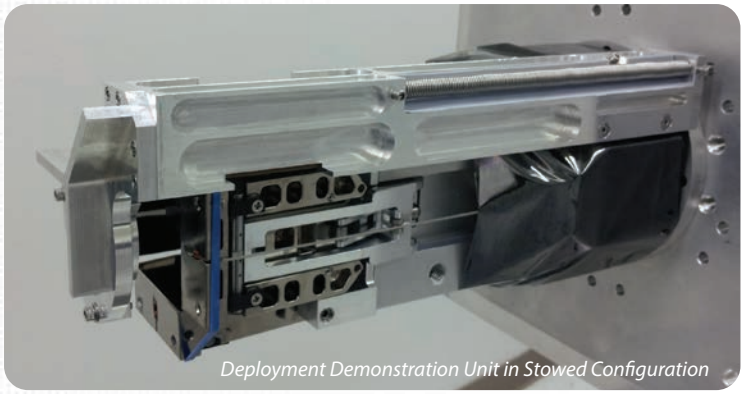
The DPT is a Cassegrain imaging system composed of a deployable primary and secondary mirror. The primary mirror is able to fold and stow into a compact volume. The secondary mirror is mounted to a kinematically-located deployable metering structure that can increase the deployed payload length by a factor of 2. A deployable secondary mirror allows for a shorter stowed payload length and a longer system focal length. Current system level image quality predictions show that the DPT would be capable of excellent image quality in the visible spectrum.

The DPT would enable CubeSats to capture high-resolution imagery in the visible and near-infrared spectrums. With state-of-the-art commercial components and deployable optics installed on a 2-3U CubeSat from a 500 km orbit, ground spatial resolution approaching 1.5 m in the visible spectrum is possible. This resolution capability would enable CubeSats to be used for mapping, water resource management, agricultural land use, population monitoring, health hazard monitoring, and disaster mitigation and management.





Deployment Demonstration Unit with Baffles and Drawn Light Path



Deployment Demonstration Unit in Stowed Configuration

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DEPLOYABLE

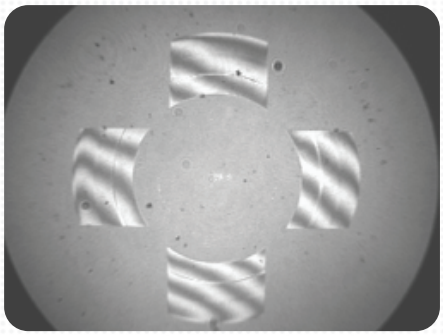
PETAL TELESCOPE

SPECIFICATIONS

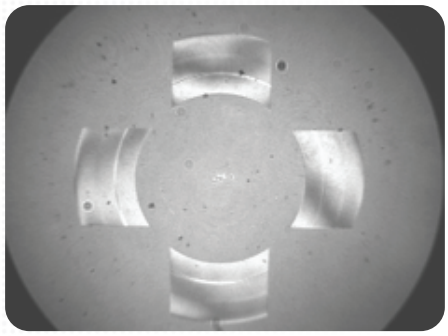
The prototype optical design of the DPT is an F/7 Cassegrain with a 1 m focal length. The parabolic primary is segmented into four separate mirrors or "petals" that are able to fold into the CubeSat standard or a 10 cm x 10 cm cross-section and deploy to an aperture diameter of 15.25 cm, giving a 1.5x gain in aperture diameter. As a stand-alone optic, the primary mirror is fast, operating at F/1.9. The patent-pending semi-kinematic opto-mechanical interfaces ensure repeatable optical alignment of the four mirrors to one another. The primary mirror design can be scaled up to a 200 mm aperture diameter and still fit within the CubeSat cross-section.

The F/7 Cassegrain optical design requires a deployed payload length of 325 mm. This length can be dramatically reduced with the implementation of a deployable secondary mirror. In the stowed configuration, the prototype telescope has a length of 250 mm. It is estimated that this length can be further reduced to 175 mm with custom packaging of the spring engine that supplies the necessary forces for deployment and alignment.

The DPT is currently estimated to be at a NASA technology readiness level (TRL) of 4, which means that a basic prototype or example of the technology has been demonstrated in a laboratory environment. To date, the primary and secondary mirrors have been tested at the component level. SDL is working on furthering this technology by performing system level image quality tests in a laboratory and relevant environments.



Deployable Primary Interferogram with Tilt Fringes



Deployable Primary Null Interferogram

PRIMARY MIRROR INTERFEROMETRIC ALIGNMENT REPEATABILITY STATISTICS

Deployment #	Measured RMS Surface Error [nm]
1	25.9
2	24.7
3	22.1
4	21.5
5	23.4
6	32.9
7	22.8
8	27.0
9	27.2
10	31.6
Mean	**25.9**
1 σ Standard Deviation	**3.9**
2 σ Standard Deviation	**7.8**

SECONDARY MIRROR DEPLOYMENT REPEATABILITY STATISTICS *(17 DEPLOYMENTS)*

Error Description	Measured 2σ	Resulting System RMS WFE	Measurement 1σ Uncertainty
Tip (Az)	8.2 arcsec	0.7 nm	0.6 arcsec
Tilt (El)	2.2 arcsec	0.2 nm	0.6 arcsec
De-Space	2.0 µm	7.1 nm	1.4 µm
De-Center	13.0 µm	1.3 nm	6.6 µm

SYSTEM LEVEL IMAGE QUALITY PERFORMANCE PREDICTION

Error Description	RMS Wavefront Error [nm]
Optical Design Residual	15.0
Primary Figure	30.0
Measured 2σ Primary Deployment	15.6
Secondary Figure	15.0
Measured 2σ Secondary De-Space	7.1
Measured 2σ Secondary Tip	0.7
Measured 2σ Secondary Tilt	0.2
Measured 2σ Secondary De-Center	1.3
RSS	**40.6**
Estimated PV Wavefront Error	**163**
Estimated Diffraction Limited Wavelength	**652**

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