Observatory for Planetary Investigations from the Stratosphere (OPIS). T. A. Hurford[1] and A. Mandell[1], and the OPIS Team[1]. [1]NASA Goddard Space Flight Center, Greenbelt, MD 20771.

Introduction: As reported in the recent Planetary Science Decadal survey, balloon-borne telescopes in Earth's stratosphere offer a cost-effective means of studying planetary bodies at wavelengths inaccessible from the ground. Moreover, their modest costs and quick development times provide training opportunities for would-be developers of future instruments on spacecraft missions. NASA's Science Mission Directorate (SMD) regularly flies balloon missions into the stratosphere, carrying payloads recommended by research and analysis programs in both the Astrophysics and Heliophysics Divisions. However, the Planetary Science Division (PSD) lags behind other divisions in utilizing this platform, partly because the platform has not been stable enough to facilitate planetary investigations. The OPIS mission aims to demonstrate the usefulness of balloon-borne observations for planetary science research.

Motivation: As depicted in Fig. 1, OPIS will fly in the near-space environment at 36.6 km, which is above 99.5% of the absorbing atmosphere. There are two main benefits to observing above Earth's atmosphere. Firstly, strong gas absorbers in Earth's atmosphere, like water (H2O) and carbon dioxide (CO2), absorb all incoming radiation at numerous mid infrared wavelengths. At the OPIS float altitude, the transmission of telluric CH_4 and H_2O vapor are nearly 1 (no terrestrial absorption) and the transmission for CO_2 is greater than 70%, such that less than 30% of the incoming radiation is being absorbed by CO_2 high in Earth's atmosphere. Secondly, atmospheric turbulence usually degrades image quality. Observing in a near-space environment enables higher spatial resolution image quality. This is comparable to utilizing adaptive optics or observing with HST. The caveat with adaptive optics is that atmospheric turbulence is only correctable for wavelengths longward of 1 μm (in the infrared). At visible wavelengths, there is no correction for atmospheric turbulence, so image quality can be rather poor, depending on the telescope and instrument characteristics. OPIS is equipped with visible and near-IR wavelength filters and the image quality will far exceed any ground-based observations with comparable primary mirror diameters and detector characteristics.

OPIS is a primarily a technology demonstration mission. The goal of OPIS is to demonstrate the feasibility of doing planetary science from a high-altitude balloon platform through the following objectives:

Objective 1: Utilize Jupiter to demonstrate the short term stability of the Wallops ArcSecond Pointing (WASP) system.

Objective 2: Utilize an exoplanet host star to demonstrate the long term stability of the WASP system.

Objective 3: Utilize an asteroid target to demonstrate the stability of the WASP system.

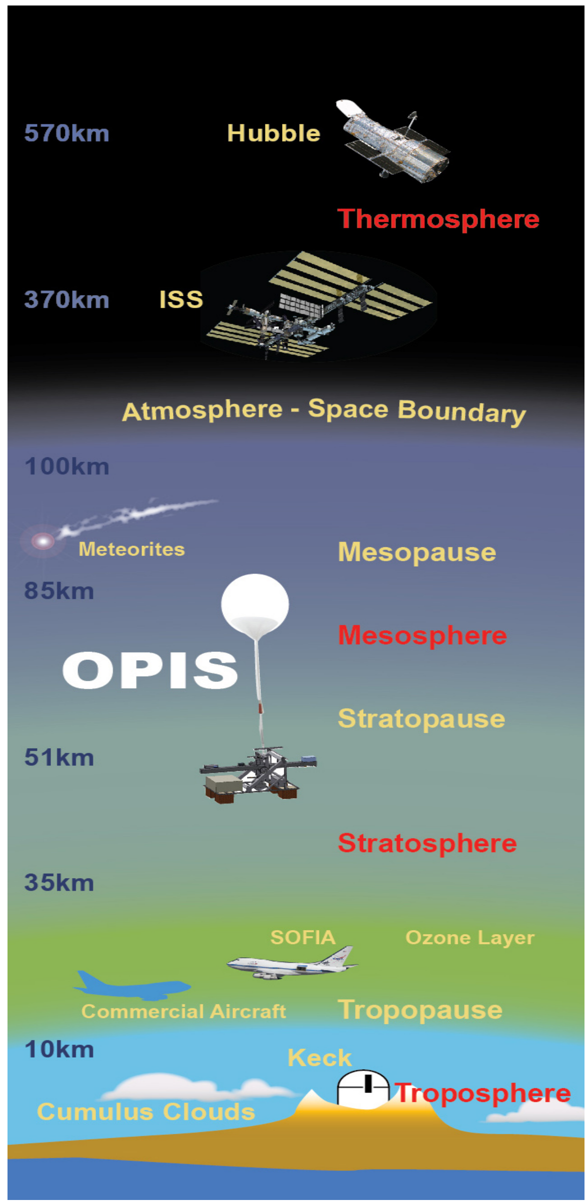

Figure 1. OPIS will fly at 36.6 km, placing it above most of Earth's atmosphere.

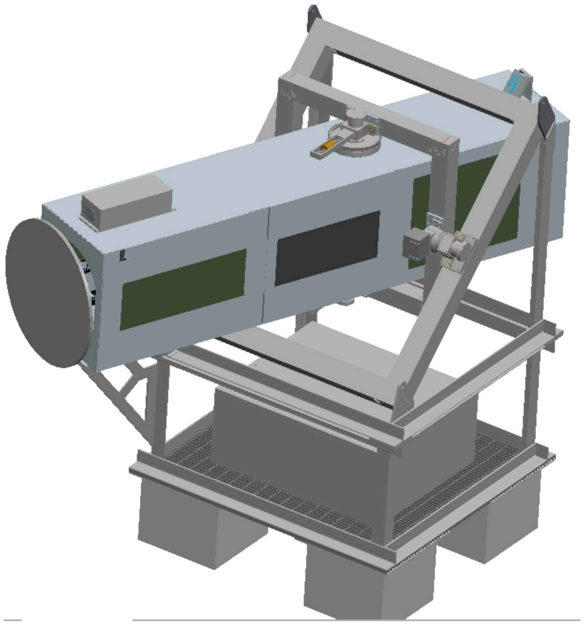

Figure 2. The OPIS telescope within the WASP system and gondola.

OPIS Telescope Assembly: The telescope assembly for OPIS is anchored by a stable aluminum-alloy frame that defines three rectangular bays: the first for the primary and secondary mirror, the second for the instrument suite, and the third for the avionics and power systems. The frame is then covered with 1/8-inch aluminum plates with access panels to each bay. The primary mirror is attached to the secondary mirror by aluminum struts, and the primary is attached to the outer frame by four brackets that connect to an aluminum case that surrounds the mirror. The OPIS frame is designed to be extremely sturdy, in order to provide structural stability during flight and absorb any significant forces during landing.

The primary and secondary mirrors were originally fabricated as a laboratory test telescope for the Cassini CIRS instrument at GSFC. They are currently made of low-CTE Zerodur with an aluminum coating, and form a Ritchey-Chretien telescope with an f/number of 10.2. The primary is 21 inches (0.53 meters) in diameter, leading to a focal length of 5.46 meters.

OPIS Imaging System: The imager will be a visible light 2184x1472 pixel Alta F32 CCD imager from Apogee Imaging Systems. The CCD camera can image at wavelengths from 0.3 to 1.1 μm. The CCD detector has a pixel size of 6.8 μm and when combined with the Cassegrain telescope will provide a resolution of 0.3 arcsecond/pixel resolutions. The field-of-view (FOV) of the full system will be 10.9x7.4 arcminutes.

A filter wheel also from Apogee Imaging Systems will be fitted with filters. Currently, it has a neutral density filter, an 600 nm edge filter, 720 nm, 750 nm, and a grating filter as well as a clear filter to collect data.

Wallops ArcSecond Pointing (WASP) system: The Wallops Arc-Second Pointing system points an instrument using a gondola mounted pitch/yaw articulated gimbal. The range of motion of the yaw-gimbal is purposely minimized to reduce kinematic coupling during fine pointing. Thus, the gondola itself is suspended beneath a standard NASA rotator to provide large angle azimuth targeting and coarse azimuth stabilization. Instrument attitude is computed by integrating output from a LN251 navigation system. While the LN251 is a fully capable GPS/INS system, its use on the WASP system is limited to that of a relatively low-cost, high-quality inertial-rate-unit. Control torques are computed using a modified PID control law in each axis.

Previous flights have demonstrated the capability of the WASP system to deliver sub-arcsecond pointing control with control residual RMS values of ~0.5 arcsecond. WASP has flown on many successful test flights. OPIS will utilize the WASP system in September 2014. The pointing control and precision will be further evaluated with the OPIS flight this year. Our expected stability performance is a conservative 0.5 arcsecond.

The Future of OPIS: The optical telescope assembly for OPIS along with the WASP system provides a foundation upon which to build. Future use of the system can replace the imaging system with other instruments to enable other planetary investigations.

Additional Information: We would like to thank the Balloon Program Office and WSP team for support of our efforts.