OBSERVATORY FOR PLANETARY INVESTIGATIONS FROM THE STRATOSPHERE. T. A. Hurford[1] and A. Mandell[1] and V. Reddy[2] and E. Young[3] and OPIS Team[1] and WASP Team[4], [1]NASA Goddard Space Flight Center, Greenbelt, MD 20771, [2]Planetary Science Institute, Tucson, AZ 85719, [3]Southwest Research Institute, Boulder, CO 80302, [4]NASA Wallops Flight Facility, Wallops Island, VA 23337.

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. The Planetary Science Division (PSD) has historically underutilized this platform for planetary investigations. However, recent advances in pointing systems for balloon-borne payloads make their use practical for planetary science. Therefore, the Observatory for Planetary Investigations from the Stratosphere (OPIS) mission was designed to demonstrate the ability of the Wallops Arc Second Pointing (WASP) system to enable planetary investigations during a high-altitude balloon flight.

In order to demonstrate the pointing accuracy as well as short and long term stability of the WASP system several observational objectives were developed.

Short Term Stability Objective: The OPIS team chose to observe Jupiter to demonstrate the short term stability of the system. While the WASP system can accurately point a telescope, it can hold that pointing with an RMS error of typically ±1". This pointing error is small and can blur images of extended planetary objects. The OPIS imaging system should be able to image Jupiter at resolutions better than 0.5" per pixel. Short exposures will freeze the jitter of the WASP pointing system and allow for resolved imaging of Jupiter. This will demonstrate the short term stability of the WASP system to allow resolved imaging of planetary objects.

Long Term Stability: The OPIS team chose to observe an exoplanet or a bright star to demonstrate the long term stability of the WASP system. Ideally, planetary targets would be imaged on the same parts of the CCD detector to eliminate errors associated with pixel-to-pixel variations within the CCD detector.

OPIS Imaging System: The OPIS imaging system (Fig. 1) was built around a refurbished 21" telescope. This telescope was built for the Cassini CIRS project to aide in thermalvac tests of that instrument. An Alta F32 CCD camera was mounted on a translation stage with a filter wheel near the focal point of the 21" telescope. In flight refocusing of the system could be done via the translation stage as the temperature environment changed the focus of the system. The system was controlled with custom built flight software and all data was saved onboard for post-flight processing.

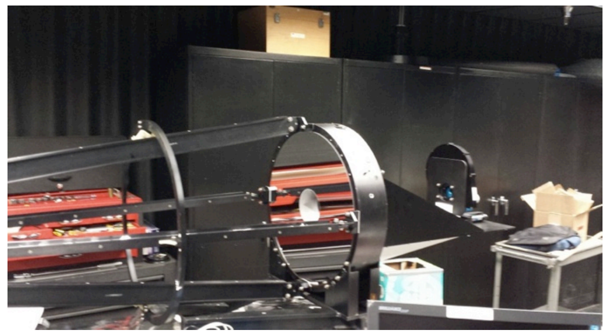

Fig. 1. The components of the OPIS imaging system, consisting of a 21" telescope, a CCD camera and filter wheel, and a translation stage.

OPIS/WASP System: The OPIS imaging system was mounted within the frame of the WASP system (Fig 2). The structure also housed the WASP avionics and the batteries for both the OPIS and WASP systems. The WASP system needs pointed masses with larger inertia to aide with its pointing stability so as much of the system was mounted in the WASP gimbals as possible. Only the systems required by the Columbia Scientific Balloon Facility were mounted elsewhere.

OPIS/WASP Fight: The OPIS/WASP mission launched on October 8th, 2014 at 8 AM. While late in the season, it managed to get ~8 hours at a float altitude of 105,000 ft. The mission was able to target Jupiter as planned, but had to track a bright star in lieu of an exoplanet target. The flight also did not get any night time viewing and planned asteroid observations were not possible.

Observations of Jupiter suffered from scattered light into the optical system (Fig. 4). However, images of Jupiter with no evidence of jitter induced smear were obtained. Over 2000 images were taken and post processing should allow images to be shifted and stacked to increase image resolutions.

Scattered light limited the OPIS system's ability to observe exoplanet targets, so tracking of a bright star served to demonstrate the long term stability of the

WASP system (Fig. 5). The bright star was tracked for about 1 hour and analysis of this data will be used to evaluate the long term stability of the WASP system.

Finally, spectra of a star were obtained to demonstrate the capability to do low cost spectral analysis of planetary objects (Fig. 6). An asteroid target was chosen but could not be imaged.

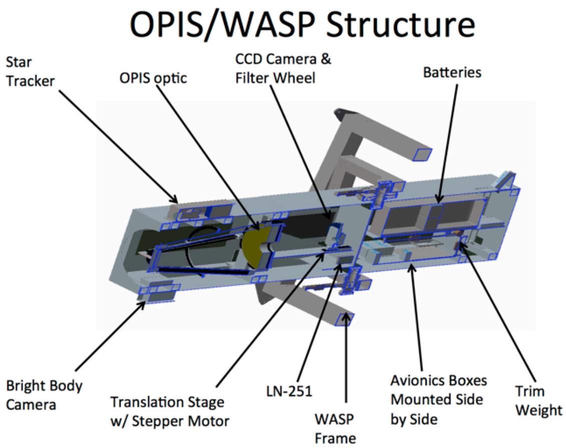

Fig. 2. CAD design of the OPIS payload mounted within the WASP system.

Fig. 3. Image of the payload at launch.

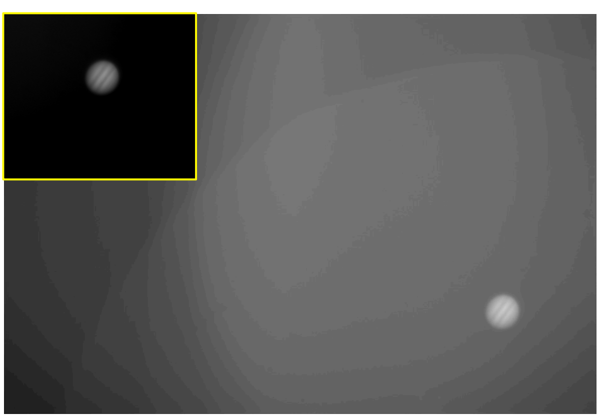

Fig. 4. Sample Jupiter image showing the scattered light and our post processing of this one image (inset).

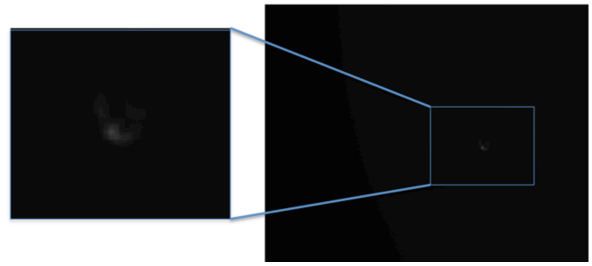

Fig. 5. Images of a bright star tracked for ~1 hour to demonstrate the long term stability of the system. Over 7000 images will were obtained and will be processed.

Fig. 6. Spectral image of a star target.

Mission Fact Sheet	
Launch Date	October 8, 2014, 8AM
Launch Site	Ft. Sumner, NM
Flight Altitude	105,000 ft.
Float Duration	~8 hours
Observation Targets	• Jupiter • Bright Star
OPIS Optics	21” (0.533m) refurbished Cassini CIRS telescope
Imager	Apogee Alta F32 CCD system
Platescale	0.25”/pixel
Wavelengths	• Clear Filter 300-900nm • 50% Neutral Density 300-900nm • Edge Filter 600-900nm • H_2O band pass 720nm • H_2O continuum 750nm • Grating Filter