

Janus: Future opportunities relevant to Apophis. D.J. Scheeres¹, E.B. Bierhaus², C. McCaa², E. Kloska², D. Brack², J. Shoer².

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Introduction: The 2022 launch delay of the Psyche mission led to the two Janus spacecraft (S/C) to be de-manifested from the Psyche launch, as the new launch provided no viable scientific mission opportunities for Janus. The S/C are now in storage at a NASA center, and are available for future use. An intriguing opportunity is to send the S/C to flyby the asteroid Apophis in advance of its Earth close approach. The Janus team has already investigated this opportunity at the behest of NASA, and were able to identify several launch opportunities that would lead to such an outcome. In this talk and abstract, we present the current state of the S/C and the nature of the Apophis options.

Background: The NASA SIMPLEX program is designed around the idea of using secondary launch opportunities to explore interplanetary destinations. SIMPLEX missions are cost-capped at \$55M USD, including all Phase E support. They are also classified as Class D missions, meaning that they are tolerant of a higher level of risk as compared to Discovery or New Frontiers mission classes.

The Janus mission was selected in 2019 as a SIMPLEX mission to be co-manifested with the NASA Discovery mission Psyche, scheduled to be launched in August 2022. Janus was designed to send two spacecraft to fly by Near Earth Objects of interest. Each of the Janus spacecraft can be targeted to fly by a separate asteroid. The original targeted asteroid systems were the binary asteroids (175706) 1996 FG3 and (35107) 1991 VH, both of which have been observed repeatedly with photometry, spectrometry and radar and have intriguing scientific questions that the mission was to address.

Spacecraft and Instrument Descriptions: The Janus spacecraft are designed to be low-mass, low-cost and small, falling into the “small sat” classification. The spacecraft are designed to be attached to an ESPA ring. They were designed and built by Lockheed Martin. Each spacecraft carries two science instruments, a visible and an IR imager, both built by Malin Space Science Systems (see Fig. 1 and Tab. 1).

Mission Approach: The Janus spacecraft can be launched as a rideshare or on a dedicated launch. Minimum launch conditions for an Apophis flyby are to transfer the S/C to the Earth-Sun L1 or L2 region, from which they can perform lunar flybys to transfer to

a flyby trajectory. A higher energy launch can yield improved flyby conditions with lower flyby speeds.

Current thinking is that the two spacecraft flyby would be phased by about 15 hours to enable both sides of Apophis to be observed, as Apophis’ spin is in a complex state with a precession period of around 30 hours. Due to the complex rotation, full observability of the asteroid cannot be guaranteed.

On approach and departure from the flyby the spacecraft will perform rigorous remote sensing campaigns when Apophis is a point source and when resolved. On approach and departure light curves will be observed to precisely determine the rotational phasing of Apophis. When resolved the spacecraft will track Apophis through closest approach, allowing for a combination of absolute surface resolution, relative resolution across the target and broad phase angle coverage.

Janus Science Goals: The Janus science goals at Apophis would be twofold. First would be to estimate and constrain the surface morphology and internal properties of a small, tumbling asteroid. The second would be to document the pre-encounter state of Apophis to enable comparative studies focused on the effect of the close approach on that asteroid.

The science goals would be achieved by combining flyby observations of the target asteroid with ground-based observations of the systems and post-flyby observations from the OSIRIS-APEX mission. This combination will enable the high resolution imaging and thermal data to be placed into a global context, leveraging all available data to construct an accurate topographical and morphological model of the body. In addition, the rotational dynamics of Apophis will be improved using the approach and departure observations, in order to constrain the inertias of the system components and hence gain insight into the mass distribution properties of this asteroid.

Conclusions: Janus originally was a SIMPLEX mission that was to launch with the NASA Discovery mission Psyche in August 2022. The spacecraft are now in storage awaiting future use. These spacecraft, the Janus team expertise, and the extensive encounter planning the Janus team developed for the nominal mission, are all transferable to a highly-consequential Apophis encounter. This combination provides a very mature, low-cost pathway to realize critical data on Apophis.

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Figure 1: The delivered Janus JCam Suite from MSSS.

Table 1: Instrument specifications.

Instrument	Specifications
Visible Imager	ECAM-M50, 2592 x 1944 pixel CMOS sensor with 2.2 μm pixels, 420-680 nm bandpass, and an electronic rolling shutter.
IR Imager	ECAM-IR3a, 640 x 480 uncooled Long-Wave Infrared (LWIR) microbolometer sensor array with 17 μm pixels and 8-12 μm bandpass.
DVR	ECAM-DVR4, power conditioning, camera control, image processing, compression, subset windowing and storage.