2025 PN$_7$: A Natural Quasi-Moon or the Zond 1 Mission?

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ABSTRACT

We examine the possibility that Earth's recently discovered "second moon" or quasi-satellite, 2025 PN$_7$, is a relic of the Soviet Zond 1 mission to Venus, launched on April 2, 1964. Zond 1 was a failure due to technological complications, though it managed to approach Venus within 100,000 km. As 2025 PN$_7$ achieved a pericytherion of 0.2 au at that time, it is less likely to be the Zond 1 probe itself but the Blok-L upper stage. Evidence for this includes a closest approach to Venus of 2025 PN$_7$ in July 1964, around the intended arrival time of Zond 1; a similar evolution in heliocentric longitude between the two objects over the probe's intended path; 2025 PN$_7$ settled into its Earth quasi-satellite orbit status close to the launch of Zond 1; and similar calculated and measured absolute magnitudes for the two objects. Future spectroscopic observations could test this association.

1. INTRODUCTION

The discovery on August 2, 2025 of a new Earth quasi-satellite, described as a candidate for Earth's "second Moon" (C. de la Fuente Marcos & R. de la Fuente Marcos 2025), has been extensively reported and widely discussed. Designated 2025 PN$_7$, this "Arjuna" object has, by definition of a quasi-satellite, an orbital period close to 1 year, though a significantly non-zero heliocentric eccentricity of ~ 0.1075, resulting in its extended presence close to Earth, despite following a heliocentric orbit.

In fact, the designation 2025 PN$_7$ as a quasi-satellite is temporary and it has only held this status since the 1960s, a period well known for major advances by both the Soviet and US space programs, particularly in exploring our Moon and the planets Venus and Mars. This naturally leads to the question: "is 2025 PN$_7$ technogenic?" - in other words is it a relic of an interplanetary mission from that time?

2. METHOD

To generate the interplanetary mission trajectories from the 1960s to the current time, the Earth departure and planetary arrival times were provided to 'Optimum Interplanetary Trajectory Software' (OITS), developed by Adam Hibberd (A. Hibberd 2017; A. Hibberd 2022), exploiting NOMAD (S. Le Digabel 2011) and MIDACO (M. Schlueter et al. 2009; M. Schlueter & M. Gerdts 2010; M. Schlueter et al. 2009). For every mission, the transfer orbit followed by the spacecraft could be generated and compared against the trajectory of 2025 PN$_7$, in order to ascertain whether this object could be associated with the mission in question.

Having derived the mission candidates, further investigation of the trajectories themselves could be conducted.

3. RESULTS

The top left panel of Figure 1 reveals 2025 PN$_7$'s mean separation from Earth, using a 20-year simple moving average, indicating that its placement as a quasi-satellite of Earth was around the time of the Zond 1 launch on April

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2, 1964 (P. S. Clark 1985).

Comparison of the heliocentric longitude of 2025 PN$_7$ at the arrival dates of 26 Venus missions with the longitudes of the corresponding missions at these times reveals a low discrepancy in the Zond 1 mission to Venus (top right), and also a similar, though slightly larger deviation for the Venera 8 mission.

Examination of the displacement of the asteroid from the Zond 1 probe for the duration of its flight (lower left panel), implies a low, yet unconvincing deviation with a minimum value of ~ 0.08 au around May of 1964.

However, comparison of the heliocentric longitudes of the two objects reveal they follow an almost identical evolution for the entire flight of Zond 1 (lower right).

Nevertheless, identifying 2025 PN$_7$ as the Zond 1 probe is problematic since the object's pericyntherion is around 0.2 au, well shy of the required ~ 0.72 au heliocentric distance. Could this instead be the Blok-L upper stage (A. LePage 2025)? Indeed, could the Blok-L have fallen short of Venus, in the way 2025 PN$_7$ did?

To explore this we consider the familiar energy equation for orbital motion (R. H. Battin 1999), and differentiate with respect to the heliocentric speed, V:

$$\frac{da}{dV} = \frac{2a^2 V}{\mu} \ , \tag{1}$$

where a is the semi-major axis, and μ gauges the gravitational mass of the Sun and has units of $\mathrm{m^3 s^{-2}}$. If we further assume that the Earth is at aphelion of the transfer orbit and the Blok-L followed a Hohmann transfer to Venus, we can rewrite this as:

$$dV = \frac{\mu}{4V a^2} dq \ , \tag{2}$$

where dq is the error in perihelion, i.e. the aforementioned ~ 0.2 au. We have for a Hohmann to Venus that a = 0.86 au and we also suppose V ~ 30 km s^{-1}. Taking $\mu = 1.327 \times 10^{20}$ m^{3}s^{-2}, we derive a velocity error of the upper stage of ~ -2 km s^{-1}.

Note this does not translate directly into the upper stage velocity increment, i.e. ΔV. Blok-L/Zond 1 were first injected into an Earth parking orbit (by a *Molniya 8K78M* launch vehicle - see A. LePage (2025); Astronautix (2025)) of ~ 200 km altitude, from which the Blok-L accelerated the Zond 1 probe towards Venus.

The following relationship holds for the Blok-L burn:

$$V_{per}^2 = V_{esc}^2 + V_{\infty}^2 \ , \tag{3}$$

where V$_{per}$ is the Blok-L geocentric velocity needed to deliver the payload to the hyperbolic excess speed (V$_{\infty}$) which will eventually send the probe towards Venus. V$_{esc}$ is the Earth escape velocity at 200 km altitude.

We have for the Zond 1 mission that V$_{\infty} = 3.5$ km s^{-1} and from equation 3 we find that V$_{per} = 11.6$ km s^{-1}.

Similarly inserting V$_{\infty} = 1.5$ km s^{-1} (i.e. 3.5 - 2.0 km s^{-1}), and using the above equation again we arrive at V$_{per}$ = 11.1 km s^{-1}. Thus the deficit in ΔV would amount to ~ 500 m s^{-1}.

A pertinent observation is that the Blok-L for the Zond 1 mission may have failed to deliver the required ΔV - see P. S. Clark (1985) - since after the Blok-L burn, Zond 1 needed to conduct an additional burn (possibly to correct for a shortfall), i.e. on April 3, 1964.

It is questionable whether the Zond 1 probe could have sufficiently corrected for such a ΔV deficit, as an estimate by P. S. Clark (1985) gives an available ΔV envelope of only 100 m s^{-1} for this spacecraft.
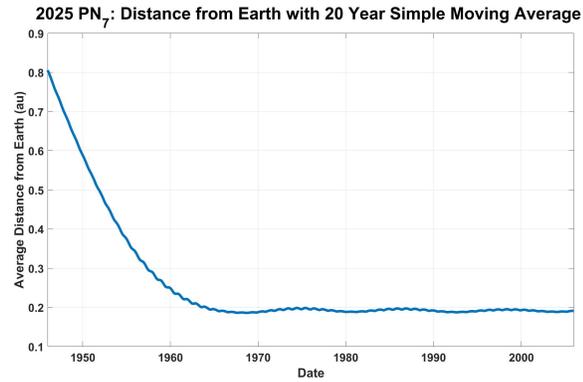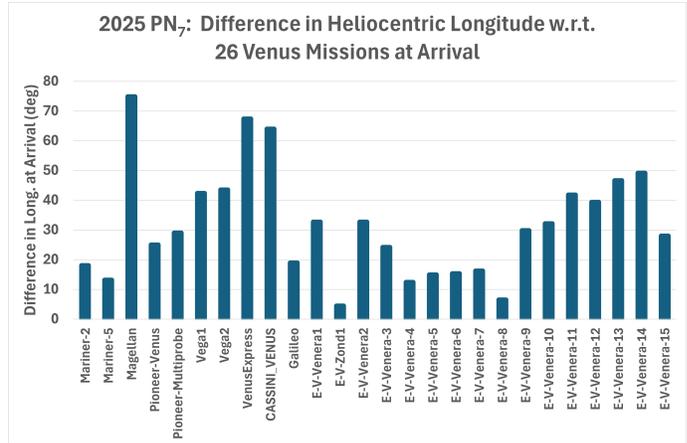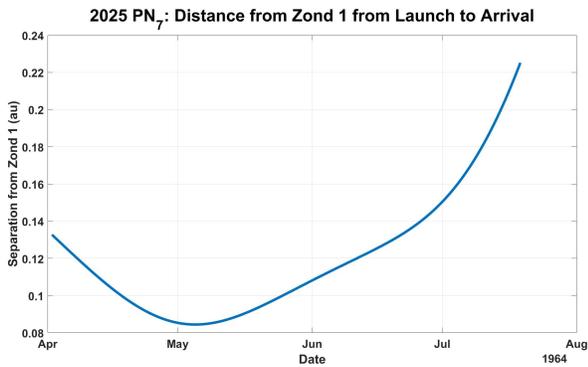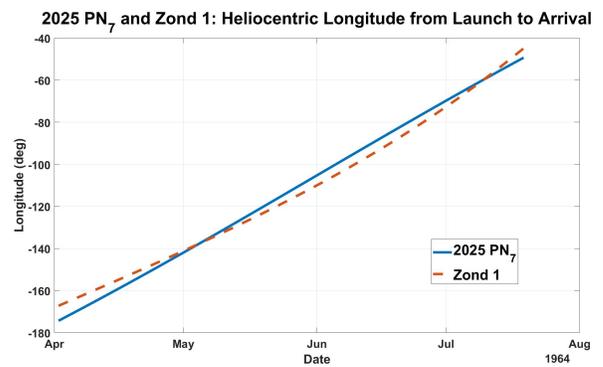
Figure 1. (a) Distance between 2025 PN$_7$ (from NASA Horizons) and Earth averaged over time indicating an arrival as Earth quasi-satellite around the mid-1960s when Zond 1 was launched, (b) difference in arrival heliocentric longitude between 2025 PN$_7$ and each Venus mission examined. (c) displacement between 2025 PN$_7$ and the Zond 1 probe throughout its trip to Venus (d) difference in heliocentric longitude with respect to Zond 1 for the entire journey.

4. DISCUSSION

Calculation of the Blok-L's absolute magnitude, based on a highly reflective albedo of $\sim$1, gives a value of $\sim$ 27.8, assuming a dimension of 3.2 m. This is comparable with C. de la Fuente Marcos & R. de la Fuente Marcos (2025), which quotes an absolute magnitude of 26.4 ± 0.3 for 2025 PN$_7$. A contributing factor to this difference is the H-G phase function used for the latter figure, which assumes a generic asteroid behavior for the body, and is clearly not applicable to the Blok-L.

Comparing the inclination of 2025 PN$_7$ around the time of Zond 1 launch with that of the spacecraft, we find $2.44°$ and $3.42°$ respectively, not that different.

5. CONCLUSION

It is possible that 2025 PN$_7$ is the Blok-L upper stage of the failed Russian Zond 1 mission to Venus, though this should be verified by spectroscopic analysis of the object. A measurement of the spectrum of 2025 PN$_7$ could potentially reveal its surface composition and test whether its origin is technological, as was the case[3] in identifying

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[3] https://www.nasa.gov/science-research/planetary-science/new-data-confirm-2020-so-to-be-the-upper-centaur-rocket-booster-from-the-1960s/

the space object 2020 SO discovered by Pan-STARRS1 as the Centaur upper stage of the Surveyor 2 mission launched by NASA on September 20, 1966.

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