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mission control

Undaunted exploration

NASA's New Horizons mission to the outer Solar System has revolutionized our understanding of the Pluto–Charon system. But, **Richard P. Binzel** explains, this is only half the story of this intrepid spacecraft, as it voyages even further through the Kuiper Belt.

Sometimes we have to step back and remind ourselves just how far we have come. When NASA's New Horizons mission to Pluto secured funding in 2003, that go-ahead paralleled the exploratory journey by Lewis and Clark commissioned 200 years earlier by President Thomas Jefferson. Each promised to be a daunting voyage to the very limits of the known frontier: expanding the horizons of exploration from the scale of a continent to that of our known planetary system in just two centuries speaks to the enduring curiosity of the human spirit.

What made us curious about Pluto? Decades of telescopic study following its discovery in 1930[1] showed Pluto to be a world unlike any we had ever viewed, slowly spinning (once per 6.4 Earth days) and tipped on its side with stunning bright and dark contrasting surface regions rotating in and out of view. With the 1978 discovery of its large moon Charon[2], roughly half the size of the ~2,400-km-diameter Pluto, the pair became the first known 'double planet'. When a thin atmosphere was discovered in 1988[3], intrigue deepened as rapid climate change became immediately foretold. At that time, with Pluto heading towards aphelion and its southernmost latitudes plunging into a century-long polar night, the imperative for exploration grew. A dozen researchers led by Alan Stern and known as the Pluto Underground built their mission concepts and science case from the late 1980s through the 1990s[4]. Pluto's exploration finally received its imprimatur from the US National Research Council's 2002 planetary decadal survey, and construction of New Horizons got underway.

To keep the New Horizons spacecraft (pictured) small — about the size of a grand piano — and under 500 kg fully fuelled, key objectives were keenly focused: to map the surface geology and composition of Pluto (and Charon), to measure the structure and composition of its atmosphere, and to characterize the system's overall space environment. Using electronics miniaturization heritage from the era of the first mobile flip phones, seven instruments, each under 10 kg and operating on only about 10 watts, were chosen to do the job and fit within the engineering constraints. Although small, the package is enviable and would likely top the list if being selected anew today: a 21-cm-aperture long-range camera, three spectral imagers ranging from the ultraviolet to the near-infrared, separate plasma and charged-particle detectors, and a student-built dust counter. A very modest 2.1 m antenna is employed to send the data home. It was not only a long road to the January 2006 launch, but also throughout the 9.5 years of flight to Pluto, and then the nearly 18 months needed for the full flyby dataset to be transmitted to the ground.

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An artist's impression of the New Horizons spacecraft, superimposed on an image of Pluto obtained with New Horizons.

Encounter day, 14 July 2015, proved tense and exhilarating, the most nail-biting experience being the four-and-a-half hours of terror as the post-flyby encounter signal traversed the span of our Solar System. Gathered team members, families, and general public alike crowded the Johns Hopkins University Applied Physics Laboratory auditorium and exalted as the successful encounter signal was confirmed.

And boy oh boy, Pluto delivered! Even seasoned Pluto veterans were left with mouths agape and bewildered stares. New Horizons revealed Pluto as an astoundingly active world that is constantly renewing large regions of its surface, with convection cells of nitrogen ice being the recycling programme keeping its broad plain (called Sputnik Planitia) crater free. Nitrogen glaciers flow into the basin from higher elevations and mountains of water ice as high as the Swiss Alps rise from the region further south. Mountain-building processes on Pluto remain a mystery, confounded by one feature (informally called Wright Mons) that has the morphology of a shield volcano. The forecast for seasonal processes was abundantly verified, with a full range of timescales appearing to be relevant. Haze-layer structures in the atmosphere could form on timescales as short as a rotational day, bright deposits of methane ice appear distributable over the orbital year, escaping methane from Pluto's atmosphere appears to cap Charon's poles, and smooth flat frozen nitrogen lakes may point to long-term Milankovitch cycles of Pluto's axis tilt (spanning 3 million years) inducing 'super seasons' of higher atmospheric pressures.

And the exploration by New Horizons continues. Ahead, in its traverse across the Kuiper Belt, is an estimated 40-km-object labelled 2014 MU69. The Kuiper Belt object flyby on 1 January 2019 promises to give our era's one and only view of this abundant population of small remnants that is forever residing beyond Neptune. Fundamentally, we hope to gain insights into how MU69 is similar to the small satellites in the Pluto system and to comets that may have been cast into the inner Solar System from the far reaches of our Sun.

Ultimately, New Horizons will become like Pioneer and Voyager: forever flying as the most enduring monuments to the boundless spirit of human exploration. ❐

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References

1. Tombaugh, C. W. & Moore, P. *Out of the Darkness* (Stackpole Books, 1980).
2. Christy, J. W. & Harrington, R. S. *Astron. J.* **83,** 1005–1008 (1978).
3. Elliot, J. L. *et al. Icarus* **77,** 148–170 (1989).
4. Neufeld, M. J. *Phys. Today* **69,** 40 (April, 2016).