Triton Hopper: Exploring Neptune's Captured Kuiper Belt Object

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Abstract. Neptune's moon Triton is a fascinating object, a dynamic moon with an atmosphere, and geysers. Triton is unique in the outer solar system in that it is most likely a captured Kuiper belt object (KBO)—a leftover building block of the solar system. When Voyager flew by it was the coldest body yet found in our solar system (33 K) and had volcanic activity, geysers, and a thin atmosphere. It is covered in ices made from nitrogen, water, and carbon-dioxide, and shows surface deposits of tholins, organic compounds that may be precursor chemicals to the origin of life.

Exploring Triton will be a challenge well beyond anything done in previous missions; but the unique environment of Triton also allows some new possibilities for mobility. We developed a conceptual design of a Triton Hopping probe that both analyzes the surface and collects it for use to propel its hops. The Hopper would land near the South Pole in 2040 where geysers have been detected. Depending the details of propulsion chosen the Hopper should be able to jump over 300 km in 60 hops or less, exploring the surface and thin atmosphere on its way. This craft will autonomously carry out detailed scientific investigations on the surface, below the surface (drilling) and in the upper atmosphere to provide unprecedented knowledge of a KBO turned moon and expanding NASA's existing capabilities in deep space planetary exploration to include Hoppers using different ices for propellant.

Triton is roughly 2700 km in diameter with a surface of mostly frozen nitrogen, mostly water ice crust and core of metal and rock. Its gravity is half that of Earth's Moon and its atmosphere is 1/70,000th of Earths or 0.3% of Mars.

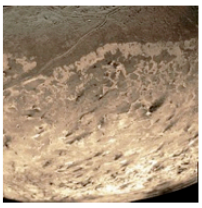

Figure 1.1—Voyager Image of South Pole of Triton Showing Geysers

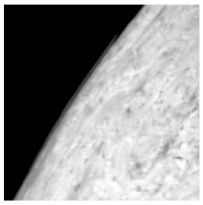

Figure 1.2—Voyager Image Showing Thin Atmosphere

Figure 1.3—Triton Hopper Concept

The mission concept studied investigated the full surface and atmospheric phenomenon: chemical composition of surface and near subsurface materials, the thin atmosphere, volcanic and geyser activity. Measurements of all these aspects of Triton's unique environment can only be made through focused *in situ* exploration with a well-instrumented craft. And this craft will be provided revolutionary mobility, nearly global, using in-situ ices as propellants.

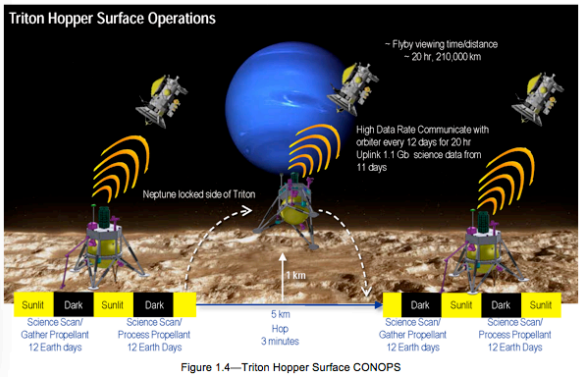

Figure 1.4—Triton Hopper Surface CONOPS

While other concepts have looked at gathering gases at Mars to propel a hopper, long periods of time are needed to gather the thin CO_2 atmosphere. Several gases, mainly nitrogen are on the surface in a readily dense ice form and just need to be picked up, vaporized and used for propellant.

This paper will describe the mission options to get to Triton, a notional descent system and the design of a hopper to explore large parts of Triton. Trades on propellant gathering and propulsion will be explained.