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# Baseline design of new horizons mission to Pluto and the Kuiper belt

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**Abstract**

The New Horizons mission is progressing toward its planned launch in January 2006. Current plans call for the New Horizons spacecraft to be launched by a newly developed evolved expendable launch vehicle (EELV) Atlas V 551 with the STAR 48B kick stage in January/February 2006. After flying for more than 32 AU and traveling through the inner and outer solar system, the spacecraft is expected to arrive at Pluto as early as July 2015 for the first scientific reconnaissance investigations of the last planet that has not yet been visited by a spacecraft. This paper describes the baseline mission design, which includes the baseline launch scenario that maximizes the launch probability with an extensive launch period of 35 days, the interplanetary trajectory design that allows the spacecraft to fly fast to Pluto by taking advantage of the gravity assist from Jupiter, the trajectory design of the close encounter with Pluto and its moon Charon, and the mission plan for the extended mission beyond Pluto to fly by a Kuiper belt object. *Note*: New Horizons is NASA's planned mission to Pluto and has not been approved for launch. All representations in this paper are contingent on a decision by NASA to go forward with the preparation for and launch of the mission.


## 1. Introduction

The New Horizons (NH) mission would send the first ever spacecraft to visit the outermost planet of the solar system, Pluto, and its half-sized moon, Charon, and also to explore the Kuiper belt for the first time. The Kuiper belt is the outer solar system beyond Neptune's orbit, extending from 30 Astronomical Units (AU) to possibly hundreds of AU from the Sun. (One AU is the mean distance between the Earth and Sun.) Within the Kuiper belt, there exist a great number of small icy bodies known as the Kuiper belt objects (KBOs). It is still under debate in the scientific community whether Pluto is a planet or the largest Kuiper belt object.

Pluto, the ninth planet from the Sun, was discovered by Clyde Tombaugh in 1930. However, it does not quite fit in with the rest of the planets. Unlike the other eight planets, whose orbits are mostly in the ecliptic plane, Pluto's orbit is greatly out of the ecliptic plane, inclined by about 17°. The orbits of the other planets are nearly circular, while the orbit of Pluto is highly eccentric. Pluto moves as close to the Sun as 29.7 AU at perihelion and as far as 49.4 AU from the Sun at aphelion. This vast variation of its distance from the Sun causes the environment and conditions on Pluto to change dramatically. After passing perihelion in September 1989, Pluto is now moving away from the Sun. Pluto's surface temperature continues to decrease as its distance from the Sun increases each year. As it gets colder and colder, the gases surrounding Pluto will eventually freeze to the ground. Planetary scientists predict that the atmosphere on Pluto may disappear as soon as 2020. Observing Pluto's atmosphere again would not be possible for another two centuries, when Pluto returns from aphelion, as the orbit period of Pluto is 248 Earth years.

The Kuiper belt was suggested by Gerald Kuiper, who predicted in 1951 as a hypothesis that the

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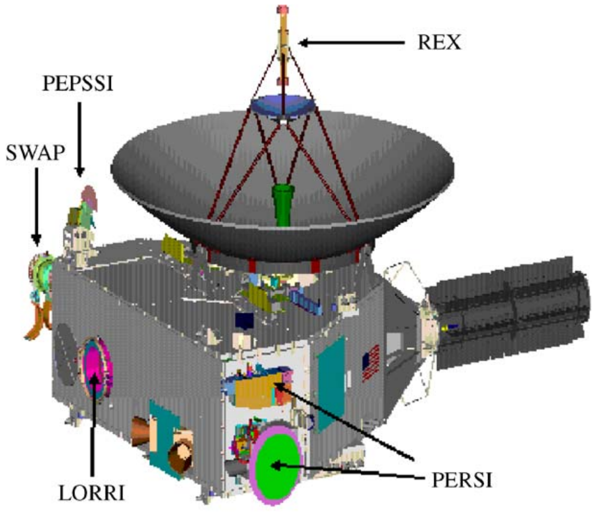
short-period comets originate from a collection of material left over from the formation of the solar system. Kuiper's theory was proved with the discovery of the first Kuiper belt object by Jewitt and Luu [1] in 1992. Since then, more and more KBOs have been discovered each year. So far, the number of KBOs identified is about 800, which is believed to be only a very small fraction of the total number of KBO. The NH spacecraft plans to make a close flyby of one or more of the KBOs after an encounter with Pluto and Charon.

Given the limited time and unique opportunity for observing Pluto's state before its atmosphere collapses, NASA made plans in 2001 to develop and launch the NH mission for a scientific reconnaissance observation of Pluto by the year 2020 and for a flyby of the Kuiper belt objects in an extended mission. Pluto–Kuiper was ranked number one in the solar system exploration priority in the National Research Council's space exploration survey [2]. The NH mission, lead by Principal Investigator Alan Stern of the Southwest Research Institute (SwRI) and designed and managed for NASA by the Johns Hopkins University Applied Physics Laboratory (JHU/APL), is the first mission of NASA's Frontier Program, a program established for medium class missions with a budget of under $500 million. A baseline mission design has been approved. This paper describes the baseline mission design of the NH mission to Pluto and the Kuiper belt. Mission options investigated during the preliminary design phase were described in Ref. [3]. Detailed discussions on the design of the Pluto–Charon encounter and the modeling and simulations of the science observations during the Pluto–Charon flyby were described in Ref. [4].

## 2. Mission overview

The first Pluto and Kuiper belt exploration is to be implemented by flying a spacecraft to the distant Pluto for a close flyby as early as 2015 and to fly by one or more Kuiper belt objects after the Pluto encounter. Comprehensive reconnaissance observations will be carried out through instruments carried onboard the spacecraft during the flybys. Data collected during the flybys, such as high-resolution images of Pluto, Charon, and KBOs, will be transmitted from the spacecraft to the Deep Space Network (DSN).

Two launch opportunities are currently being considered for the NH mission, the 2006 baseline launch and the 2007 backup launch. The 2006 baseline launch opportunity window opens on January 11 and closes on February 14, a launch period of 35 days. The 2006 window requires a maximum launch energy ($C_3$) of 164 $km^2/s^2$. The 2007 Backup launch has a 14-day launch period from February 2 to 15, 2007, with arrival at Pluto in 2019 and 2020. The 2007 backup launch requires a higher $C_3$ of 166.2 $km^2/s^2$, which results in a lighter spacecraft with propellant loading of 20 kg less than that of the 2006 launch. The NH spacecraft will be launched aboard an Atlas V 551 with a STAR 48B kick stage from the Cape Canaveral Air Force Station in Florida.




- Wet mass:478 kg
- Communications: X-band, 2.1m high gain antenna
- Data downlink rate at Pluto: 768 bits per second
- Attitude control:3-axis and spin-stabilized modes
- Propulsion: Hydrazine monopropellant

Fig. 1. New Horizons spacecraft (baseline design).

The NH spacecraft weighs as much as 478 kg, including 80 kg of propellant, and has a triangular shape, as shown in Fig. 1. The baselined radioisotope thermoelectric generator (RTG) will provide electric power to the spacecraft and instruments throughout the mission, as the usual solar power does not work for spacecraft traveling to the outer solar system. The spacecraft's communication system consists of a 2.1-m high gain antenna (HGA), a medium-gain antenna, and a low-gain antenna. Telemetry data are transmitted in the X-band. The spacecraft can either be spin-stabilized or three- axis-stabilized. During cruises, the spacecraft is mostly spinning with the HGA pointing at Earth. During the Jupiter, Pluto–Charon, and KBO