New Horizons Mission Overview

This material was originally adapted from the New Horizons web site. During the migration to Planetary Data System's (PDS) PDS4 data standards, this current description was adapted from the latest PDS3 New Horizons mission catalog file, providing light edits to the text, format, and flow. The mission stop date is the stop date of the Pluto mission phase. Later mission phases are part of the New Horizons Kuiper Belt Extended Mission.

Summary

Launch:	January 19, 2006
Launch Vehicle:	Atlas V 551 first stage; Centaur second stage; Star 48B solid rocket third stage
Location:	Cape Canaveral Air Force Station, Florida
Trajectory:	To Pluto and the Kuiper Belt via Jupiter Gravity Assist

Mission Overview

The primary science goals of the New Horizons (NH) mission are to characterize the global geology and morphology of Pluto and Charon, to map the surface composition of Pluto and Charon, and to characterize the neutral atmosphere of Pluto and its escape rate (NASA AO 01-OSS-01 (2001); Stern & Spencer (2004a)).

Mission Design

The New Horizons spacecraft trajectory was designed to have as early an arrival time at Pluto as practicable.

There are two reasons why the New Horizons science team wanted to reach Pluto and Charon quickly. The first has to do with the Pluto atmosphere: Since 1989, Pluto has been moving farther from the Sun, getting less heat every year (Lunine et al. (1995)). As Pluto gets colder scientists expect its atmosphere will freeze out, so the team wanted to arrive while there is a chance to see a thicker atmosphere.

The second reason is to map as much of Pluto and Charon as possible. As New Horizons approaches and flies by the Pluto system, parts of Pluto or Charon will be in constant darkness, and, the later the flyby, the more of Pluto and Charon that will be unlit.

In addition, the trajectory was designed to enable all of the science goals, including Solar and Earth occultations by Pluto and Charon.

Prime Opportunity: Jupiter

By launching in January 2006, New Horizons took advantage of a gravity assist from Jupiter. In February 2007, New Horizons passed through the Jupiter system at about 80,000 km/h, ending up on a path that gets it to Pluto on July 14, 2015.

Science Opportunities at Jupiter included meteorology, aurora studies, magnetospheric sampling, and dust sampling and ultraviolet mapping of the torus around Io. Surface mapping, compositional mapping and atmospheric studies of the Jovian moons were possible, as was a close encounter with a small Jovian satellite.

Cruise from Jupiter to Pluto

During the PLUTOCRUISE mission phase from Jupiter to Pluto, the mission team monitored the health of the spacecraft while planning and practicing for the encounter with Pluto and Charon. At the same time, observers used telescopes on Earth and in Earth orbit to search for Kuiper Belt Objects (KBOs) the spacecraft can fly by after Pluto and Charon (as part of an extended mission). The KBOs are ancient, icy bodies that orbit beyond Neptune.

Closing In: Pluto

The cameras on New Horizons started taking data on Pluto and Charon months before the spacecraft arrived. Pluto and Charon first appeared as unresolved bright dots, but the view of the planet and its largest moon grew as the encounter date approached. About three months from the closest approach - when Pluto and Charon were about 105 million kilometers away - the cameras on the spacecraft made the first maps. For those three months, the mission team took images and spectral measurements.

Pluto and Charon each rotate once every 6.4 Earth days. For the last three Pluto days before encounter (21 Earth days), the team compiled maps and gathered spectral measurements of Pluto and Charon every half-day. The team then compared these maps to look for changes over a Pluto day, at a scale of about 48 kilometers.

The Encounter

The busiest part of the Pluto-Charon flyby lasted a full Earth day, from a half-day before closest approach to a half-day after. On the way in, the spacecraft looked for ultraviolet emission from the Pluto atmosphere and made the best global maps of Pluto and Charon in green, blue, red and a special wavelength detector that is sensitive to methane frost on the surface. It also made spectral maps in the near-infrared, telling the science team about the Pluto and Charon surface compositions and locations and temperatures of these materials.

The spacecraft closest approaches were 13,674 kilometers from the center of Pluto at 14-JUL-2015 11:48:28.771 UTC (+/-0.6s or +/-8km time-of-flight; +/-5km cross-track) and 29,428 kilometers from the center of Charon at 14-JUL-2015 12:02:22.072 UTC. The flyby distances are based on the New Horizons SPICE data set circa October, 2016. During the half-hour when the spacecraft was closest to Pluto or its largest moon, it took close-up images in both visible and near-infrared wavelengths. The best images of Pluto depict surface features as small as about 60 meters across.

Even after the spacecraft passed Pluto and its moons, its work was far from done. Looking back at the mostly dark side of Pluto or Charon was the best way to spot haze in the atmosphere, to look for rings, and to determine whether their surfaces are smooth or rough. Also, the spacecraft flew through the shadows cast by Pluto and Charon. As it looked back at the Sun and

Earth, it measured the light from the Sun and the radio waves from transmitters on Earth. A unique time to measure the atmosphere occurred when the spacecraft measured those signals as the Sun and Earth set behind Pluto and Charon and then rose again on the other side.

Calibration Campaign

The year following Encounter, in July 2016, a Calibration Campaign was conducted with calibration activities for each instrument, providing performance data for the analysis of data from the Encounter.

Mission Phases

Summary of mission phases

Mission phases provide convenient handles and approximate time boundaries to

1. partition the data into very broad categories of mission activity
2. provide approximate time boundaries for PDS archive data sets

The mission is continuous, so the boundaries are very soft i.e. in an operational sense they do not exist in a noticeable way.

That being the case, the user should not expect the actual range of times covered by data in any given data set to exactly agree with the boundaries of the corresponding mission phase described below; the data set time range may be far less or it may overlap the boundaries. This is intentional and will not be changed.

For example, during the New Horizons mission it was decided to deliver data sets for the first three years of the 7.5-year Pluto Cruise mission phase before that mission phase was complete. As such, the time range of those data sets was from 2007 until mid- to late-2010, while the mission phase described below extends through the end of 2014. The intention was to deliver the balance of the Pluto Cruise at a later date. Once all Pluto Cruise data are delivered this paragraph will become obsolete; nonetheless this paragraph may be left in place as an example of the intentional flexibility of the boundaries between the mission phases defined in the dates below.

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                                     Full MISSION_PHASE_NAME,
Short name    Start(1,3)  Stop(2,3)  plus optional Description
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LAUNCH        2006-01-19  2006-12-31 POST-LAUNCH CHECKOUT

JUPITER       2007-01-01  2007-06-26 JUPITER ENCOUNTER

PLUTOCRUISE   2007-06-27  2015-01-15 PLUTO CRUISE,
                                     Jupiter-Pluto/Charon
                                       Interplanetary Cruise

PLUTO         2015-01-15  2016-10-26 PLUTO ENCOUNTER,
                                      Pluto mission phase,
                                      Pluto/Charon approach,
                                       flyby, post-encounter

Notes:

1 Start at 00:00:00 UTC on the spacecraft that day
2 End before 00:00:00 UTC on the spacecraft next day
3 Start and end dates are not exact and identical for all
  instruments; some instruments take single observations over several
  days which span these mission phase boundaries. Late (re)playbacks
  can also require the inclusion of new or modified data files from
  an earlier mission phase.
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Post-Launch Checkout

Short phase name:	LAUNCH
Formal mission phase name:	POST-LAUNCH CHECKOUT
Mission Phase Start Time:	2006-01-19
Mission Phase Stop Time:	2006-12-31

This phase includes spacecraft and instrument checkouts, instrument calibrations, trajectory correction maneuvers, and rehearsals for the Jupiter encounter.

Jupiter Encounter

Short phase name:	JUPITER
Formal mission phase name:	JUPITER ENCOUNTER
Mission Phase Start Time:	2007-01-01
Mission Phase Stop Time:	2007-06-26

Closest approach occurred on Feb. 28, 2007. Moving about 21 kilometers per second, New Horizons flew 3 to 4 times closer to Jupiter than the Cassini spacecraft, coming within 32 Jupiter radii of Jupiter.

Pluto Cruise

Short phase name:	PLUTOCRUISE
Formal mission phase name:	PLUTO CRUISE
Mission Phase Start Time:	2007-06-27
Mission Phase Stop Time:	2015-01-15

Activities during the approximately 8-year PLUTOCRUISE mission phase to Pluto include annual spacecraft and instrument checkouts (Annual CheckOuts (ACOs)), trajectory corrections, instrument calibrations and Pluto encounter rehearsals.

Pluto-Charon Encounter

Short phase name:	PLUTO
Formal mission phase name:	PLUTO ENCOUNTER
Mission Phase Start Time:	2015-01-15
Mission Phase Stop Time:	2016-10-26

The Pluto-Charon Encounter phase is broken down into several general sub-phases and/or designation conventions that may be found in various documents throughout the data sets. The overlaps between these designations is intentional and indicate the loose nature of these assignments.

Approach:

Mission Phase Start Time:	2015-01-15
Mission Phase Stop Time:	2015-07-14

Ten weeks before encounter, image resolution exceeded that of the best Hubble Space Telescope images. Four weeks before encounter, daily studies began. New Horizon acquired maps and spectra throughout this period.

Three additional APproach (AP) conventions, AP1, AP2 and AP3, were also in common use, starting on 2015-01-15, 2015-04-05 and 2015-06-23, respectively.

CORE:

Mission Phase Start Time:	2015-07-07
Mission Phase Stop Time:	2015-07-16

This phase comprises all activities in the CORE command sequence load 15188, from seven days before through two days past the Near Encounter with Pluto (NEP; see below). The CORE subphase completely overlaps the NEP designation.

Near Encounter with Pluto (NEP, or Flyby; also Near Encounter Phase):

Mission Phase Start Time:	2015-07-14
Mission Phase Stop Time:	2015-07-14

NEP is not a formal phase, but is used as a designation commonly enough that it is included here.

Activities included taking the highest resolution visible and spectral imaging at closest approach to Pluto and Charon. The time near occultations (Pluto/Sun, Pluto/Earth, Charon/Sun and Charon/Earth) were used for atmospheric studies.

The Time of Closest Approach to Pluto was 14-JUL-2015 11:48:28.771 UTC. The flyby speed was 13.8km/s; the miss distance was 13,674km from the modeled center of Pluto; the 1-sigma uncertainties in that flyby were +/- 0.6s in Time Of Flight (8km along-track), and +/-3.5km cross-track. Refer to the NH SPICE data set NH-J/P/SS-SPICE-6-V1.0 for more detail.

Departure (Post-Encounter):

Mission Phase Start Time: 2015-07-14
Mission Phase Stop Time: 2016-01-09

Four weeks of post-encounter studies and five months of downloading data.

Three additional DeParture (DP) conventions, DP1, DP2 and DP3, were also in common use, starting on 2015-07-16, 2015-08-04 and 2015-10-22, respectively.

Transition:

Mission Phase Start Time: 2016-01-09
Mission Phase Stop Time: 2016-10-26

The transition sub-phase consisted of continued downlink of data from the Pluto Encounter, as well as the Calibration Campaign, and a few distant KBO observations in September of 2016.

Mission phases and sub-phases in data products

Those general phase descriptions above were implemented slightly differently in mission data products; a table of data product mission phase and sub-phase designations follow.

Phase	Sub-phase	UTC	DOY	MET
CHECKOUT		2006-01-16	2006-016	-324483
	LAUNCH	2006-01-16	2006-016	-324483
JUPITER		2007-01-01	2007-001	29915517
	JUPITER	2007-01-01	2007-001	29915517
PLUTOCRUISE		2007-06-29	2007-180	45381117
	PLUTOCRUISE	2007-06-29	2007-180	45381117
	ACO1	2007-09-24	2007-267	52897917
	ACO2	2008-01-01	2008-001	61451517
	ACO3	2009-01-01	2009-001	93073917
	ACO4	2010-01-01	2010-001	124609917
	ACO5	2011-01-01	2011-001	156145917
	ACO6	2012-01-01	2012-001	187681917
	ACO7	2013-01-01	2013-001	219304317

	ACO8	2014-01-01	2014-001	250840317
PLUTO		2015-01-15	2015-015	283585917
	AP1	2015-01-15	2015-015	283585917
	AP2	2015-04-05	2015-095	290497917
	AP3	2015-06-23	2015-174	297323517
	CORE	2015-07-07	2015-188	298533117
	DP1	2015-07-16	2015-197	299310717
	DP2	2015-08-04	2015-216	300952317
	DP3	2015-10-22	2015-295	307777917
	TRANSITION	2016-01-09	2016-009	314603517

Mission Objectives Summary

Group 1 Objectives: Mandatory Science Floor

- Characterize the global geology and morphology of Pluto and Charon
- Map surface composition of Pluto and Charon
- Characterize the neutral atmosphere of Pluto and its escape rate

Group 2 Objectives: Highly Desired

- Characterize the time variability of the Pluto surface and atmosphere
- Image Pluto and Charon in stereo
- Map the terminators of Pluto and Charon with high resolution
- Map the surface composition of selected areas of Pluto and Charon at high resolution
- Characterize the Pluto ionosphere and solar wind interaction
- Search for neutral species including H, H_2, HCN, and C_xH_y, and other hydrocarbons and nitriles in the Pluto upper atmosphere
- Search for an atmosphere around Charon
- Determine bolometric Bond albedos for Pluto and Charon
- Map the surface temperatures of Pluto and Charon

Group 3: Desirable

- Characterize the energetic particle environment of Pluto and Charon
- Refine bulk parameters (radii, masses, densities) and orbits of Pluto and Charon
- Search for additional satellites and rings

References

Lunine, J.I., D. Cruikshank, A.A. Galeev, D. Jennings, D. Jewitt, S. Linkin, R. McNutt, F. Neubauer, L. Soderblom, A. Stern, R. Terrile, D. Tholen, L. Tyler, and R. Yelle, Pluto Express: Report of the Science Definition Team (NASA; unpublished; reconstructed and provided with the New Horizons data sets starting in 2014, now within PDS with LID urn:nasa:pds:nh_documents:mission:lunineetal1995), 1995.

NASA, Pluto Kuiper Belt Mission Announcement of Opportunity. AO 01-OSS-01, 2001. https://webharvest.gov/peth04/20041017163805/http://research.hq.nasa.gov/code_s/nra/current/AO-01-OSS-01/index.html (as of 2023-03-24). Copy provided in PDS with LID urn:nasa:pds:nh_documents:mission:pluto_ao.

Stern, A., and J. Spencer, New Horizons: The First Reconnaissance Mission to Bodies in the Kuiper Belt, In: Davies, J.K., Barrera, L.H. (eds), The First Decadal Review of the Edgeworth-Kuiper Belt, Springer, Dordrecht, 2004. https://doi.org/10.1007/978-94-017-3321-2_42

Further Reading

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