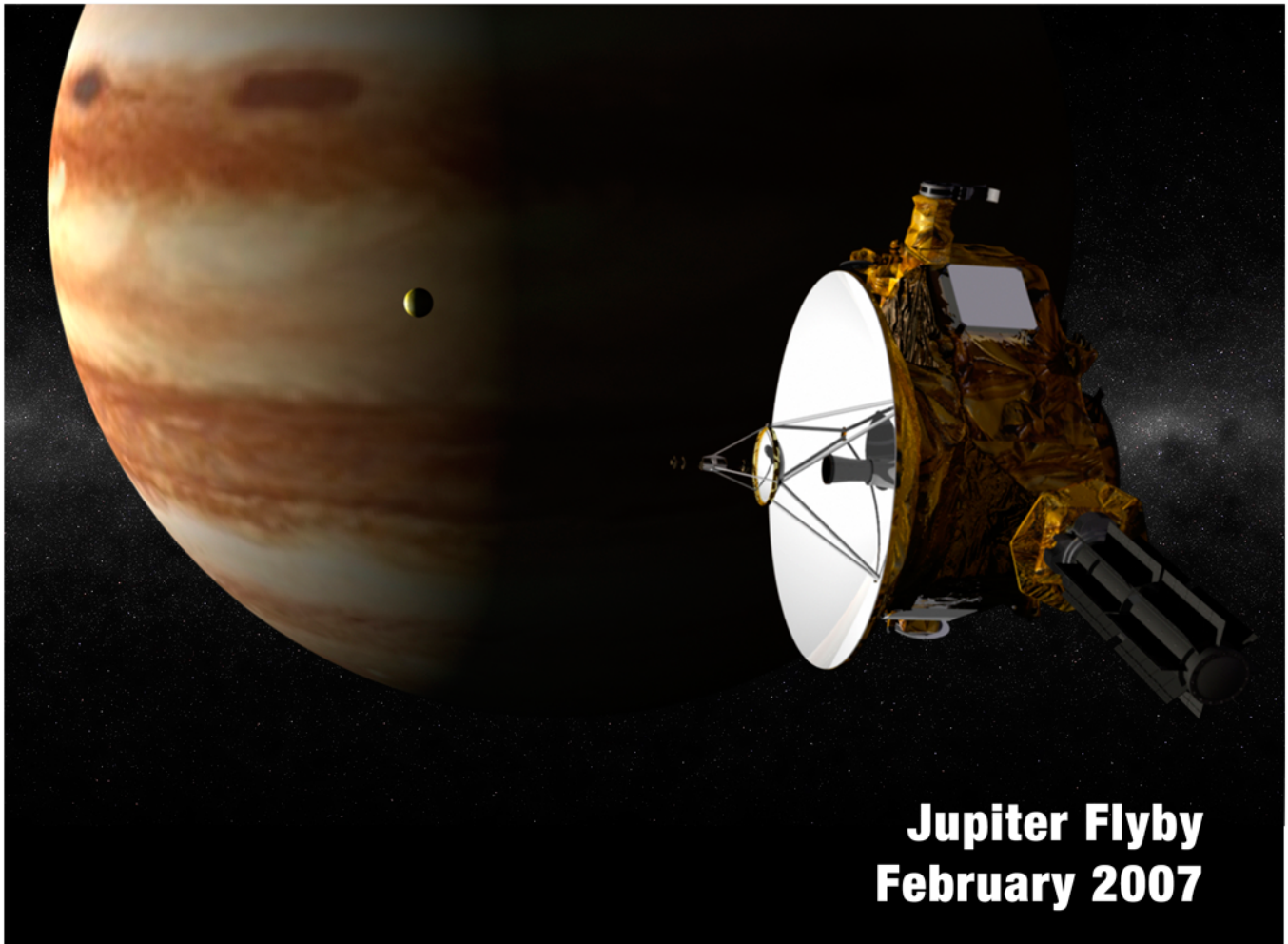


# NEW HORIZONS

The First Mission to Pluto and the Kuiper Belt:  
Exploring Frontier Worlds



**Jupiter Flyby  
February 2007**



A NASA New Frontiers Mission

## Media Contacts

### **NASA Headquarters**

Dwayne Brown  
(202) 358-1726  
dwayne.c.brown@nasa.gov  
www.nasa.gov

### **Policy/Program Management**

### **The Johns Hopkins University Applied Physics Laboratory**

Michael Buckley  
(240) 228-7536 or (443) 778-7536  
michael.buckley@jhuapl.edu  
www.jhuapl.edu

### **Mission Management/Spacecraft Operations**

### **Southwest Research Institute**

Maria Martinez  
(210) 522-3305  
mmartinez@swri.org  
www.swri.org

### **Principal Investigator Institution**

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The information in this press kit was current as of January 18, 2007.  
For mission updates, visit <http://pluto.jhuapl.edu>.

## General Release

### Zooming to Pluto, New Horizons Closes in on Jupiter

Just a year after it was dispatched on the first mission to Pluto and the Kuiper Belt, NASA's New Horizons spacecraft is on the doorstep of the solar system's largest planet — about to swing past Jupiter and pick up even more speed on its voyage toward the unexplored regions of the planetary frontier.

The fastest spacecraft ever launched, New Horizons will make its closest pass to Jupiter on Feb. 28, threading its path through an "aim point" 1.4 million miles (2.3 million kilometers) from the center of Jupiter. Jupiter's gravity will accelerate New Horizons away from the Sun by an additional 9,000 miles per hour — half the speed of a space shuttle in orbit — pushing it past 52,000 mph and hurling it toward a pass through the Pluto system in July 2015.

At the same time, the New Horizons mission team is taking the spacecraft on the ultimate test drive — using the flyby to put the probe's systems and seven science instruments through the paces of a planetary encounter. More than 700 observations of Jupiter and its four largest moons are planned from January through June, including scans of Jupiter's turbulent, stormy atmosphere and dynamic magnetic cocoon (called a magnetosphere); the most detailed survey yet of its gossamer ring system; maps of the composition and topography of the large moons Io, Europa, Ganymede and Callisto; and an unprecedented look at volcanic activity on Io.

The flight plan also calls for the first-ever trip down the long "tail" of Jupiter's magnetosphere, a wide stream of charged particles that extends tens of millions of miles beyond the planet, and the first close-up look at the "Little Red Spot," a nascent storm south of Jupiter's famous Great Red Spot.

"Our highest priority is to get the spacecraft safely through the gravity assist and on its way to Pluto," says New Horizons Principal Investigator Dr. Alan Stern, of the Southwest Research Institute, Boulder, Colo. "But we also have an incredible opportunity to conduct a real-world-encounter stress test to wring out our procedures and techniques for Pluto, and to collect some valuable science data."

The Jupiter test matches or exceeds the mission's Pluto study in duration, data volume sent back to Earth, and operational intensity. Like at Pluto, much of the data from the Jupiter flyby won't be sent back to Earth until after closest approach, because the spacecraft's main priority is to observe the planet and store data on its recorders before transmitting information home.

"We designed the Jupiter encounter to prove out our planning tools, our simulation capabilities, our spacecraft and our instrument sensors on a real planetary target, well before the Pluto encounter," says Glen Fountain, New Horizons project manager at the Johns Hopkins University Applied Physics Laboratory (APL), Laurel, Md., which built and operates the spacecraft. "If the team needs to adjust anything before Pluto, we'll find out about it now."

The mission team at APL, SwRI and other institutions has learned much in a hectic year since New Horizons lifted off from Cape Canaveral Air Force Station, Fla., last Jan. 19. The spacecraft has undergone a full range of system and instrument checkouts, instrument calibrations and commissioning, some flight software enhancements, and three small propulsive maneuvers to adjust its trajectory. Operational highlights of the past year included long-distance snapshots of both Jupiter and Pluto, and a flyby of asteroid 2002 JF56 (recently named “APL” by the International Astronomical Union).

With closest approach to Jupiter coming 13 months after launch, New Horizons will reach the planet faster than any of its seven previous visitors. Pioneers 10 and 11, Voyagers 1 and 2, Ulysses and Cassini all used Jupiter’s gravity to reach other destinations; NASA’s Galileo orbited the planet from 1995-2003.

New Horizons also provides the first close-up look at the Jovian system since Galileo, and the last until NASA’s Juno mission arrives in 2016.

“The Jupiter system is incredibly dynamic,” says New Horizons Jupiter Encounter Science Team lead Dr. Jeff Moore, of NASA Ames Research Center, Moffett Field, Calif. “From constant changes in Jupiter’s magnetosphere and atmosphere, to the evolving surfaces of moons such as Io, you get a new snapshot every time you go there.”

After an eight-year cruise from Jupiter across the expanse of the solar system, New Horizons will conduct a five-month-long study of Pluto and its three moons in 2015, characterizing their global geology and geomorphology, mapping their surface compositions and temperatures, and examining Pluto’s atmospheric composition and structure. Then, as part of a potential extended mission, New Horizons would conduct similar studies of one or more smaller worlds in the Kuiper Belt, the region of ancient, rocky and icy bodies far beyond Neptune’s orbit.

The New Horizons science payload includes imaging infrared and ultraviolet spectrometers, a multi-color camera, a long-range telescopic camera, two particle spectrometers, a space-dust detector and a radio science experiment. The compact, 1,050-pound spacecraft, drawing electricity from a single radioisotope thermoelectric generator, currently operates on slightly more power than a pair of 100-watt light bulbs.

New Horizons is the first mission in NASA’s New Frontiers Program of medium-class spacecraft exploration projects. Stern leads the mission and science team as principal investigator; APL manages the mission for NASA’s Science Mission Directorate. The mission team also includes Ball Aerospace Corporation, the Boeing Company, NASA Goddard Space Flight Center, NASA Jet Propulsion Laboratory, Stanford University, KinetX, Inc., Lockheed Martin Corporation, University of Colorado, the U.S. Department of Energy, and a number of other firms, NASA centers, and university partners.

For more information on New Horizons, visit: <http://pluto.jhuapl.edu>

## Media Services Information

### News and Status Reports

NASA and the New Horizons team will issue periodic news releases and status reports on mission activities and make them available online at <http://pluto.jhuapl.edu> and [www.nasa.gov](http://www.nasa.gov).

When events and science results merit, the team will hold media briefings at NASA Headquarters in Washington or the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. Briefings will be carried on NASA TV and the NASA Web site.

### NASA Television

NASA Television is carried on the Web and on an MPEG-2 digital signal accessed via satellite AMC-6, at 72 degrees west longitude, transponder 17C, 4040 MHz, vertical polarization. It is available in Alaska and Hawaii on AMC-7, at 137 degrees west longitude, transponder 18C, at 4060 MHz, horizontal polarization. A Digital Video Broadcast compliant Integrated Receiver Decoder is required for reception. For NASA TV information and schedules on the Web, visit [www.nasa.gov/ntv](http://www.nasa.gov/ntv).

### New Horizons on the Web

New Horizons information — including an electronic copy of this press kit, press releases, fact sheets, mission details and background, status reports and images — is available on the Web at <http://pluto.jhuapl.edu>. New Horizons multimedia files, background information and news are also available at [www.nasa.gov/newhorizons](http://www.nasa.gov/newhorizons).

Various downloadable New Horizons presentations and pictures can be found at [www.boulder.swri.edu/pkb](http://www.boulder.swri.edu/pkb).

## New Horizons Quick Facts

### Mission

**Launch:** January 19, 2006, from Launch Complex 41 at Cape Canaveral Air Force Station, Florida, aboard a Lockheed Martin Atlas V-551. With a boost from a Boeing STAR-48 solid-propellant third stage, New Horizons sped away from Earth at 36,000 miles per hour — the fastest spacecraft ever launched.

**Primary mission:** First flyby study of Pluto and its moons, Charon, Nix and Hydra.

**Asteroid encounter:** Flew about 102,000 kilometers (63,000 miles) from and “tracked” asteroid 2002 JF56 on June 13, 2006; determined the asteroid’s color, shape and size.

**Jupiter gravity assist:** February 28, 2007. Closest approach at 05:45 Universal Time (12:45 a.m. EST).

**Jupiter closest approach distance and speed relative to Jupiter:** About 2.3 million kilometers (1.4 million miles) at 21 kilometers per second (47,000 miles per hour) relative to Jupiter.

**Heliocentric (Sun-relative) speed at closest approach:** 23 kilometers per second (51,000 miles per hour).

**One-way speed-of-light (radio transmission) time from Jupiter to Earth in February 2007:** 45 minutes.

**Pluto flyby:** Closest approach is July 14, 2015; encounter observations begin in early 2015.

**Planned Pluto closest approach distance and speed:** About 10,000 kilometers (6,200 miles) — or closer if the science team desires — at 14 kilometers per second (31,000 miles per hour).

**Planned Charon closest approach and speed:** About 27,000 kilometers (17,000 miles) — or closer if the science team desires — at same approximate Pluto flyby speed.

**One-way speed-of-light (radio transmission) time from Pluto to Earth in July 2015:** 4 hours, 25 minutes.

**Pluto distance from Earth in July 2015:** Approximately 4.8 billion kilometers (3 billion miles, or 32 astronomical units).

### Spacecraft

**Size:** The primary structure is 0.7 meters (27 inches) tall, 2.1 meters (83 inches) long and 2.7 meters (108 inches) at its widest. A 2.1-meter (83-inch) diameter antenna dish is attached to the top deck; the spacecraft measures 2.2 meters (87 inches) tall from the payload attachment fitting on the bottom deck to the top of the dish antenna stack.

**Launch weight:** 478 kilograms (1,054 pounds); included 77 kilograms (170 pounds) of hydrazine propellant and a 30-kilogram (66-pound) science instrument payload.

**Power:** Total power available for the Pluto-Charon encounter in 2015 is approximately 200 watts from the spacecraft’s single radioisotope thermoelectric generator. Available power at Jupiter is 234 watts.

**Propulsion:** 16 hydrazine-fueled thrusters provide for trajectory adjustments and attitude (pointing) control.

**Science instruments:** The New Horizons science payload is the most capable suite of instruments ever launched on a first reconnaissance mission to an unexplored planet. It includes an imaging spectrometer to probe atmospheric composition and planet structure; a visible and infrared camera to obtain high-resolution color maps and surface composition maps; a long-range telescopic camera for high-resolution surface images; particle spectrometers to measure charged particles in and around Pluto’s atmosphere;

a detector to measure masses of space-dust particles; and a radio science experiment to examine atmospheric structure, surface thermal properties and planet mass.

## Program

First mission in NASA's New Frontiers Program, a class of principal investigator-led exploration projects larger than Discovery missions.

**Management:** Led by Principal Investigator Dr. Alan Stern of Southwest Research Institute, Boulder, Colorado; project manager is Glen Fountain, Johns Hopkins University Applied Physics Laboratory (APL), Laurel, Maryland; project scientist is Dr. Harold Weaver of APL.

**Cost:** Approximately \$700 million (including spacecraft and instrument development, launch vehicle, mission operations, data analysis and education/public outreach) over the period 2001–2016.

## A Mission of Firsts

New Horizons is the first . . .

- mission to Pluto
- mission to a double planet
- mission to an ice dwarf planet
- mission to study Kuiper Belt Objects
- mission since Voyager in the 1970s to launch to an unexplored planet
- principal investigator (PI)-led outer planets mission
- planetary mission to carry a student-built instrument
- outer planets mission led by the Johns Hopkins Applied Physics Laboratory and Southwest Research Institute
- NASA New Frontiers mission



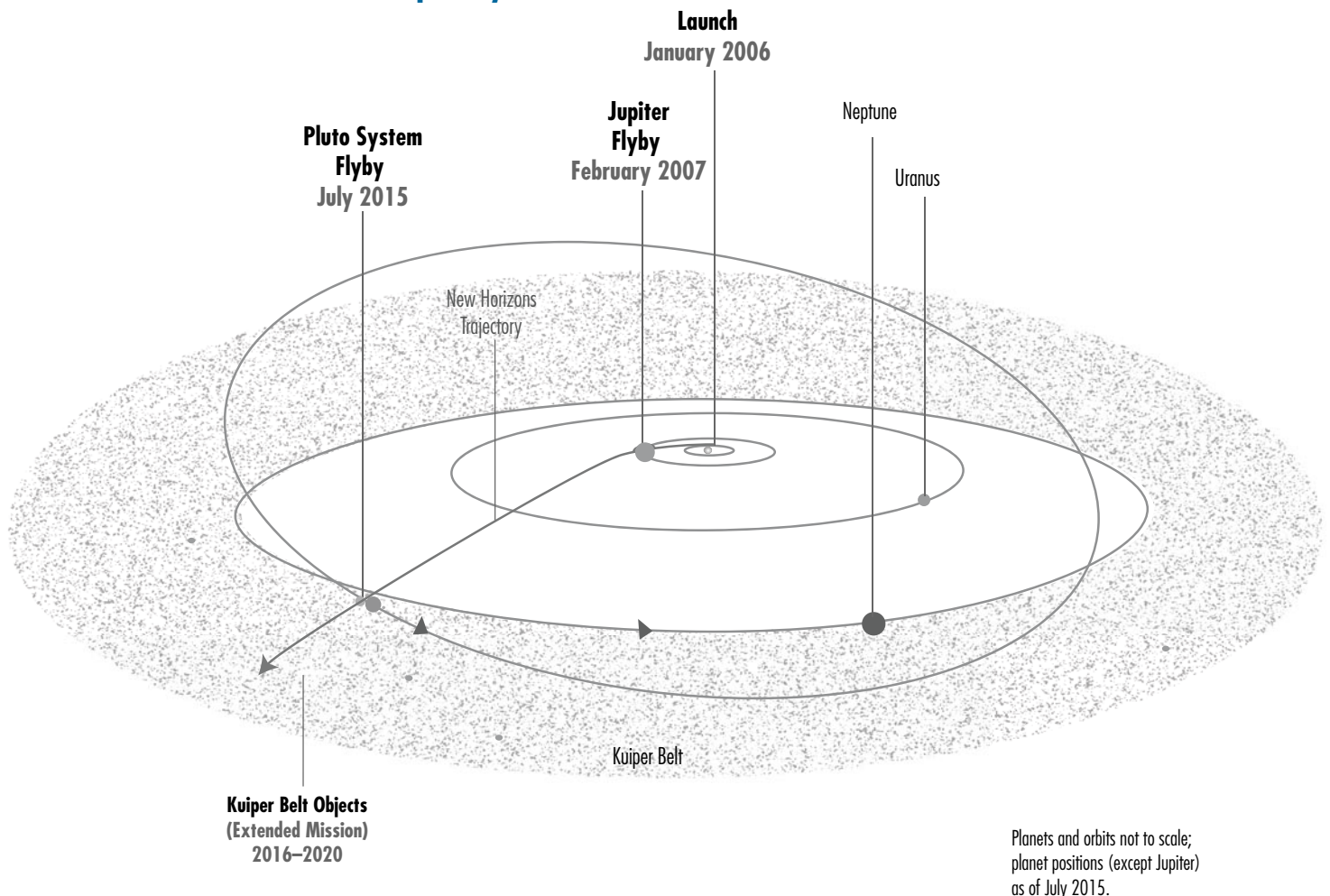
## Mission Overview

New Horizons will help us understand worlds at the edge of our solar system by making the first reconnaissance of Pluto, its large moon, Charon, and its two small moons, Nix and Hydra. Pluto — which makes up a “double planet” with Charon — is the last of the original nine planets in our solar system to be visited by spacecraft. If NASA approves an extended mission, New Horizons will also explore one or more primordial Kuiper Belt Objects (KBOs) after the Pluto system.

Packed with robust electronics and a full suite of science instruments, the compact New Horizons spacecraft is fortified for a long voyage of discovery. New Horizons was the fastest spacecraft ever launched, passing lunar orbit distance in nine hours and set to reach Jupiter for a gravity assist, system calibration activities and scientific studies just 13 months later. No spacecraft has ever crossed the orbit of the moon or reached Jupiter so quickly.

In 2015 New Horizons will conduct a five-month-long flyby study of Pluto and its moons. Then, as part of a potential extended mission, it will head deeper into the Kuiper Belt to study one or more of the icy mini-worlds in that vast region at least a billion miles beyond Neptune’s orbit. Sending New Horizons on this long journey will help us answer basic questions about the surface properties, geology, interior makeup and atmospheres on these mysterious relics of solar system formation — and tell us much about the origins and evolution of the worlds in the solar system’s “third zone,” different than the inner, rocky planets and outer gas giants.

## New Horizons Mission Trajectory



## Launch

New Horizons lifted off from Launch Complex 41 at Cape Canaveral Air Force Station, Florida, on a Lockheed Martin Atlas V-551 launch vehicle at 2 p.m. EST on January 19, 2006.

The launch vehicle featured a Common Core Booster first stage, bolstered by five strap-on solid rocket boosters, and a Centaur booster second stage. A custom Boeing solid-propellant STAR 48B third-stage kick motor gave New Horizons a final push toward Jupiter and, eventually, Pluto.

After separating from the third stage, New Horizons sped from Earth at about 16 kilometers per second, or 36,000 miles per hour — the fastest spacecraft ever launched. New Horizons reached lunar orbit distance (about 384,000 kilometers or 238,600 miles from Earth) approximately nine hours after launch.

## Asteroid Encounter: 2002 JF56

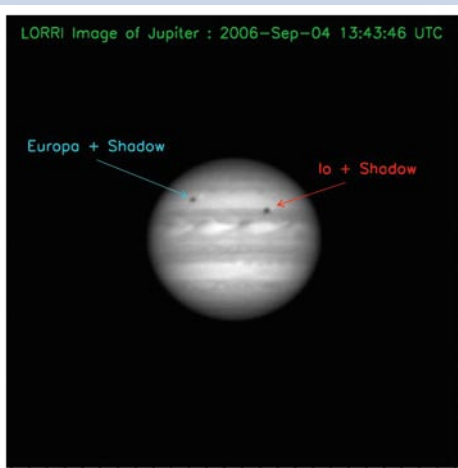
In May 2006, the New Horizons team learned it would have a chance to observe 2002 JF56, a small, relatively unknown main-belt asteroid less than 5 kilometers (3 miles) in diameter. This provided an unexpected opportunity to test the spacecraft and its instruments before reaching Jupiter.

On June 11 and 13, after six weeks of intense planning, the team pointed the Ralph imager — with its color camera, panchromatic cameras and infrared imaging spectrometer — at the asteroid. Flying some 102,000 kilometers (63,000 miles) away, New Horizons was able to measure the color, photometric properties, size and composition of JF56. Most importantly, the team gained valuable experience in tracking moving targets for the Jupiter and Pluto flybys.

In early January 2007, the International Astronomical Union approved the name “APL” for the asteroid, recognizing the Johns Hopkins Applied Physics Laboratory’s leading role in New Horizons and other landmark NASA missions.

## Journey to Jupiter

New Horizons has also undergone a full range of system and instrument checkouts, instrument calibrations and commissioning, and three small trajectory correction maneuvers. Among the operations highlights were



## The First Look

With New Horizons on the outskirts of the asteroid belt, the LORRI camera snapped its first image of Jupiter during a test sequence on September 4, 2006. It was taken close to solar opposition, meaning that the Sun was almost directly behind the camera when it spied Jupiter. Because Jupiter is six times closer to the Sun than Pluto, it is almost blindingly bright to LORRI’s sensitive vision, about 40 times brighter than Pluto will be for LORRI’s primary observations of the Pluto system in 2015.

Set for a mere 6-millisecond exposure (to avoid saturation), the image showed belts, zones and large storms in Jupiter’s atmosphere, as well as the Jovian moons Io and Europa and their shadows on Jupiter.

LORRI wasn’t the only New Horizons instrument peeking at Jupiter that day; the Ralph imager’s Multispectral Visible Imaging Camera (MVIC) scanned Jupiter to test a technique the team will employ near closest approach, and scientists observed Jupiter in the infrared using Ralph’s Linear Etalon Imaging Spectral Array (LEISA).

## Gravity Assist: Getting a Boost

For a gravity assist, a spacecraft flies close to a planet and picks up a tiny amount of the planet's orbital momentum around the Sun. Because the effect of the change in momentum depends on the mass of the object, and the spacecraft's mass is negligible compared to Jupiter's, this process has a negligible effect on the planet's orbit around the Sun. But the spacecraft receives a great boost on the way to its next destination. Gravity assist maneuvers can also be used to slow a spacecraft down.

Closest approach distance and direction, and the speed of the spacecraft relative to the planet all affect the acceleration and direction change of the spacecraft's trajectory. The greatest change in the spacecraft's speed and direction would occur for a slow-moving spacecraft approaching just above the surface or cloud tops of a massive planet. The least change in the spacecraft's speed and direction would occur for a fast-moving spacecraft approaching a great distance from a small planet.

Jupiter's gravity has sent several spacecraft toward the outer solar system, including Pioneers 10 and 11, Voyagers 1 and 2, and Cassini. The Ulysses probe swung around Jupiter in the opposite direction, using the planet's gravity to leave the ecliptic plane and set up a polar orbit around the Sun.

successful upgrades to the software that dictates how the spacecraft processes commands and handles data, software for guidance and navigation, and the autonomy package the spacecraft uses to monitor its own systems.

## Jupiter Gravity Assist

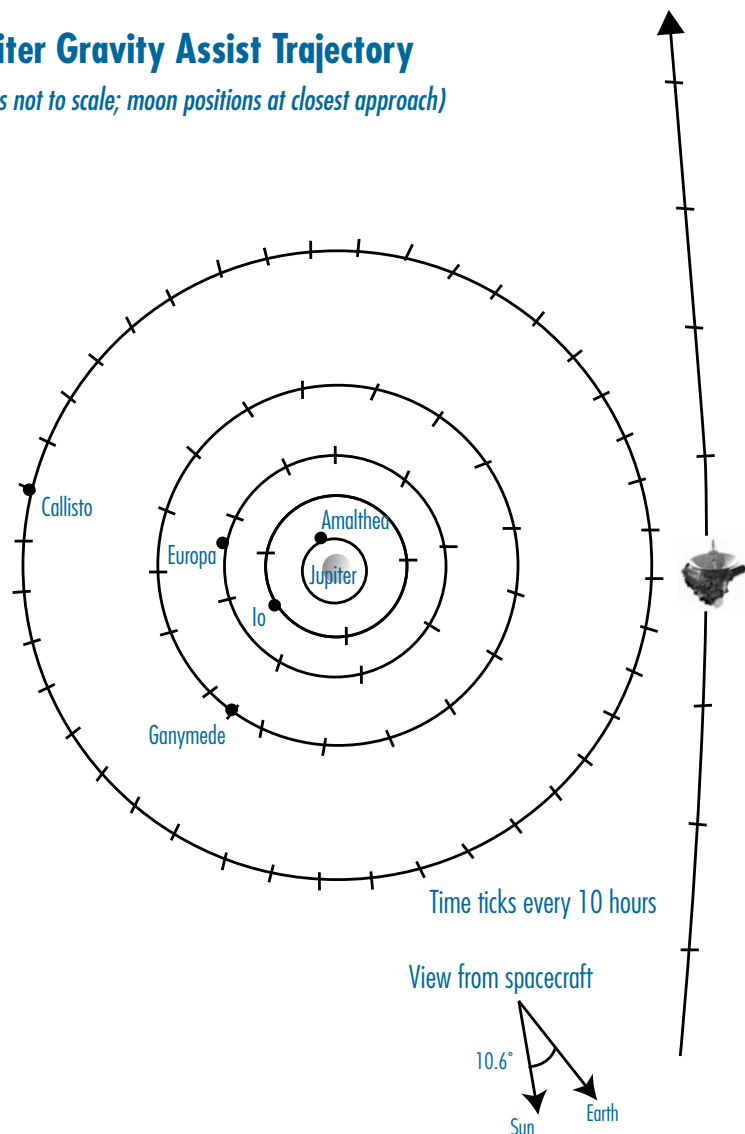
New Horizons' launch in mid-January 2006 allowed it to take advantage of a Jupiter gravity assist that shortens the trip to Pluto by several years. Without it, the earliest New Horizons would have reached the Pluto system was 2018.

New Horizons enters Jupiter's "sphere of influence" and begins to accelerate on February 14, 2007, with the planet about 23 million kilometers (14 million miles) away. At its closest point, New Horizons will fly just outside of the orbit of Jupiter's large moon Callisto — about 2.3 million kilometers (1.4 million miles) from the giant planet, or 32 times the radius of Jupiter itself.

The spacecraft's heliocentric speed — its velocity relative to the Sun — through the Jupiter system will be 23 kilometers per second, about 51,000 miles per hour. The flyby increases New Horizons' speed away from the Sun by nearly 4 kilometers per second, or close to 9,000 miles per hour, and raises its

## Jupiter Gravity Assist Trajectory

*(orbits not to scale; moon positions at closest approach)*



trajectory to Pluto 2.34 degrees above the solar system's ecliptic plane, the level on which the planets orbit the Sun.

New Horizons will venture more than four times closer to Jupiter than the Cassini spacecraft did in late 2000, when Cassini used Jupiter for a gravity assist on the way to Saturn. From this closer range and with its unique set of instruments, New Horizons will perform a number of Jupiter system studies that will improve on or complement those from Cassini — observations such as Jovian meteorology, studies of the great and little red spots, auroral studies, magnetospheric sampling and dust sampling, and ultraviolet mapping of the gas ring (torus) around Jupiter's volcanic moon, Io. Surface mapping, compositional mapping and atmospheric studies of Jupiter's largest moons are planned as well.

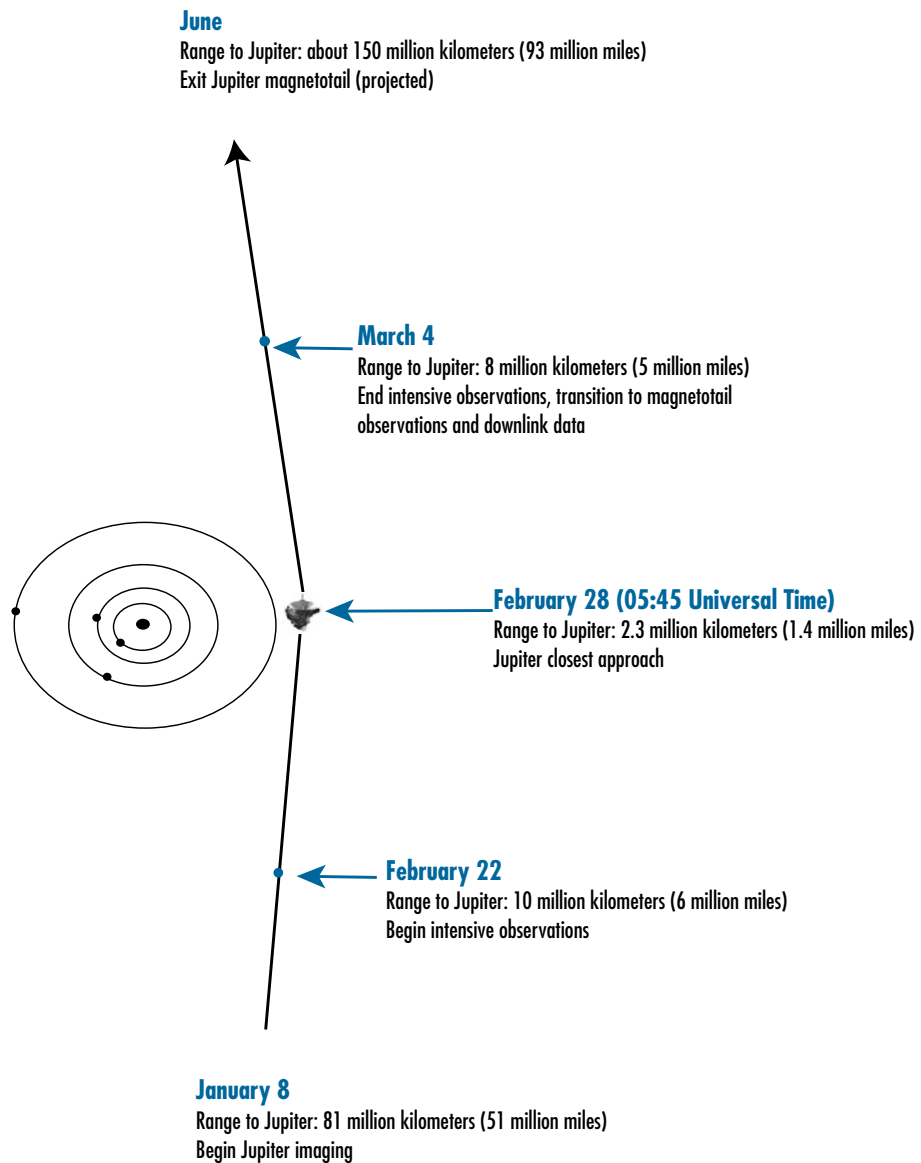
## The Third Stage: First to Jupiter

The Boeing solid-propellant STAR 48B third-stage motor that propelled New Horizons on its final kick toward Jupiter (and separated from the spacecraft 45 minutes after launch) will actually fly past the giant planet first, though without the aid of maneuvering thrusters it won't come as close as New Horizons.

By the time it reaches Jupiter several hours before New Horizons, the defunct stage will be about 400,000 kilometers (nearly 250,000 miles) away from the spacecraft. Owing to it missing the Pluto "aim point" at Jupiter by this amount, the third stage will miss Pluto by about 200 million kilometers (nearly 125 million miles) — about as far as the average distance from the Sun to Mars.

## 2007 Jupiter Encounter Timeline

*(Distances not to scale)*



## Hibernation

New Horizons will “sleep” for most of the cruise between Jupiter and Pluto in spin-stabilized hibernation mode, designed to reduce spacecraft operation costs and free up Deep Space Network tracking resources for other missions. Hibernation, during which the spacecraft’s redundant components and guidance and control system are powered off, also reduces wear and tear on spacecraft electronics — an important consideration for the long journey to Pluto.

Operators will put New Horizons into hibernation by turning off most of its electronics and setting it in a steady attitude, spinning at 5 rpm. The antenna dish will point toward Earth while the onboard flight computer monitors system health and broadcasts a weekly beacon tone through the medium-gain antenna. New Horizons will transmit a “green” coded tone if all is well, or send back one of seven coded “red” tones if it detects a problem and requires help from the operations team.

New Horizons is the first mission to make operational use of hibernation in flight and the associated beacon communications mode. NASA’s Deep Space 1 mission implemented the reception of the spacecraft beacon feature as a technology demonstration.

## Annual Checkouts

Operators will wake New Horizons out of hibernation once a year to perform trajectory correction maneuvers, system checkouts and instrument calibrations. During the checkouts — lasting about 50 days — operators will verify the health of and perform routine maintenance on subsystems and instruments, and gather navigation data. The first annual checkout is scheduled for six months after the Jupiter flyby.

## Fastest and Farthest

Speeding nearly 100 times faster than a jetliner throughout its journey, New Horizons was the fastest spacecraft ever to leave Earth. Given that no spacecraft has ever traveled such a great distance before reaching its primary science target, that speed is critical to mission success.

New Horizons crossed the moon’s orbit in just nine hours — something that took the Apollo astronauts more than three days to accomplish. Just 13 months later New Horizons will fly past Jupiter for a gravity assist toward Pluto; the two most recent NASA missions sent to Jupiter, Galileo and Cassini, took six and four years, respectively, to reach the giant planet. And yet, Jupiter, almost half a billion miles from Earth, is only a fraction of the distance to Pluto.

## Science at Jupiter

New Horizons will use the strong gravity of the massive planet Jupiter (318 times the mass of Earth) to accelerate itself toward Pluto — but this flyby is also an opportunity to test the New Horizons instruments on a major target and do valuable science at the same time.

At Jupiter the New Horizons spacecraft will get the ultimate treadmill test, an unprecedented technical workout in which operators put each system through the intense paces of a planetary encounter. The science instruments alone will be programmed to make more than 700 observations of the Jupiter system, scientifically valuable exercises that will be just as (if not more) important for the clues they yield into how the spacecraft will perform at its ultimate target, Pluto.

Observations of the Jupiter system began in early January 2007, about 60 days before closest approach to the planet on February 28. Its pioneering exploration of Jupiter's giant, long magnetic tail will continue for approximately 120 days after closest approach, taking the spacecraft about 150 million kilometers down this "plasma" tail. Visit <http://pluto.jhuapl.edu> for the latest timeline of activities.

The Jupiter gravity assist is the top priority, since this is what sends New Horizons to its primary mission objective, the Pluto system. Next on the list are the spacecraft system and instrument checks and calibrations, since the Jupiter encounter affords a chance for the team to analyze and change any operations before the Pluto encounter. As those operational goals are fulfilled, the team will then turn its attention to gathering science data on the Jovian system.

### Science Goals

New Horizons science plans at Jupiter fall into four main categories:

- Studies of Jupiter's magnetosphere, including a history-making first flight down the tail of charged particles escaping the planet's strong magnetic field.
- Looking at Jupiter's atmosphere and storms (such as the Great Red Spot).
- Observations of Jupiter's faint rings, including a search for additional satellites that generate the rings.
- Satellite observations, such as a look at how the volcanic world Io has changed since Galileo observed it in 2001, and mapping surface compositions on Europa, Ganymede and Callisto better than any previous mission.

### Jupiter's Giant Magnetosphere

Jupiter's magnetosphere fills a vast volume of space — 1,000 times the volume of the Sun and a million times the volume of Earth's magnetosphere. Ionized material from the atmosphere of the volcanic moon Io supplies about a ton of plasma (sulfur and oxygen ions, plus accompanying electrons) *every second*. This ionized material is trapped in Jupiter's magnetic field and rotates with Jupiter's 10-hour period, forming a giant torus (or donut-shaped cloud) that circles the planet. The Io plasma torus glows brightly in ultraviolet light that the Alice

### Jupiter at a Glance

- Largest planet in the solar system, fifth from the Sun
  - Named for the king of the Roman gods
- Diameter is approximately 143,000 kilometers (88,860 miles), about 12 times the diameter of Earth
- Average distance from the Sun is approximately 778 million kilometers (483 million miles)
- Orbits the Sun every 11 years and 315 days
- Rotates on its axis once every 9 hours, 55 minutes
- Has 63 known moons
  - Largest moon, Ganymede, is bigger than both Mercury and Pluto
- Jupiter is composed mostly of hydrogen and helium
- Mostly hydrogen, helium and methane compose its atmosphere
- Atmosphere includes the Great Red Spot, a 300-year-old storm that is more than twice the size of Earth, and with wind speeds up to 150 meters per second
- Its giant magnetic field, controlling a region of space known as the magnetosphere, extends some 1.6 million kilometers (1 million miles) around the planet
- First spacecraft to visit Jupiter was Pioneer 10, which flew by in 1973
  - Subsequent flybys: Pioneer 11 (1974), Voyager 1 and Voyager 2 (1979), Ulysses (1992), Cassini (2000)
  - NASA's Galileo orbited the planet from 1995–2003 and dropped a probe into its atmosphere
  - Next up after New Horizons: NASA's Juno mission arrives in 2016

Source: NASA



instrument will observe as New Horizons approaches Jupiter. Alice will also observe the powerful auroral emissions produced when ions and other energetic charged particles from the magnetosphere bombard Jupiter's atmosphere near its poles.

New Horizons will provide unique science opportunities — most notable is that the trajectory it must fly to Pluto takes it down Jupiter's magnetotail for about 100 million miles over a period of several months after the closest approach to Jupiter. Never before in the history of spaceflight has the magnetotail of any planet been traversed this way. As such, New Horizons will provide a bonanza of new information about the workings of Jupiter's magnetosphere — with important implications for the magnetospheres of the other giant planets as well.

Based on the spacecraft's trajectory, the team estimates that New Horizons could travel as far as 150 million kilometers (about 93 million miles) down the tail — however, because the magnetotail actually "flaps" in the solar wind, no one can say for sure when or where the spacecraft will exit. During its magnetotail exploration, New Horizons will obtain magnetospheric plasma measurements with the Solar Wind at Pluto (SWAP) and Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) instruments, and dust measurements with the Venetia Burney Student Dust Counter.

As New Horizons moves away from Jupiter, LORRI will make night-side images of visible aurora, providing unique data on their fine details and how they change with altitude.

These various observations will address whether the ton per second of material coming from Io is ejected from the magnetosphere

in large, dense blobs (like coronal mass ejections from the Sun) or whether the flow is a steady "drizzle." And they will provide an unprecedented look at the dynamics of a planetary magnetic field.

This historic magnetotail exploration also includes a campaign to observe Jupiter's aurora with space- and ground-based telescopes (such as the Hubble Space Telescope, Far Ultraviolet Spectroscopic Explorer [FUSE], the European Space Agency's Rosetta spacecraft and the Keck Observatory in Hawaii) at the same time New Horizons flies inside the magnetosphere, measuring the particles that trigger auroral emissions.

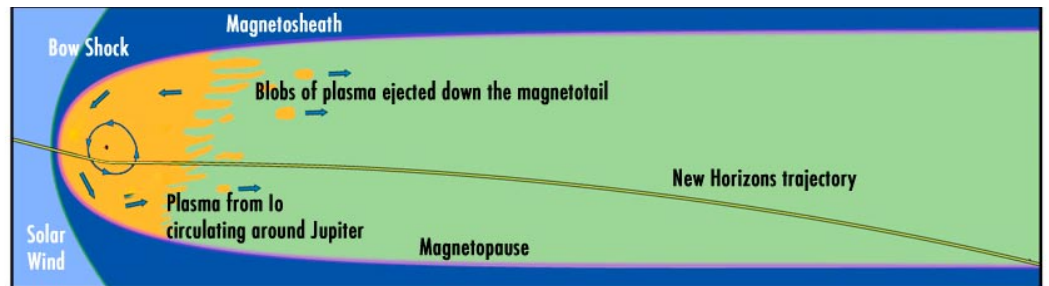
## Studying the Atmospheres of Jupiter's Icy Moons

Io's atmosphere, predominantly composed of sulfur dioxide, glows in ultraviolet and visible light as a result of bombardment by the Jovian magnetosphere. Jupiter's satellites Europa and Ganymede have tenuous oxygen atmospheres that can also be detected through ultraviolet light emissions of atomic oxygen (at 1,304 and 1,356 Angstroms); these emissions are generated by bombarding magnetospheric electrons from Jupiter. The Alice ultraviolet spectrometer will obtain high quality disk-integrated spectra of these emissions to investigate the extent of the satellites' atmospheres, their response to changes in the Jovian magnetosphere, and their response to Jupiter eclipse (passing through Jupiter's shadow). LORRI will look for visible light emissions with long-exposure images during Jupiter eclipse. Alice will also be used to attempt a detection of atmospheric emissions from Callisto for the first time.

## Jupiter's Mysterious Airglow

Jupiter's airglow, excited by sunlight, is much fainter than auroral emissions but also presents a longstanding problem. The Voyager spacecraft both observed that the ultraviolet emission showed a strong longitudinal asymmetry, with one region having a much stronger emission called the "Lyman  $\alpha$  bulge." The Earth-orbiting International Ultraviolet Explorer and the Hubble Space Telescope have also studied this feature for years. The New Horizons Alice and Ralph spectrometers will each make maps of Jupiter's airglow just days before closest approach

A **magnetosphere** is a "bubble" of charged gas that rotates around a planet, under the control of the planet's magnetic field. Earth is surrounded by a magnetosphere, as are Jupiter, Saturn, Uranus and Neptune.



to study this mysterious bulge.

## Storm Fronts: Jupiter's Atmosphere Up Close

New Horizons has a unique chance to measure how giant storms develop on Jupiter, starting with "movies" from the LORRI camera that track global storm movement and activity over two weeks. Near closest approach, LORRI's high resolution will help the team study atmospheric storms in three dimensions, specifically measuring localized cloudy regions of dramatic vertical and horizontal dynamics. Building on results from the Galileo orbiter mission, the team has special interest in the turbulent wake behind the Great Red Spot, a powerful cyclone more than 20,000 kilometers across (more than twice the size of Earth) and more than three centuries old.

New Horizons also plans to provide the first close-up view of a feature that formed in 2005 from the merging of three smaller storms, the "Little Red Spot," which is about half the size of the Great Red Spot. Given the spacecraft's closer vantage point, New Horizons images should be 10 times more detailed than those provided by the Hubble Space Telescope and ground-based telescopes — the equivalent of naked eye vs. simple binocular views of the moon.

New Horizons scientists also plan to measure Jupiter's upper atmospheric structure and temperature using a stellar occultation, measuring the absorption of starlight as the planet passes in front of a star. Observations from the Alice ultraviolet spectrometer will provide composition and vertical-structure information for many important atmospheric species (such as hydrogen, methane, acetylene and higher hydrocarbons) over a wide range of pressures high in Jupiter's atmosphere ( $10^{-4}$  to  $10^4$  microbars). The hydrogen and long-lived hydrocarbon scale heights will be used to provide an atmospheric temperature profile, while the profiles of more chemically active hydrocarbon species will provide strong constraints on upper atmospheric dynamics and photochemical models. This experiment also provides practice for similar occultations New Horizons will perform at Pluto.

## Rings and Things

The New Horizons science team plans to address two open questions about the Jovian ring system: Where are the parent bodies that generate the ring particles, and how many of these small moonlets are there at Jupiter?

Jupiter's rings are composed mainly of micron-sized dust, but tiny grains are quickly lost from the system and must be replenished regularly from some embedded source. The moons Adrastea and Metis certainly play a role, but other parent bodies that are meters to kilometers in size are probably the main source of material in the rings.

### Search for New, Close-in Jovian Satellites

New Horizons has the unique capability to comprehensively search for small moons close to Jupiter. The smallest known inner satellite of Jupiter is Adrastea, with a radius of 8 kilometers (5 miles). It orbits near the outer tip of the Jovian ring. Searching for other moons will provide important information about the gap in size between the ring moons and the largest embedded parent bodies. The search will take place four to two days before closest approach to Jupiter.

### Ring Phase Curve

The size and shape of the dusty ring particles can be estimated from their phase curve, or the variation in their brightness as the view direction changes from looking opposite the Sun (low phase angles, or back-scattering) to looking toward the Sun (high-phase angles, or forward-scattering). New Horizons can make the first spatially resolved phase curve for the ring, enabling scientists to distinguish unambiguously the locations of the dust

## New Dimensions: Seeing Jupiter's Clouds and Storms in 3-D

New Horizons will map the three-dimensional structure of clouds and storms in Jupiter's atmosphere, something atmospheric scientists find incredibly valuable. This will be accomplished by imaging many colors (wavelengths) of light simultaneously and measuring how much sunlight the clouds reflect in each of these colors. Some colors of sunlight don't travel very far into Jupiter's atmosphere; methane and hydrogen gas in the atmosphere absorb these colors. Other colors make it farther down before being absorbed. If an image shows cloud features in colors that are strongly absorbed by the atmosphere, that means the clouds are so high that they can reflect the sunlight before the atmospheric gases adsorb the color. By watching what happens to the various colors of light as a function of location, New Horizons can help to accurately determine cloud-top altitudes.



(which is brightest in forward-scattered light) and larger parent bodies (which are brightest in backscattered light), as well as learn more about the dust particles themselves.

## Crossing the Ring Plane

Several important observations can be carried out only when the Jovian ring is nearly or exactly edge-on to the observer, which will happen for New Horizons almost two days after closest approach, late on March 1, 2007. The spacecraft will get a unique look at the vertical structure and thickness of the rings, as well as the puzzling “ripples” in the rings glimpsed by the Galileo Jupiter orbiter.

## Surveying the Satellites

Following up on discoveries made by NASA’s Galileo and Cassini missions, New Horizons will turn its instruments on Jupiter’s four largest, planet-sized moons, the Galilean satellites Io, Europa, Ganymede and Callisto. The planned observations include visible and near-infrared imaging of high-temperature volcanic thermal emission on Io; mapping plumes and surface changes on Io; mapping global topography on Europa across new swaths of terrain; making ultraviolet stellar occultations and auroral emission studies of the atmospheres of these worlds; and the broadest highest-resolution near-infrared mapping of their surface composition ever obtained.

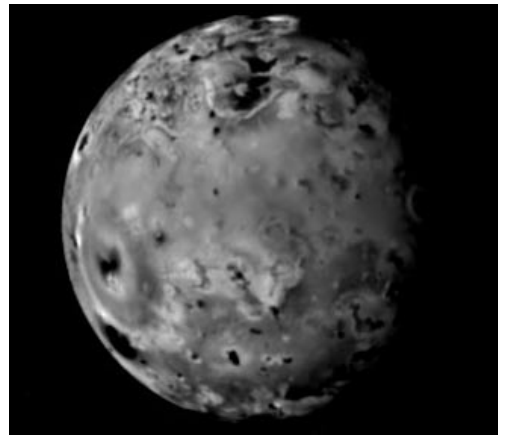
### Exploring Io: The Most Volcanic World in the Solar System

Using LORRI, New Horizons will create a global map of Io at high resolution; this will allow scientists to see how frost and volcanic deposits have resurfaced the rapidly evolving moon since the last global map, made in 2000-2001. Ralph’s MVIC will map these deposits in color, but only on the night side, illuminated by Jupiter. (MVIC is so sensitive that images of Io’s day side will be overexposed.) Given New Horizons’ path past the moon — and the lighting angles it flies through — LORRI mapping will also shed light on Io’s global topography.

The Ralph imager will make multi-wavelength visible and infrared images of thermal radiation from the volcanoes on Io’s night side, using the color of the radiation to determine the temperatures of these volcanoes. These observations are important because similar Galileo observations suggested that some of the volcanoes erupt lava that is hotter than terrestrial lavas, perhaps implying exotic lava compositions.

Scientists are also interested in the distribution and lifetime of Io’s volcanic plumes since they replenish and redistribute surface and atmospheric volatiles, and supply dust to Jupiter’s magnetosphere. New Horizons will provide the most complete inventory of volcanic plumes since Voyager’s 1979 studies, almost 30 years ago, and extend the time-base of plume-lifetime data by a decade beyond Galileo’s intensive observations.

Io has a tenuous atmosphere of sulfur dioxide, about one billionth of Earth atmospheric pressure, supplied by volcanic gases. New Horizons will study this atmosphere using auroral emissions and by two stellar occultations, in which Alice will watch as a star passes behind Io and Io’s atmosphere absorbs starlight. This observation may provide our best information yet on Io’s night-side atmosphere, and in particular may tell us whether the atmosphere freezes onto Io’s surface at night.



**Simulated LORRI View of Io.**

## Cool Views of the Icy Moons: Europa, Ganymede and Callisto

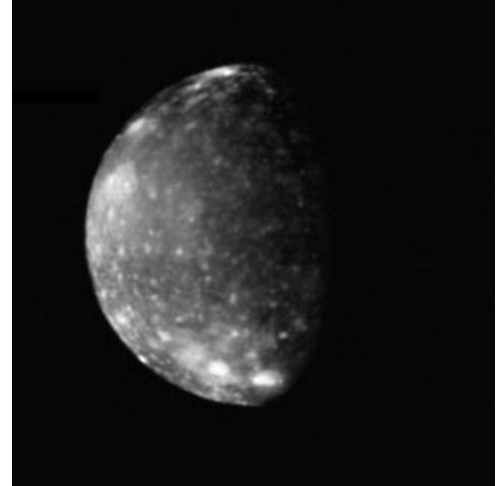
With Ralph's LEISA infrared spectrometer, New Horizons will look at Europa, Ganymede and Callisto for compositional mapping, including searches for minor components in addition to the water ice that dominates their surfaces. Scientists will also test analysis techniques (such as temperature mapping) that New Horizons will use in the Pluto system.

LEISA observations of the Galilean satellites are especially valuable, since LEISA's spectral resolution (its ability to discriminate between similar wavelengths) is much higher than any previous imaging spectrometer on a spacecraft visiting Jupiter. LEISA can measure the composition of surface regions as small as 150 kilometers (93 miles) on the Galilean moons.

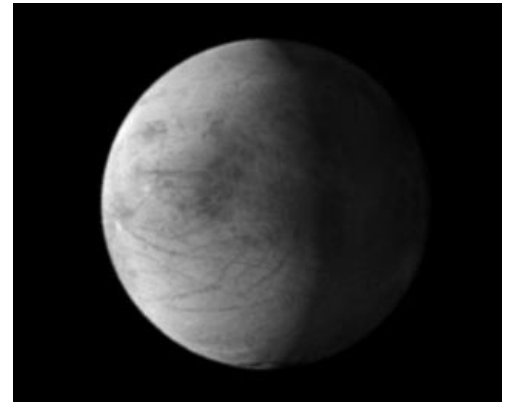
An intriguing mystery emerging from Galileo's exploration of Europa swirls around the composition of brownish "non-ice" material on this fascinating moon's surface. This material could originate from the ocean beneath the surface or be generated by a process on the surface (such as bombardment by energetic charged particles).

Non-ice materials are also present on Ganymede, and New Horizons will make observations similar to those described above for Europa. In fact, a large swath of Ganymede's surface remains unexplored by *any* composition mapping spectrometer, and New Horizons plans to fill this gap in our knowledge.

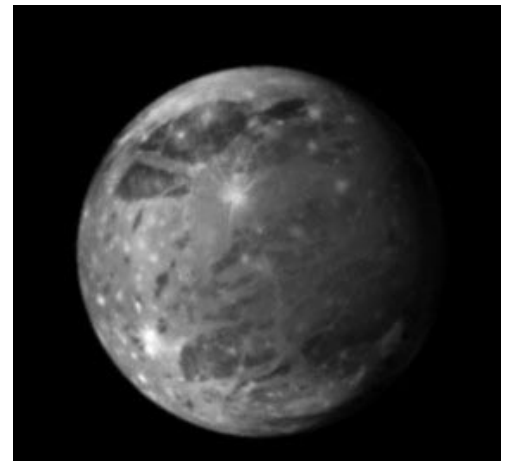
By taking high-resolution images at the terminator (the line between night and day) on the icy moons, scientists hope to make the best determinations yet of their surface topography.



Simulated LORRI View of Callisto.



Simulated LORRI Views of Europa (above) and Ganymede (below).



## Beyond Jupiter: Looking to Pluto

After traveling some 5 billion kilometers (3 billion miles) from Earth, New Horizons must thread a celestial needle and fly through a circle only 300 kilometers (about 186 miles) in diameter to accomplish its science objectives at Pluto. Fortunately, the team has a chance to guide New Horizons along the way.

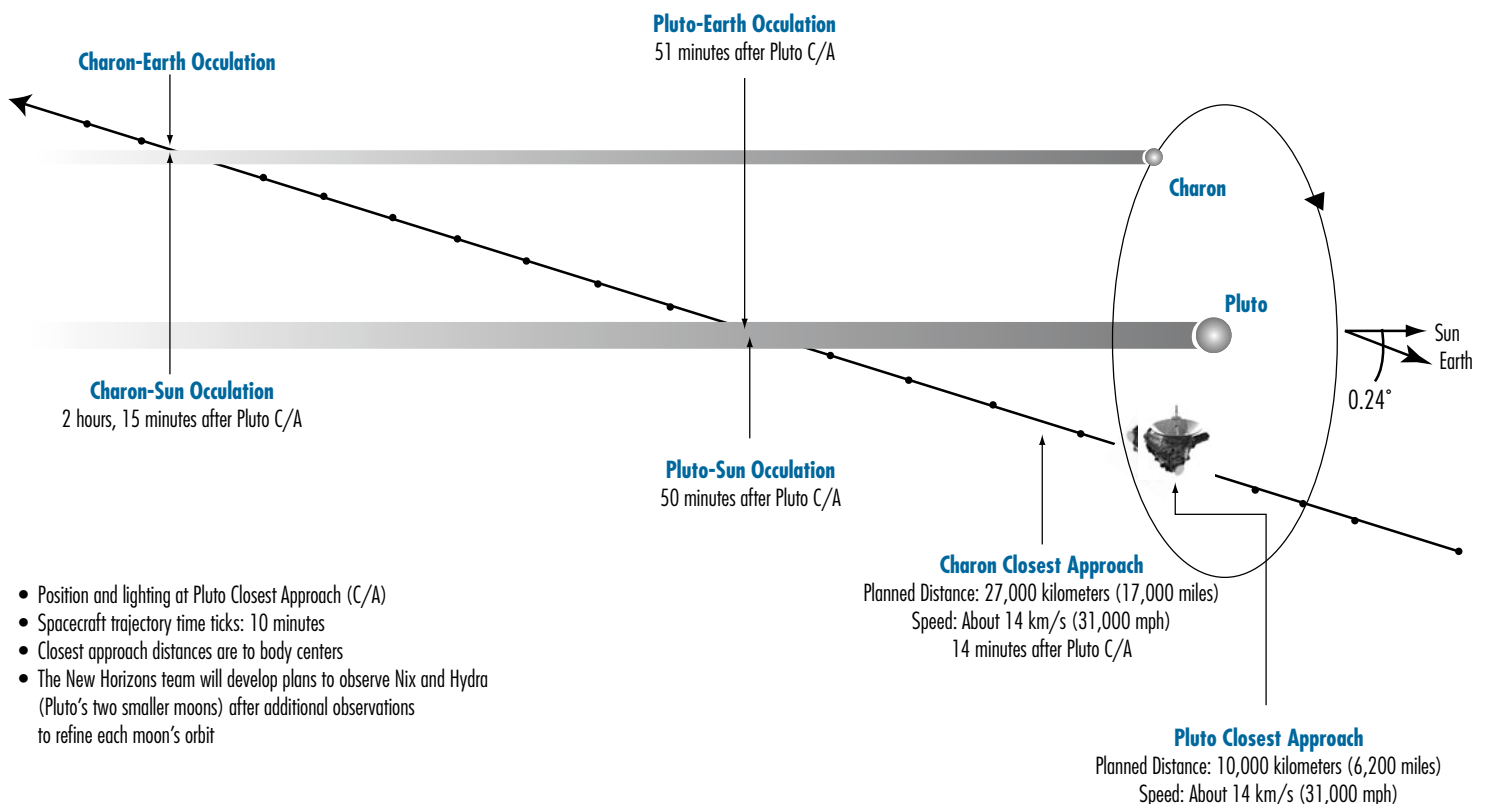
As New Horizons gets closer to Pluto, it will take detailed pictures of the Pluto system, to help the team determine if the spacecraft is moving in the right direction. (This is called “optical navigation.”) New Horizons uses its smaller thrusters to spin “down” into a stable pointing mode and change direction. The large thrusters only have 4.4 newtons (about 1 pound) of force — not much for a spacecraft that weighs more than 1,000 pounds — but they only need to make small corrections.

The cameras and spectrometers on New Horizons will start taking data on the Pluto system five months before the spacecraft arrives. Pluto and its large moon Charon will first appear as small, bright dots, but will loom larger as the encounter date approaches. About three months from the closest approach — when Pluto and Charon are about 100 million kilometers (60 million miles) away — the cameras on the spacecraft can make the first maps. For three months, the mission team will take pictures and spectra measurements of Pluto, Charon, and the small moons Nix and Hydra as each rotates. For the last four Pluto days before encounter (26 Earth days), the team will compile maps and gather spectra measurements of Pluto, Charon, Nix and Hydra every half Pluto day. The team can then compare these maps to check changes over a Pluto day, at scales as good as about 48 kilometers (30 miles), that might indicate new snow or other weather.

### The Encounter

The busiest part of the Pluto-Charon flyby will last a full Earth day, from about 12 hours before closest approach to about 12 hours after. On the way in, the spacecraft will study ultraviolet emissions from Pluto’s atmosphere

### Pluto-Charon Flyby: Closest Approach (July 2015)



- Position and lighting at Pluto Closest Approach (C/A)
- Spacecraft trajectory time ticks: 10 minutes
- Closest approach distances are to body centers
- The New Horizons team will develop plans to observe Nix and Hydra (Pluto’s two smaller moons) after additional observations to refine each moon’s orbit

and make its best global maps of Pluto and Charon in green, blue, red and a special wavelength that is sensitive to methane frost on the surface. It will also take spectral maps in the near infrared, telling the science team about Pluto's and Charon's surface compositions at all locations, as well as the variation in temperature across the surface. New Horizons will also sample material coming from Pluto's atmosphere, and it will image all of Pluto's moons during this period. During the half-hour when the spacecraft is closest to Pluto and Charon, it will take close-up pictures in both visible and near-infrared wavelengths. The best pictures of Pluto will depict surface features about 100 meters (328 feet) across, or the size of a football field.

Even after the spacecraft passes Pluto, Charon, Nix and Hydra, its work is far from done. Looking back at the mostly dark side of Pluto or Charon is the best way to spot haze in the atmosphere, to look for rings and to determine whether their upper surfaces are smooth or rough. Also, the spacecraft will fly through the shadows cast by Pluto and Charon and observe both the Earth and Sun setting, and then rising, through Pluto's atmosphere. It will look back at the Sun and Earth, and watch the light from the Sun and pick up radio waves from transmitters on Earth. These measurements will reveal the composition, structure and thermal profile of Pluto's atmosphere in exquisite detail.

Many similar measurements were made by spacecraft (such as the Voyagers) exploring other outer planets. However, New Horizons brings some revolutionary new capabilities to bear, including temperature and composition mapping capabilities and a dust detector to pick up tiny debris particles near Pluto. The technology for these latter kinds of instruments was not available when the Pioneer and Voyager spacecraft were developed to reconnoiter Jupiter, Saturn, Uranus and Neptune.

New Horizons will approach Pluto from the planet's southern hemisphere — in July 2015 the southern hemisphere will be sunlit and the northern cap dark. The spacecraft flies toward Pluto at a solar phase angle of 15 degrees — excellent lighting conditions for remote sensing.

Pluto will be more than 4.9 billion kilometers (3 billion miles) from Earth — about 32 times the distance between the Sun and Earth — when New Horizons arrives. The one-way light time delay (the time for a radio signal to reach New Horizons from Earth) at that distance is 4 hours and 25 minutes. The arrival timing has to be precise: the team must transmit the signals used for probing the atmosphere with the Radio Science Experiment (REX) 4 hours and 25 minutes before the anticipated Earth occultation time.

The entire encounter sequence will be intricately choreographed by planners on Earth and then precisely programmed in New Horizons' redundant flight computers. In fact, mission operators will not have continuous contact with New Horizons during the flyby, since the spacecraft will be turning various ways to collect data on Pluto and its moons.

## Long-Distance Data

A major mission challenge is the relatively low downlink rate at which New Horizons can transmit data to Earth — owing primarily to the long distance over which the spacecraft has to send (or receive) a signal. During the Jupiter encounter in 2007, New Horizons will send data home at about 38 kilobits per second (kbps), just a little slower than the transmission speed for most computer modems. The situation becomes much more challenging at Pluto, where the downlink rate will typically range between 600 to 1,200 bits per second. At that rate, mission operators would need several hours to downlink even a single image from New Horizons' long-range camera, and more than a month of continuous connection with NASA's Deep Space Network (DSN) to gather the entire set of data from the Pluto-Charon encounter. Because a constant DSN connection isn't practical — given the large number of missions that rely on these antennas — the team will downlink the data in the spacecraft's recorder over five months, with the highest-priority data coming down in the first days and weeks after the encounter.

## Into the Kuiper Belt — and Beyond

If NASA approves an extended mission, plans for New Horizons after Pluto include one to two encounters with ancient Kuiper Belt Objects — the building blocks of the outer planets. New Horizons target KBOs will have diameters of 35 to 50 kilometers (22 to 30 miles), or a bit larger.

To accomplish the first flyby, three weeks after Pluto-Charon closest approach, New Horizons controllers would command the spacecraft to fire its thrusters and set a trajectory that gets it to the first target KBO within two to three years, after a journey of about 1 billion miles.

The first target KBO doesn't have to be selected until just before the Pluto encounter. And because scientists will continue to learn so much more about this region — and discover more objects — the extra time allows the mission team to search for the most desirable targets within New Horizons' range. As New Horizons travels in space, scientists on Earth will search for candidate KBOs along the spacecraft's nominal trajectory out to 55 astronomical units — 55 times the distance from Earth to the Sun, and the farthest operating range of New Horizons' antennas.

Navigators will use pictures from the LORRI and Ralph cameras to find the target KBO as early as possible, so they can refine the spacecraft's path to the object using a minimum amount of propellant. At any KBO, New Horizons would follow a science timeline similar to the Pluto-Charon encounter. Studies would include surface mapping, surface composition mapping, surface temperature mapping, a search for any atmosphere, and studies of any moons around the target KBOs.

After its last KBO flyby, the spacecraft will continue beyond the Kuiper Belt and into interstellar space. Like the Pioneer and Voyager spacecraft, New Horizons will escape the Sun's gravity and will not return to our solar system.

## The New Horizons Science Team

**Principal Investigator:** Dr. Alan Stern, Southwest Research Institute

**Project Scientist:** Dr. Hal Weaver, Johns Hopkins University Applied Physics Laboratory

**Deputy Project Scientist:** Dr. Leslie Young, Southwest Research Institute

**Co-Investigators:**

Dr. Fran Bagenal, University of Colorado

Dr. Richard Binzel, Massachusetts Institute of Technology

Dr. Bonnie Buratti, NASA Jet Propulsion Laboratory

Dr. Andy Cheng, Johns Hopkins University Applied Physics Laboratory

Dr. Dale Cruikshank, NASA Ames Research Center

Dr. Randy Gladstone, Southwest Research Institute

Dr. Will Grundy, Lowell Observatory

Dr. David Hinson, Stanford University

Dr. Mihaly Horanyi, University of Colorado

Dr. Don Jennings, NASA Goddard Space Flight Center

Dr. Ivan Linscott, Stanford University

Dr. Dave McComas, Southwest Research Institute

Dr. William McKinnon, Washington University

Dr. Ralph McNutt, Johns Hopkins University Applied Physics Laboratory

Dr. Jeffrey Moore, NASA Ames Research Center

Dr. Scott Murchie, Johns Hopkins University Applied Physics Laboratory

Dr. Carolyn Porco, Space Science Institute

Dr. Harold Reitsema, Ball Aerospace

Dr. Dennis Reuter, NASA Goddard Space Flight Center

Dr. Dave Slater, Southwest Research Institute

Dr. John Spencer, Southwest Research Institute

Dr. Darrell Strobel, Johns Hopkins University

Dr. Michael Summers, George Mason University

Dr. Len Tyler, Stanford University

## NASA's New Frontiers Program

With the New Frontiers Program, NASA aims to explore the solar system with frequent, medium-class, scientifically focused spacecraft missions. NASA established the program in 2003 while building on the innovative approaches used in its Discovery and Explorer programs — providing a way to identify and select missions too challenging within Discovery's cost and time constraints. New Frontiers missions will tackle specific exploration goals identified as top priorities in the landmark 2002 National Research Council study, *New Frontiers in the Solar System: An Integrated Exploration Strategy*. Also known as the "Decadal Survey," the study was conducted by the Space Studies Board of the National Research Council at NASA's request. In doing so, NASA sought to examine the big picture of solar system exploration, survey the current knowledge of our solar system, compile the scientific questions that should guide solar system exploration in the next decade, and list (in order) the most promising avenues for flight investigations and supporting ground-based activities.

The initial high-priority scientific goals identified by the study related to the exploration of Pluto and the Kuiper Belt, the surface of Venus, Jupiter's interior, the south pole of the moon (including the Aitken Basin) and a comet-sample return.

### Open Competition

New Frontiers missions start as proposals — sent to NASA after an open announcement — and are chosen through a competitive peer review process. A principal investigator (PI), typically affiliated with a university or research institution, leads each mission. The PI selects team members from industry, small businesses, government laboratories and universities to develop the science objectives and instrument payload. The PI is responsible for the overall success of the project by assuring it will meet all cost, schedule and performance objectives. The New Frontiers Program encourages use of validated new technologies, efficient management, and control of design, development and operations costs while maintaining a strong commitment to flight safety. Total mission cost must be under \$700 million in Fiscal Year 2001 dollars.

### Missions

With its mission plan and management structure already closely aligned to the program's goals, the **New Horizons** Pluto-Kuiper Belt mission became the first New Frontiers mission when the program was established. The second New Frontiers mission is **Juno**, scheduled to launch in 2011 and conduct an in-depth study of Jupiter. Juno plans to place a spacecraft in a polar orbit around the giant planet to look for an ice-rock core, determine how much water and ammonia exists in the atmosphere, study convection and deep wind profiles in the atmosphere, examine the origin of the Jovian magnetic field, and explore the polar magnetosphere. The other New Frontiers goals remain candidates for future missions.

NASA's Discovery and New Frontiers Program Office at Marshall Space Flight Center in Huntsville, Alabama, assists the Science Mission Directorate at NASA Headquarters with program management, systems assessment, flight assurance and public outreach. The Marshall location assures the availability of the technical expertise to quickly assess needs and manage the support structure to provide oversight to these missions. For more information on the New Frontiers Program, visit <http://newfrontiers.nasa.gov>.

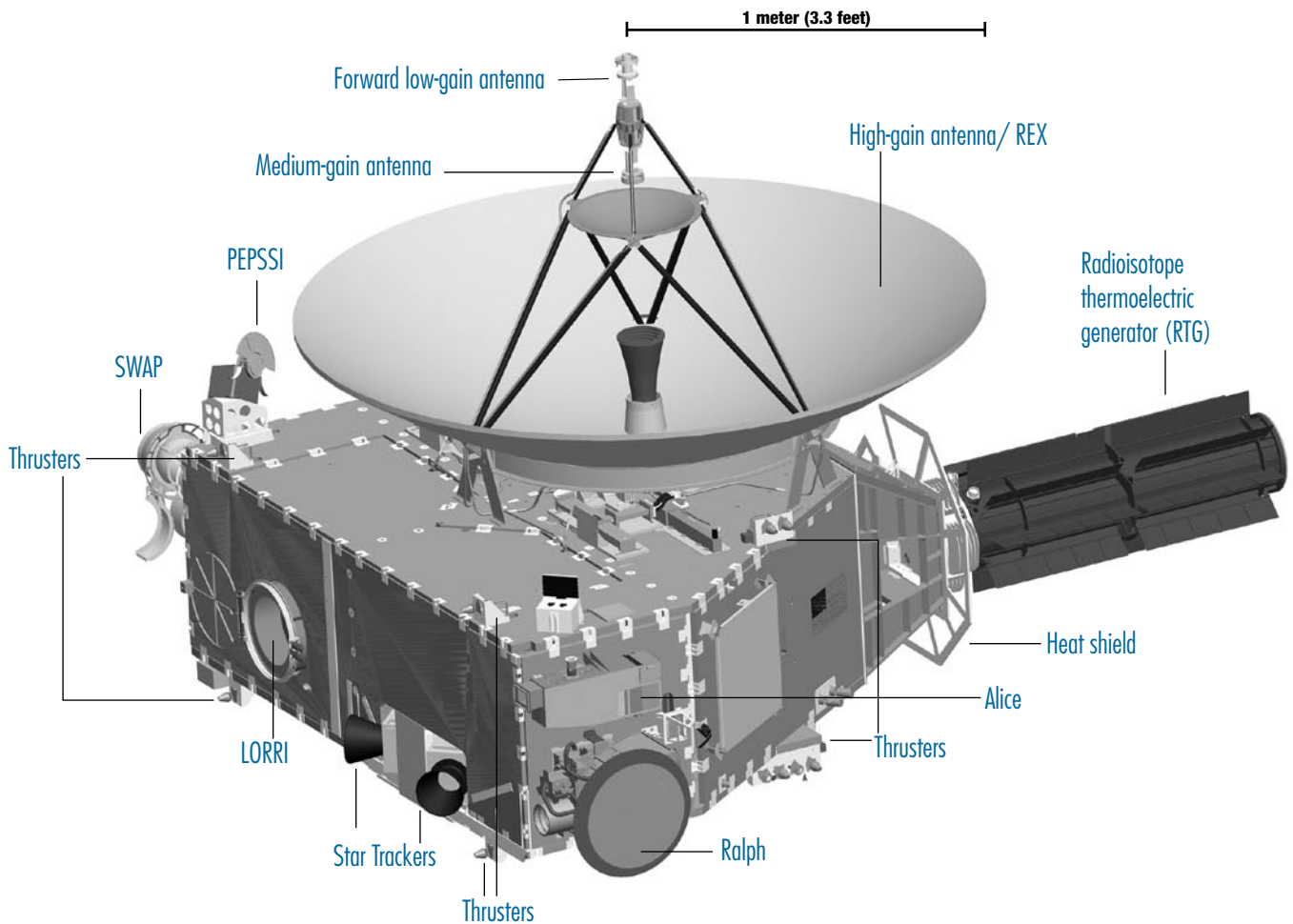


## The New Horizons Spacecraft

Designed and integrated at the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Maryland — with contributions from companies and institutions in the United States and abroad — the New Horizons spacecraft is a robust, lightweight observatory designed to withstand the long, difficult journey from the launch pad on Earth to the solar system's coldest, darkest frontiers.

The New Horizons science payload was developed under direction of the Southwest Research Institute (SwRI), with instrument contributions from SwRI, APL, NASA's Goddard Space Flight Center, the University of Colorado, Stanford University and Ball Aerospace Corporation. Fully fueled, the agile, piano-sized probe weighed 478 kilograms (1,054 pounds) at launch. Designed to operate on a limited power source — a single radioisotope thermoelectric generator — New Horizons needs less power than a pair of 100-watt light bulbs to complete its mission at Pluto.

On average, each of the seven science instruments uses between 2 and 10 watts — about the power of a night light — when turned on. The instruments send data to one of two onboard solid state memory banks, where data is recorded before later playback to Earth. During normal operations, the spacecraft communicates with Earth through its 2.1-meter (83-inch) wide high-gain antenna. Smaller antennas provide backup communications. And when the spacecraft hibernates through long stretches of its voyage, its computer is programmed to monitor its systems and report its status back home with a specially coded, low-energy beacon signal.





New Horizons' "thermos bottle" design retains heat and keeps the spacecraft operating at room temperature without large heaters. Aside from protective covers on five instruments that were opened shortly after launch, and one small protective cover that will be opened after the Jupiter encounter, New Horizons has no deployable mechanisms or scanning platforms. It does have backup devices for all major electronics, its star-tracking navigation cameras and data recorders.

New Horizons has operated mostly in a spin-stabilized mode during early checkouts and while cruising between planets, and also in a three-axis "pointing" mode that allows for pointing or scanning instruments during calibrations and planetary encounters (like the Jupiter flyby). There are no reaction wheels on the spacecraft; small thrusters in the propulsion system handle pointing, spinning and course corrections. The spacecraft navigates using onboard gyros, star trackers and Sun sensors.

The spacecraft's high-gain antenna dish is linked to advanced electronics and shaped to receive even the faintest radio signals from home — a necessity when the mission's main target is more than 3 billion miles from Earth and round-trip transmission time is nine hours.

## Science Payload

The New Horizons science payload consists of seven instruments — three optical instruments, two plasma instruments, a dust sensor and a radio science receiver/radiometer. This payload was designed to investigate the global geology, surface composition and temperature, and the atmospheric pressure, temperature and escape rate of Pluto and its moons — but they will go through a comprehensive dress rehearsal in the Jupiter system, studying the giant planet and its largest moons in early 2007. If an extended mission is approved, following the Pluto encounter, the instruments will probe one or more Kuiper Belt Objects.

The payload is incredibly power efficient — with the instruments collectively drawing less than 28 watts — and represent a degree of miniaturization that is unprecedented in planetary exploration. The instruments are designed specifically to handle the cold conditions and low light levels at Pluto and in the Kuiper Belt beyond.

All seven instruments have been turned on, checked out, and calibrated en route to Jupiter. All are functioning properly.

### Alice

**Mass:** 4.5 kilograms (9.9 pounds)

**Average Power:** 4.4 watts

**Development:** Southwest Research Institute

**Principal Investigator:** Alan Stern, Southwest Research Institute

**Purpose:** Study atmospheric composition and structure at Pluto, Charon and KBOs.



Alice is a sensitive ultraviolet imaging spectrometer designed to probe the composition and structure of Pluto's dynamic atmosphere. A spectrometer separates light into its constituent wavelengths (like a prism). An "imaging spectrometer" both separates the different wavelengths of light and produces an image of the target at each wavelength.

Alice's spectroscopic range extends across both extreme and far-ultraviolet wavelengths from approximately 500 to 1,800 Angstroms. The instrument will detect a variety of important atomic and molecular species in Pluto's atmosphere, and determine their relative abundances, giving scientists the first complete picture of Pluto's atmospheric composition. Alice will search for an ionosphere around Pluto and an atmosphere around Pluto's moon Charon. It will also probe the density of Pluto's atmosphere, and the atmospheric temperature of Pluto, both as a function of altitude.

Alice consists of a compact telescope, a spectrograph and a sensitive electronic detector with 1,024 spectral channels at each of 32 separate spatial locations in its long, rectangular field of view. Alice has two modes of operation: an "airglow" mode that measures ultraviolet emissions from atmospheric constituents, and an "occultation" mode that views the Sun or a bright star through an atmosphere and detects atmospheric

constituents by the amount of sunlight it absorbs. Absorption of sunlight by Pluto's atmosphere will show up as characteristic "dips" and "edges" in the ultraviolet part of the spectrum of light that Alice measures. This technique is a powerful method for measuring even traces of atmospheric gas.

A first-generation version of New Horizons' Alice (smaller and a bit less sophisticated) is flying successfully aboard the European Space Agency's Rosetta spacecraft, which will examine the surface of Comet 67P/Churyumov-Gerasimenko and study its escaping atmosphere and complex surface.

**Jobs at Jupiter:** *Take spectra of auroral emissions from Jupiter, its Io torus, and of the atmospheres of the Galilean satellites; investigate the atmospheres of Jupiter and the Galilean satellites through stellar occultation techniques.*

## Ralph

**Mass:** 10.3 kilograms (22.7 pounds)

**Average Power:** 6.3 watts

**Development:** Ball Aerospace Corporation, NASA Goddard Space Flight Center, Southwest Research Institute

**Principal Investigator:** Alan Stern, Southwest Research Institute

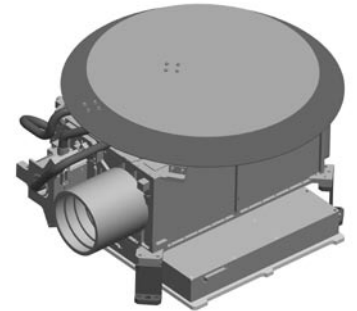
**Purpose:** Study surface geology and morphology of Pluto, its moons and KBOs; obtain surface composition and temperature maps of these bodies.

Ralph is the main "eyes" of New Horizons and will make the maps that show what Pluto, its moons and other Kuiper Belt Objects look like. The instrument is so named because it's coupled with an ultraviolet spectrometer called Alice in the New Horizons remote-sensing package — a reference familiar to fans of "The Honeymooners" TV show.

Ralph consists of three panchromatic (black-and-white) and four color imagers inside its Multispectral Visible Imaging Camera (MVIC), as well as an infrared compositional mapping spectrometer called the Linear Etalon Imaging Spectral Array (LEISA). LEISA is an advanced, miniaturized short-wavelength infrared (1.25-2.50 micron) spectrometer provided by scientists from NASA's Goddard Space Flight Center. MVIC operates over the bandpass from 0.4 to 0.95 microns.

Ralph's suite of eight detectors — seven charge-coupled devices (CCDs) similar to those found in a digital camera, and an infrared array detector — are fed by a single, sensitive magnifying telescope with a resolution more than 10 times better than the human eye. The entire package operates on less than half the wattage of a night light. Ralph will take images twice daily as New Horizons approaches, flies past and then looks back at the Pluto system. Ultimately, MVIC will map landforms in black-and-white and color with a best resolution of about 250 meters (820 feet) per pixel, take stereo images to determine surface topography, and help scientists refine the radii and orbits of Pluto and its moons. It will aid the search for clouds and hazes in Pluto's atmosphere, and for rings and additional satellites around Pluto and other Kuiper Belt Objects. It will also obtain images of Pluto's night side, illuminated by "Charon-light." At the same time, LEISA will map the amounts of nitrogen, methane, carbon monoxide, and frozen water and other materials, including organic compounds, across the sunlit surfaces of Pluto and its moons (and later Kuiper Belt Objects). It will let scientists map surface temperatures across Pluto and Charon by sensing the spectral features of frozen nitrogen, water and carbon monoxide. And Pluto is so far from the Sun that Ralph must work with light levels 1,000 times fainter than daylight at Earth — or 400 times fainter than conditions Mars probes face — so it is incredibly sensitive.

**Jobs at Jupiter:** *MVIC: Color images of Io's night side, Io's aurora and volcanic hot spots, other large moons of Jupiter and the terminator regions on Jupiter; LEISA: Three-dimensional images of storm activity on Jupiter; images of Jupiter's aurora; compositional maps of the Galilean satellites and volcanic hot spots on Io.*



## Radio Science Experiment (REX)

**Mass:** 100 grams (3.5 ounces)

**Average Power:** 2.1 watts

**Development:** Johns Hopkins University Applied Physics Laboratory, Stanford University

**Principal Investigator:** Len Tyler, Stanford University

**Purpose:** Measure Pluto's atmospheric temperature and pressure (down to the surface); measure density of the ionosphere; search for an atmosphere around Charon.

REX consists only of a small printed circuit board containing sophisticated signal-processing electronics integrated into the New Horizons telecommunications system. Because the telecom system is redundant within New Horizons, the spacecraft carries two copies of REX. Both can be used simultaneously to improve the data return from the radio science experiment.

REX will use an occultation technique to probe Pluto's atmosphere and to search for an atmosphere around Charon. After New Horizons flies by Pluto, its 2.1-meter (83-inch) dish antenna will point back at Earth. On Earth, powerful transmitters in NASA's largest Deep Space Network antennas will beam radio signals to the spacecraft as it passes behind Pluto. The radio waves will bend according to the average molecular weight of gas in the atmosphere and the atmospheric temperature. The same phenomenon could happen at Charon if the large moon has a substantial atmosphere, but Earth-based studies indicate this is unlikely.

Space missions typically conduct this type of experiment by sending a signal from the spacecraft through a planet's atmosphere and back to Earth. (This is called a "downlink" radio experiment.) New Horizons will be the first to use a signal from Earth — the spacecraft will be so far from home and moving so quickly past Pluto-Charon that only a large, ground-based antenna can provide a sufficiently strong signal. This new technique, called an "uplink" radio experiment, is an important advance beyond previous outer-planet missions.

REX will also measure the weak radio emissions from Pluto and other bodies the spacecraft flies by, such as Charon, or Jupiter and its largest moons. Scientists will use the data to derive accurate globally averaged day-side and night-side temperature measurements. Also, by using REX to track slight changes in the spacecraft's path, scientists will measure the masses of Pluto and its moons, and possibly the masses of additional Kuiper Belt Objects. By timing the length of the radio occultations of Pluto and Charon, REX will also yield improved radii measurements for each body.

***Job at Jupiter:** Calibrations, using Jupiter as a source.*

## Long Range Reconnaissance Imager (LORRI)

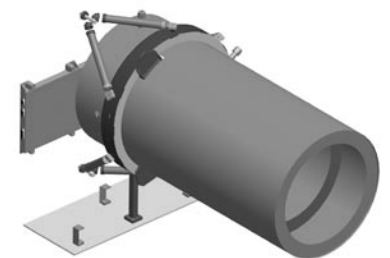
**Mass:** 8.8 kilograms (19.4 pounds)

**Average Power:** 5.8 watts

**Development:** Johns Hopkins University Applied Physics Laboratory

**Principal Investigator:** Andy Cheng, Applied Physics Laboratory

**Purpose:** Study the geology of Pluto, its moons and KBOs; provide high-resolution approach and highest-resolution encounter images of these bodies.



LORRI, the "eagle eyes" of New Horizons, is a panchromatic high-magnification imager, consisting of a telescope with an 8.2-inch (20.8-centimeter) aperture that focuses visible light onto a charge-coupled device (CCD). It's essentially a digital camera with a large telephoto telescope — only fortified to operate in the cold, hostile environs near Pluto. LORRI images will be New Horizons' first of the Pluto system, starting about 200 days before closest approach. At the time, Pluto and its moons will resemble little more than bright dots, but these system-wide views will help navigators keep the spacecraft on course and help scientists refine their orbit calculations of Pluto and its moons. At 90 days before closest approach — with the system more than 100 million kilometers (60 million miles) away — LORRI images will surpass Hubble-quality resolution, providing never-before-seen details each day. At closest approach, LORRI will image select sections of Pluto's sunlit surface at football-field-size resolution, resolving features at least 100 meters across.

This range of images will give scientists an unprecedented look at the geology on Pluto, Charon and additional Kuiper Belt Objects — including the number and size of craters on each surface, revealing the history of impacting objects in that distant region. LORRI will yield important information on the history of Pluto's surface, search for activity such as geysers on that surface, and look for hazes in Pluto's atmosphere. LORRI will also provide the highest resolution images of any Kuiper Belt Objects New Horizons would fly by in an extended mission.

LORRI has no color filters or moving parts — operators take images by pointing the LORRI side of the spacecraft directly at their target. The instrument's innovative silicon carbide construction will keep its mirrors focused through the extreme temperatures New Horizons will experience on the way to and past the Pluto system.

**Job at Jupiter:** *Take images of Jupiter's cloud motions; images of aurora at Jupiter and the Galilean satellites, of surface changes, plume activity and volcanic hot spots on Io, and of topography on Europa; aid the search for small satellites in Jupiter's rings; take images of Jupiter's ring structure and of the small outer Jovian satellites Himalia and Elara.*

## Solar Wind at Pluto (SWAP)

**Mass:** 3.3 kilograms (7.3 pounds)

**Average Power:** 2.3 watts

**Development:** Southwest Research Institute

**Principal Investigator:** David McComas, Southwest Research Institute

**Purpose:** Study solar wind interactions with Pluto and escape rate of Pluto's atmosphere.

The SWAP instrument will measure interactions of Pluto with the solar wind — the high-speed stream of charged particles flowing from the Sun. The incredible distance of Pluto from the Sun required the SWAP team to build the largest-aperture instrument ever used to measure the solar wind.

Pluto's small gravitational acceleration (approximately 1/16 of Earth's gravity) leads scientists to think that 50 to 500 kilograms (or, about 100 to 1,000 pounds) of material escape its atmosphere every second. If so, then the planet behaves like a comet, though Pluto is more than 1,000 times larger than a typical comet nucleus. The atmospheric gases that escape Pluto's weak gravity leave the planet as neutral atoms and molecules. These atoms and molecules are ionized by ultraviolet sunlight (similar to the Earth's upper atmosphere and ionosphere). Once they become electrically charged, the ions and electrons become "picked up" and are carried away by the solar wind. In the process, these pick-up ions gain substantial energy (thousands of electron-volts). This energy comes from the solar wind, which is correspondingly slowed down and diverted around Pluto. SWAP measures low-energy interactions, such as those caused by the solar wind. By measuring how the solar wind is perturbed by the interaction with Pluto's escaping atmosphere, SWAP will determine the escape rate of atmospheric material from Pluto.

At the top of its energy range SWAP can detect some pickup ions (up to 6.5 kiloelectron volts, or keV). SWAP combines a retarding potential analyzer (RPA) with an electrostatic analyzer (ESA) to enable extremely fine, accurate energy measurements of the solar wind, allowing New Horizons to measure minute changes in solar wind speed.

The amount of Pluto's atmosphere that escapes into space provides critical insights into the structure and destiny of the atmosphere itself.

**Job at Jupiter:** *Measure the density, temperature and flow speeds of sulfur and oxygen ions that are ionized near Io and spread out to fill the giant magnetosphere of Jupiter; explore the low-energy plasma in Jupiter's magnetotail.*



## Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI)

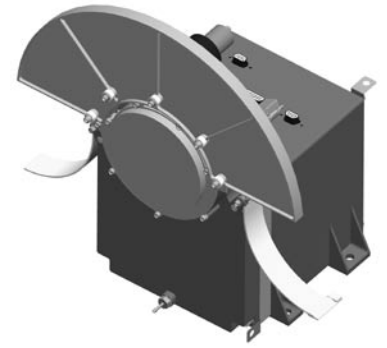
**Mass:** 1.5 kilograms (3.3 pounds)

**Average Power:** 2.5 watts

**Development:** Johns Hopkins University Applied Physics Laboratory

**Principal Investigator:** Ralph McNutt Jr., Applied Physics Laboratory

**Purpose:** Study the density, composition, and nature of energetic particles and plasmas resulting from the escape of Pluto's atmosphere.



PEPSSI, the most compact, lowest-power directional energetic particle spectrometer flown on a space mission, will search for neutral atoms that escape Pluto's atmosphere and become charged by their interaction with the solar wind. It will detect the material that escapes from Pluto's atmosphere (such as molecular nitrogen, carbon monoxide and methane), which break up into ions and electrons after absorbing the Sun's ultraviolet light, and stream away from Pluto as "pick up" ions carried by the solar wind.

The instrument will likely get its first taste of Pluto's atmosphere when the planet is still millions of kilometers away. By using PEPSSI to count particles, and knowing how far New Horizons is from Pluto at a given time, scientists will be able to tell how quickly the planet's atmosphere is escaping and gain new information about what the atmosphere is made of. PEPSSI is a classic "time-of-flight" particle instrument: particles enter the detector and knock other particles (electrons) from a thin foil; they zip toward another foil before hitting a solid-state detector. The instrument clocks the time between the foil collisions to tell the particle's speed and determines its total energy when it collides with the solid-state detector. The combination determines the particle's mass. From this, scientists can determine the composition of each particle. PEPSSI can measure energetic particles up to 1,000 kiloelectron volts (keV), many times more energetic than SWAP can. Together the two instruments make a powerful combination for studying the Pluto system.

***Job at Jupiter:** Measure fluxes of the energetic particles to investigate how ionized plasma accelerates and spreads out in Jupiter's rapidly rotating magnetosphere; explore the high-energy particles in Jupiter's magnetotail.*

## Venetia Burney Student Dust Counter (VB-SDC)

**Mass:** 1.9 kilograms (4.2 pounds)

**Average Power:** 5 watts

**Development:** Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder

**Principal Investigator:** Mihaly Horanyi, University of Colorado at Boulder

**Purpose:** Measure concentration of dust particles in outer solar system



Designed and built by students at the University of Colorado at Boulder, the VB-SDC (or "Venetia") will detect microscopic dust grains produced by collisions among asteroids, comets and Kuiper Belt Objects during New Horizons' long journey. Officially a New Horizons Education and Public Outreach project, Venetia is the first science instrument on a NASA planetary mission to be designed, built and "flown" by students.

Venetia will count and measure the sizes of dust particles along New Horizons' entire trajectory and produce information on the collision rates of such bodies in the deep outer solar system. The counter will also be used to search for dust in the Pluto system; such dust might be generated by collisions of tiny impactors on Pluto's small moons.

The instrument includes two major pieces: an 18-by-12-inch detector assembly, which is mounted on the outside of the spacecraft and exposed to the dust particles; and an electronics box inside the spacecraft that, when a hit occurs on the detector, deciphers the data and determines the mass and speed of the particle. Because no dust detector has ever flown beyond 18 astronomical units from the Sun (nearly 1.7 billion miles, about the distance from Uranus to the Sun), Venetia data will give scientists an unprecedented look at the



sources and transport of dust in the solar system. With faculty support, University of Colorado students will also distribute and archive data from the instrument, and lead a comprehensive education and outreach effort to bring their results and experiences to classrooms of all grades over the next two decades.

**Job at Jupiter:** *Search for Jovian dust streams and measure dust particles down the length of Jupiter's magnetotail.*

## Systems and Components

### Structure

New Horizons' primary structure includes an aluminum central cylinder that supports honeycomb panels, serves as the payload adapter fitting that connected the spacecraft to the launch vehicle, supports the interface between the spacecraft and its power source, and houses the propellant tank. To keep launch mass down, the panels surrounding the central cylinder feature an aluminum honeycomb core with ultra-thin aluminum face sheets (about as thick as two pieces of paper). To keep it perfectly balanced for spinning operations, the spacecraft was weighed and then balanced with additional weights just before mounting on the launch vehicle.

### Command and Data Handling

The Command and Data Handling system — a radiation-hardened 12-megahertz Mongoose V processor guided by intricate flight software — is the spacecraft's "brain." The processor distributes operating commands to each subsystem, collects and processes instrument data, and sequences information sent back to Earth. It also runs the advanced "autonomy" algorithms that allow the spacecraft to check the status of each system and, if necessary, correct problems, switch to backup systems or contact operators on Earth for help.

For data storage, New Horizons carries two low-power solid-state recorders (one backup) that can hold up to 8 gigabytes (64 gigabits) each. The main processor collects, compresses, re-formats, sorts and stores science and housekeeping data on the recorder — similar to a flash memory card for a digital camera — for transmission to Earth through the telecommunications subsystem. The Command and Data Handling processor, data recorder, power converters, Guidance and Control processor, radio science and tracking electronics, and interfaces between the processors and science instruments are housed in the Integrated Electronics Module (IEM), a space- and weight-saving device that combines the spacecraft's core avionics in a single box. New Horizons carries a redundant IEM as a backup.

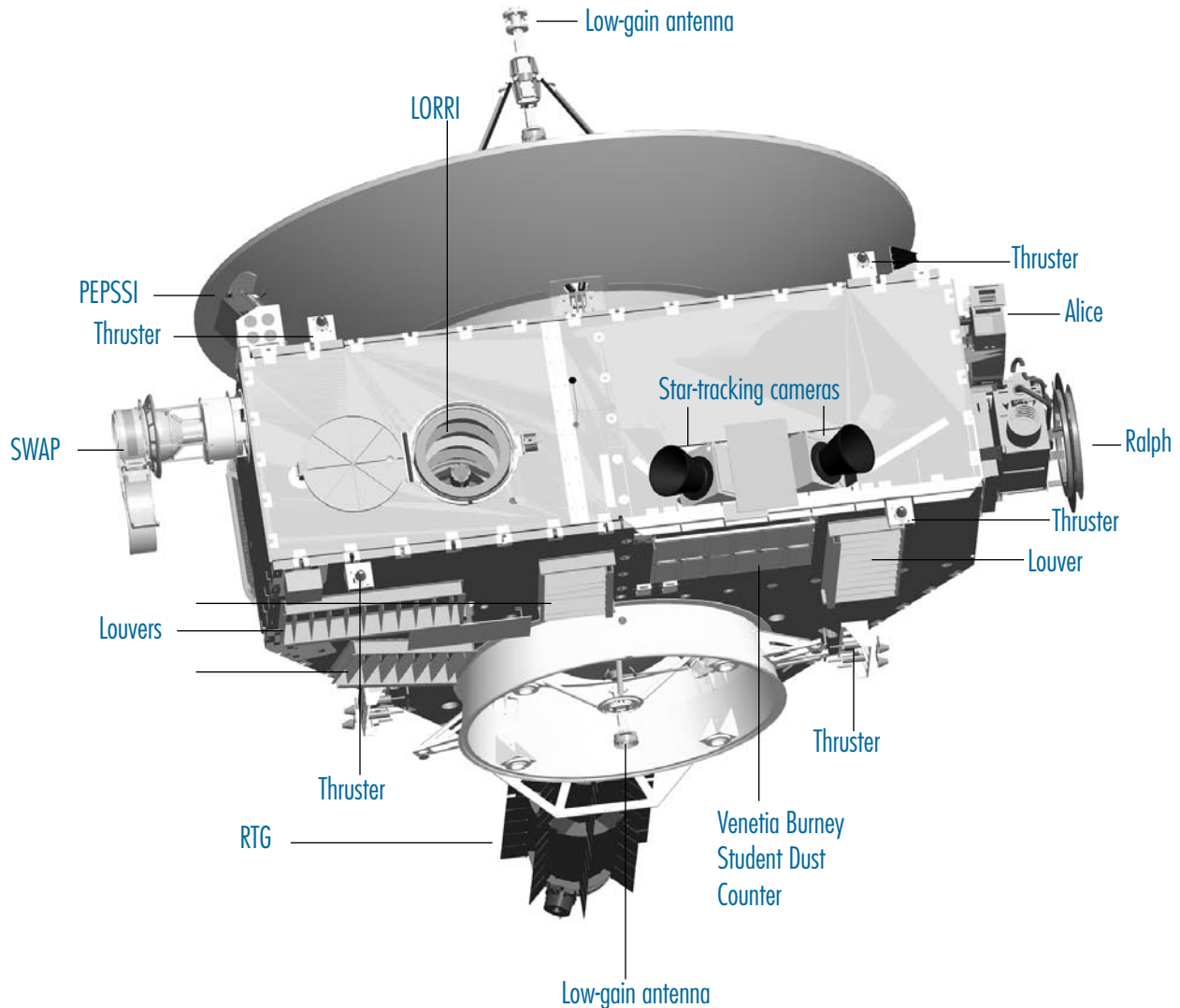
### Thermal Control

New Horizons is designed to retain heat like a thermos bottle. The spacecraft is covered in lightweight, gold-colored, multilayered thermal insulation blankets, which hold in heat from operating electronics to keep the spacecraft warm. Heat from the electronics will keep the spacecraft operating at between 10-30 degrees Celsius (about 50-85 degrees Fahrenheit) throughout the journey. New Horizons' sophisticated, automated heating system monitors power levels inside the craft to make sure the electronics are running at enough wattage to maintain safe temperatures. Any drop below that operating level (settable between 100 and 150 watts) activates small heaters around the craft to make up the difference. When the spacecraft is closer to Earth and the Sun, louvers (that act as heat vents) on the craft open when internal temperatures are too high.

The thermal blanketing — 18 layers of Dacron mesh cloth sandwiched between aluminized Mylar and Kapton film — also helps to protect the craft from micrometeorites.

### Venetia: Honoring a Famous Student

In June 2006, the Student Dust Counter instrument was renamed to honor one of astronomy's most famous students — the "little girl" who named the ninth planet more than 75 years ago. The name Venetia Burney Student Dust Counter, or "Venetia" for short, honors Venetia Burney Phair, who at age 11 offered the name "Pluto" for the newly discovered ninth planet in 1930.



## Propulsion

The propulsion system on New Horizons is used for course corrections and for pointing the spacecraft. It is not needed to speed the spacecraft to Pluto; that is done entirely by the launch vehicle and the gravity assist at Jupiter.

The New Horizons propulsion system includes 16 small hydrazine-propellant thrusters mounted across the spacecraft in eight locations, a fuel tank and associated distribution plumbing. Four thrusters that each provide 4.4 newtons (1 pound) of thrust are used mostly for course corrections. The spacecraft uses 12 smaller thrusters — providing 0.8 newtons (about 3 ounces) of thrust each — to point, spin up and spin down. Eight of the 16 thrusters aboard New Horizons are considered the primary set; the other eight comprise the backup (redundant) set.

At launch, the spacecraft carried 77 kilograms (170 pounds) of hydrazine, stored in a lightweight titanium tank. Helium gas pushes fuel through the system to the thrusters. The Jupiter gravity assist, along with the fact that New Horizons does not need to slow down enough to enter orbit around Pluto, reduces the amount of propellant needed for the mission.

Three small trajectory maneuvers were carried out shortly after launch; the team envisions another in May 2007, after the Jupiter encounter.

## Guidance and Control

New Horizons must be oriented in a particular direction to collect data with its scientific instruments, communicate with Earth, or maneuver through space. Attitude determination — knowing which direction New Horizons is facing — is performed using star-tracking cameras, Inertial Measurement Units (containing sophisticated gyroscopes and accelerometers that measure rotation and horizontal/vertical motion), and digital solar sensors. Attitude control for the spacecraft — whether in a steady, three-axis pointing mode or in a spin-stabilized mode — is accomplished using thrusters.

The IMUs and star trackers provide constant positional information to the spacecraft's Guidance and Control processor, which like the Command and Data Handling processor is a 12-MHz Mongoose V. New Horizons carries two copies of each of these units for redundancy. The star-tracking cameras store a map of about 3,000 stars; 10 times per second one of the cameras snaps a wide-angle picture of space, compares the locations of the stars to its onboard map, and calculates the spacecraft's orientation. The IMU feeds motion information 100 times a second. If data show New Horizons is outside a predetermined position, small hydrazine thrusters will fire to re-orient the spacecraft. The Sun sensors back up the star trackers; they would find and point New Horizons toward the Sun (with Earth nearby) if the other sensors couldn't find home in an emergency.

Operators use thrusters to maneuver the spacecraft, which has no internal reaction wheels. Its smaller thrusters are used for fine pointing; thrusters that are approximately five times more powerful are used during the trajectory course maneuvers that guide New Horizons toward its targets. New Horizons spins — typically at 5 revolutions per minute (rpm) — during trajectory-correction maneuvers, long radio contacts with Earth, and while it "hibernates" during long cruise periods. Operators will steady and point the spacecraft during science observations and instrument-system checkouts.

## Communications

New Horizons' X-band communications system is the spacecraft's link to Earth, returning science data, exchanging commands and status information, and allowing for precise radiometric tracking through NASA's Deep Space Network of antenna stations. The system includes two broad-beam, low-gain antennas on opposite sides of the spacecraft for near-Earth communications; a 30-centimeter (12-inch) diameter medium-gain dish antenna and a large, 2.1-meter (83-inch) diameter high-gain dish antenna. The antenna assembly on the spacecraft's top deck consists of the high, medium and forward low-gain antennas; this stacked design provides a clear field of view for the low-gain antenna and structural support for the high and medium-gain dishes.

Operators aim the antennas by turning the spacecraft toward Earth. The high-gain beam is only 0.3 degrees wide, so it must point directly at Earth. The medium-gain beam is wider (14 degrees), so it is used in conditions when the pointing might not be as accurate. (The low-gain antennas, designed for communications close to Earth, are no longer useful.) All antennas have Right Hand Circular and Left Hand Circular polarization feeds. Data rates depend on spacecraft distance, the power used to send the data and the size of the antenna on the ground.

For most of the mission, New Horizons will use its high-gain antenna to exchange data with the Deep Space Network's largest antennas, 70 meters across. Even then, because New Horizons will be more than 3 billion miles from Earth and radio signals will take more than four hours to reach the spacecraft, it can send information at about 600 to 1,200 bits per second. It will take five months to send the full set of Pluto encounter science data back to Earth.

### Accurate Ranging

New Horizons is the first mission to use onboard regenerative ranging to track the distance between the spacecraft and Earth.

When a spacecraft is far from home, the ranging tone sent from the ground to measure distance is weak (or "noisy") by the time it reaches the spacecraft's communications system. In normal ranging, the spacecraft simply amplifies and sends the noisy tone back to Earth, which adds errors to the range measurement. In regenerative ranging, the spacecraft's advanced electronics track and "regenerate" the tone without the noise. The ground station on Earth receives a much clearer signal — giving navigators and operators a more accurate lock on the spacecraft's distance, and improving their ability to guide New Horizons through the solar system.



New Horizons flies the most advanced digital receiver ever used for deep space communications. Advances include regenerative ranging and low power — the receiver consumes 66% less power than other modern deep space receivers. The Radio Science Experiment (REX) to examine Pluto's atmosphere is also integrated into the communications subsystem. The entire telecommunications system on New Horizons is redundant, with two of everything except the high-gain antenna structure itself.

## Mission Operations

New Horizons mission operations are conducted from the Mission Operations Center at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, where the spacecraft was designed and built. Flight controllers and mission analysts monitor and operate the spacecraft, working closely with the multi-institutional science team, the mission design team at APL, and the navigation team at KinetX Inc., based in Simi Valley, California.

Mission operators and scientists work together to plan, design and test commands for New Horizons' science instruments. Working with the mission design and navigation teams, operators build, test and send the commands that fire New Horizons' thrusters and refine its path to Pluto. The instruments aboard New Horizons are operated by command sequences generated at the Clyde Tombaugh Science Operations Center, located at Southwest Research Institute in Boulder, Colorado. This facility, named after the American astronomer who discovered Pluto in 1930, will also process instrument data for the science team and produce data archives for the scientific community at large.

Like all NASA interplanetary missions, New Horizons will rely on the agency's Deep Space Network of antenna stations to track and communicate with the spacecraft. The stations are located in California's Mojave Desert; near Madrid, Spain; and near Canberra, Australia. All three complexes communicate directly with the control center at NASA's Jet Propulsion Laboratory, Pasadena, California, which in turn communicates with the New Horizons Mission Operations Center.

## Education and Public Outreach

The New Horizons education and public outreach (E/PO) program taps into the excitement of visiting uncharted territories and unexplored worlds in a new region of the solar system. With a range of hands-on, minds-on learning experiences and materials, the program provides unique opportunities for students, educators, museums, science centers, Web surfers and other members of the public to ride along on the first mission to Pluto and the Kuiper Belt.

The E/PO program calls for a variety of formal lesson plans and learning materials — based on New Horizons science and engineering goals, and aligned with National Research Council's National Science Education Standards — that will help students in grades K-12 gain a better understanding of science, mathematics and technology. The learning doesn't stop in high school: college students have designed and built an actual flight instrument on New Horizons — the Venetia Burney Student Dust Counter — and held internships with the spacecraft integration and test team. Many of the New Horizons higher education initiatives focus on students from historically black colleges and universities and minority-serving institutions.

New Horizons E/PO programs go beyond the classroom, from a unique chance for people to send their names to Pluto on board the New Horizons spacecraft, to opportunities for the public to access real-time mission data, milestone events and general information in places such as museums, science centers and libraries, TV and the Web. For more information on the E/PO team and New Horizons educational materials, visit <http://pluto.jhuapl.edu/education/index.html>.

## Program/Project Management

Dr. Alan Stern, of the Southwest Research Institute's (SwRI) Boulder, Colorado, operation, leads the New Horizons mission as principal investigator. The Johns Hopkins University Applied Physics Laboratory (APL), Laurel, Maryland, manages the New Horizons mission for the Science Mission Directorate, NASA Headquarters, Washington.

At NASA Headquarters, Dr. Mary Cleave is the associate administrator for the Science Mission Directorate and Dr. Colleen Hartman is deputy associate administrator for the Science Mission Directorate. Dr. James Green is the acting director of the Planetary Science Division. Mr. Kurt Lindstrom is the New Horizons program executive and Dr. Denis Bogan is the New Horizons program scientist. Mr. Paul Gilbert is the New Frontiers Program manager and Mr. Allen Bacskay is New Horizons mission manager at Marshall Space Flight Center, Alabama.

At APL, Mr. Glen Fountain is the New Horizons project manager and Dr. Harold Weaver is New Horizons project scientist. Mr. Mark Holdridge is mission manager, Ms. Alice Bowman is mission operations manager, Mr. Chris Hersman is mission systems engineer, Dr. Yanping Guo is mission design team lead and Ms. Kerri Beisser is education and public outreach manager. Mr. Robert Strain is the head of the APL Space Department and Dr. Richard Roca is the director of the Applied Physics Laboratory.

At SwRI in Boulder, Dr. Leslie Young is the New Horizons deputy project scientist, and Dr. Joe Peterson is the Tombaugh Science Operations Center team lead. At SwRI in San Antonio, Texas, Mr. John Andrews is New Horizons payload manager. Dr. James Burch is vice president of the Space Science and Engineering Division and Mr. J. Dan Bates is the president of the Southwest Research Institute, San Antonio.

Mr. Eric Carranza leads the navigation team at KinetX Inc., Simi Valley, California.

The New Horizons Jupiter Encounter Science Team (JEST), established by PI Stern to plan the Jupiter encounter, is led by mission co-investigator and imaging team lead Dr. Jeff Moore, of NASA Ames Research Center, Moffett Field, California. Mission co-investigator and imaging team deputy lead Dr. John Spencer, of SwRI's Boulder office, is the JEST deputy lead.

The New Horizons science team includes co-investigators from: Southwest Research Institute; Johns Hopkins University Applied Physics Laboratory; NASA Goddard Space Flight Center, Greenbelt, Maryland; University of Colorado, Boulder; Massachusetts Institute of Technology, Cambridge; NASA Jet Propulsion Laboratory, Pasadena, California; NASA Ames Research Center; Lowell Observatory, Flagstaff, Arizona; Stanford University, Palo Alto, California; Washington University, St. Louis; Space Science Institute, Boulder, Colorado; Ball Aerospace, Boulder, Colorado; and George Mason University, Fairfax, Virginia.



# ***FIRST***

mission to Pluto and the Kuiper Belt

# ***FASTEST***

spacecraft ever launched from Earth

# ***FARTHEST***

distance a spacecraft has traveled  
to begin its primary science mission



<http://pluto.jhuapl.edu>