2 DESCRIPTION AND COMPARISON OF ALTERNATIVES

Pluto, the most distant planet in our solar system and the last to be discovered, has yet to be visited by a spacecraft. The proposed New Horizons mission would conduct the first survey of Pluto and would thus complete the initial reconnaissance of our solar system. The New Horizons spacecraft would fly by Pluto and its moon, Charon, and use remote sensing instrumentation to characterize the physical and chemical properties of these bodies. Following the Pluto-Charon encounter, the New Horizons spacecraft could be directed to fly by and observe one or more Kuiper Belt Objects (KBO).

This Draft Environmental Impact Statement (DEIS) for the New Horizons mission evaluates the Proposed Action and the No Action Alternative.

- Proposed Action—The National Aeronautics and Space Administration (NASA) proposes to continue preparations for and implement the New Horizons mission to Pluto, its moon Charon, and possibly one or more objects within the Kuiper Belt. The New Horizons spacecraft would be launched on board an Atlas V 551 expendable launch vehicle from Cape Canaveral Air Force Station (CCAFS), Florida, during January – February 2006, and would be inserted into a trajectory toward Pluto. The spacecraft would arrive at the Pluto-Charon system as early as 2015, depending on the exact launch date, and would remotely gather scientific data during the flyby encounter. The spacecraft may then be directed on an extended mission to one or more KBOs.

  In the event NASA is unable to launch the New Horizons spacecraft during the primary January – February 2006 opportunity, a backup opportunity could occur during February 2007. For this backup opportunity, arrival at Pluto would occur in either 2019 or 2020 depending on the exact launch date.

  A description of the New Horizons mission is presented in Section 2.1.

- No Action Alternative—Under this alternative, NASA would discontinue preparations for the New Horizons mission and the spacecraft would not be launched. There would be no close reconnaissance of Pluto, Charon, or any KBO within the timeframe of the Proposed Action. Potential advancements in science resulting from this mission would not be realized. Continuing observations of Pluto, Charon, and the KBOs would be limited to those obtained only from existing ground-based and Earth-orbiting resources.

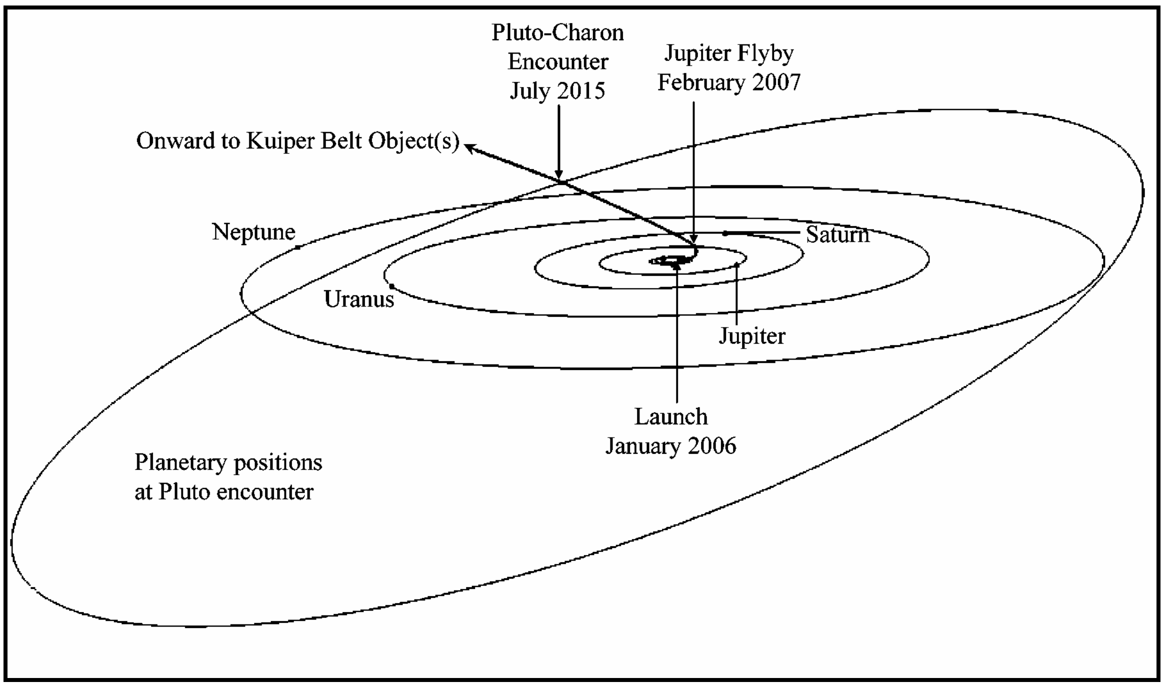
  A description of the No Action Alternative is presented in Section 2.2.

2.1 DESCRIPTION OF THE PROPOSED ACTION

2.1.1 Mission Description

The material presented in this section is summarized from *New Horizons Pluto-Kuiper Belt Mission and System Description* (APL 2003d).

The New Horizons spacecraft would be launched from CCAFS, Florida, on board an Atlas V 551 (hereinafter referred to as the Atlas V) expendable launch vehicle from Space Launch Complex 41 (SLC-41). During the primary launch opportunity of January 11 through February 14, 2006, launch dates between January 11 and February 2 allow use of a Jupiter Gravity Assist (JGA) maneuver to minimize the flight time to Pluto. The early dates (January 11 – January 27) during this opportunity yield an arrival at Pluto in 2015. Figure 2-1 depicts the baseline (preferred) mission trajectory for a launch in early January 2006. Launch dates in late January and early February yield arrival dates in 2016 and 2017, respectively. After February 2, 2006, Jupiter would no longer be in a position to provide a gravity assist, and only direct trajectories to Pluto would be available. For these direct trajectories, arrival at Pluto would range from 2018 through 2020, depending on the exact launch date in February 2006.

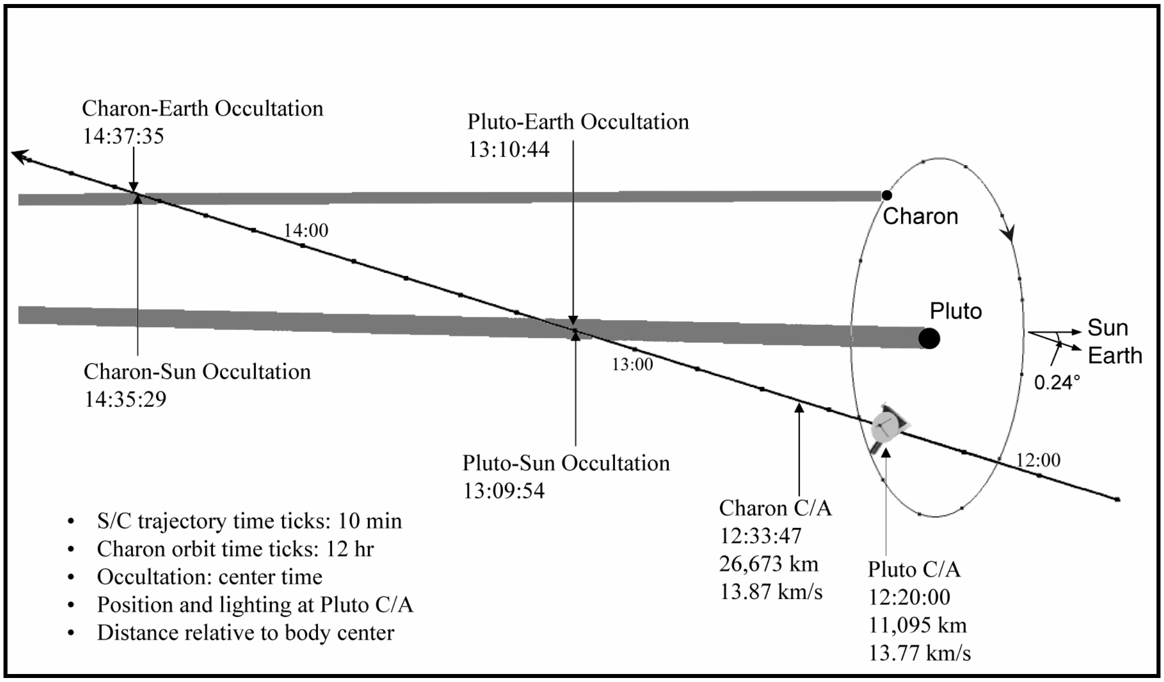


Source: APL 2003d

FIGURE 2-1. THE NEW HORIZONS 2006 JUPITER GRAVITY ASSIST TRAJECTORY

The gravity assist maneuver at Jupiter would occur in February 2007 and would redirect the spacecraft to the desired Pluto flyby trajectory. The spacecraft would fly by Jupiter at a distance of about 2.3 million kilometers (km) (1.4 million miles (mi)), and would conduct science observations of Jupiter and its satellites during a 4-month period. The spacecraft would then be placed in a low-power operational mode, with occasional status checks during the cruise to Pluto.

The spacecraft's science instruments would be activated 6 months prior to closest approach to Pluto in preparation for the flyby. The science observation phase would begin about 3 months prior to the encounter. The relative flyby speed of the spacecraft through the Pluto-Charon system would be somewhat less than 50,000 kilometers per hour (km/h) (31,000 miles per hour (mph)). The spacecraft's closest approach to Pluto would be about 11,000 km (6,835 mi) and, 14 minutes later, its closest approach to Charon would be about 26,700 km (16,590 mi). Figure 2-2 depicts the encounter geometry as the spacecraft passes through the Pluto-Charon system.



Source: APL 2003d

FIGURE 2-2. NEW HORIZONS MISSION PLUTO-CHARON ENCOUNTER GEOMETRY

Science observations and data gathering activities would begin 90 days before closest approach and end 90 days after closest approach, with the most intense science activity occurring during the 24-hour period centered around closest approach. Activities would include imaging, visible and infrared spectral mapping, ultraviolet spectroscopy, in situ measurements of energetic particles, and radio science. During the half-hour prior to closest approach to Pluto and Charon, the spacecraft would image each body in both visible and infrared wavelengths. The highest resolution images of Pluto are expected to depict surface features of about 100 meters (m) (330 feet (ft)) in diameter. The spacecraft would observe the dark side of Pluto to detect haze in the atmosphere and search for possible rings and smaller satellites. The spacecraft would also perform solar occultation experiments as it passes Pluto and Charon. Data obtained about Pluto and Charon would be stored on board the spacecraft and transmitted to Earth starting about two weeks after the flyby. Data transmission would be completed about 9 months after the flyby.

After the data transmission is complete, the spacecraft could be redirected to one or more KBOs. It would take three to six years to reach the KBOs. Science observations similar to those performed at Pluto and Charon would be obtained at the KBOs and would be transmitted to Earth.

In the event NASA is unable to utilize the January – February 2006 launch opportunity to Pluto, NASA could use a backup launch opportunity in February 2007. This backup launch opportunity would involve a direct trajectory to Pluto, would use the Atlas V launch vehicle from CCAFS, and the New Horizons spacecraft would arrive at Pluto in 2019 or 2020, depending on the exact launch date.

2.1.2 Spacecraft Description

The material presented in this section is summarized from *New Horizons Pluto-Kuiper Belt Mission and System Description* (APL 2003d).

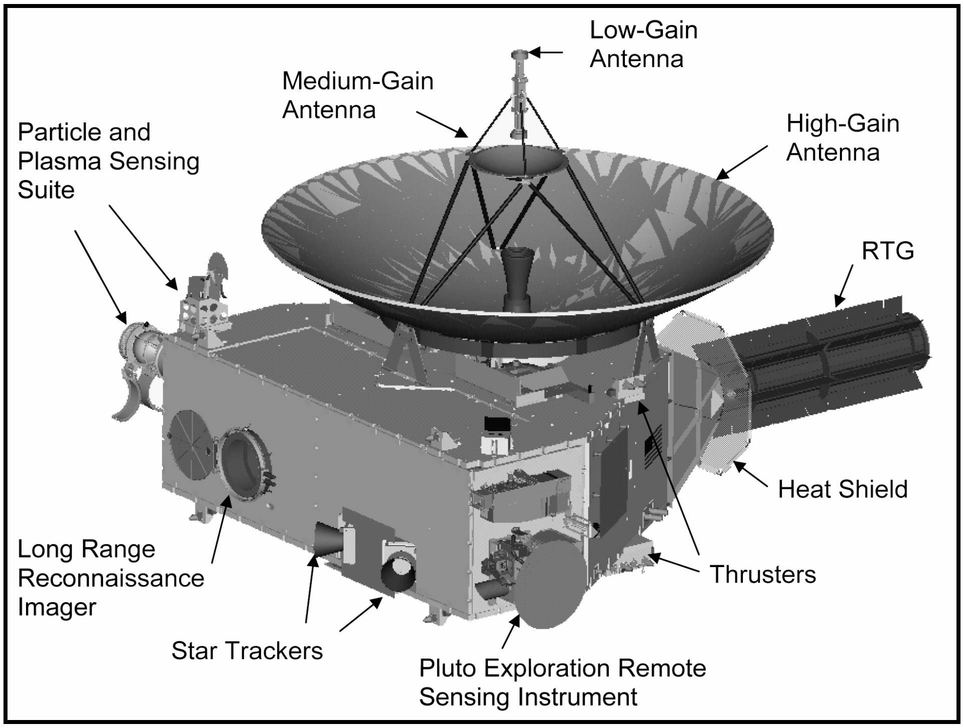
The New Horizons spacecraft (Figure 2-3), provided under contract to NASA by The Johns Hopkins University's Applied Physics Laboratory (APL), would be based on a triangular shaped structure constructed of aluminum honeycomb panels. The spacecraft would be approximately 2.2 m (7.2 ft) in height, 2.7 m (8.9 ft) in width, and 3.2 m (10.5 ft) in length, and would have a maximum design mass of about 465 kilograms (kg) (1,025 pounds (lb)). The spacecraft's major components would consist of the 2.1 m (6.9 ft) diameter high gain antenna (HGA), equipment platform, propulsion system, and the radioisotope thermoelectric generator (RTG). The RTG would be externally mounted at one end of the triangular structure and would provide electrical power for the spacecraft. A combination of excess heat from the RTG, heat generated from the electronics, electrical heaters, and insulation would be used to maintain the temperature within the spacecraft. The spacecraft propulsion system would consist of propellant tanks and thrusters, and would use a nominal propellant load of about 80 kg (176 lb) of hydrazine for trajectory and attitude control maneuvers.

The suite of science instruments planned for the New Horizons mission would consist of the Pluto Express Remote Sensing Instrument (PERSI), the Radio Science Experiment (REX), the Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI)[1], the Solar Wind Around Pluto (SWAP), and the Long Range Reconnaissance Imager (LORRI). Data obtained from these instruments would fulfill the science objectives discussed in Chapter 1. In addition to these science instruments, a student experiment called the Student Dust Counter (SDC) would be included as a part of the science payload on the New Horizons spacecraft. An overview of the function and purpose of each instrument is presented in Table 2-1.

2.1.3 Spacecraft Electrical Power

The proposed New Horizons spacecraft would use a General Purpose Heat Source (GPHS)-RTG, provided to NASA by the U.S. Department of Energy (DOE), as the source of electrical power for its engineering subsystems and science payload. A detailed discussion of the RTG is provided in Section 2.1.3.2.

[1] The PEPSSI instrument uses 1 nanocurie of americium-241 as a calibration source.



Source: APL 2003d

FIGURE 2-3. MAJOR COMPONENTS OF THE NEW HORIZONS SPACECRAFT

2.1.3.1 Electrical Power Performance Criteria

The New Horizons spacecraft's lengthy mission (nearly ten years to reach Pluto and another three to six years to reach one or more KBOs) would impose stringent performance criteria for its systems and components. The spacecraft would be subject to the radiation environment of Jupiter during the gravity-assist flyby. Further, the Pluto encounter would occur at a distance of about 33 astronomical units (AU) from the Sun, where solar illumination would be less than one-thousandth[2] of that encountered in Earth orbit. The flyby of the KBOs would occur at distances up to 50 AU from the Sun. Therefore, the electrical power system must satisfy a variety of performance and operational requirements, including but not limited to the following:

- operation during passage through Jupiter's radiation fields;
- provision of sufficient power at great distances from the Sun;
- a low mass-to-power ratio (high specific power); and,
- provision of a long-term source of electrical power with high reliability.

[2] The intensity of solar illumination is inversely proportional to the square of the distance from the Sun.

TABLE 2-1. OVERVIEW OF THE FUNCTION AND PURPOSE OF THE NEW HORIZONS SCIENCE INSTRUMENTS

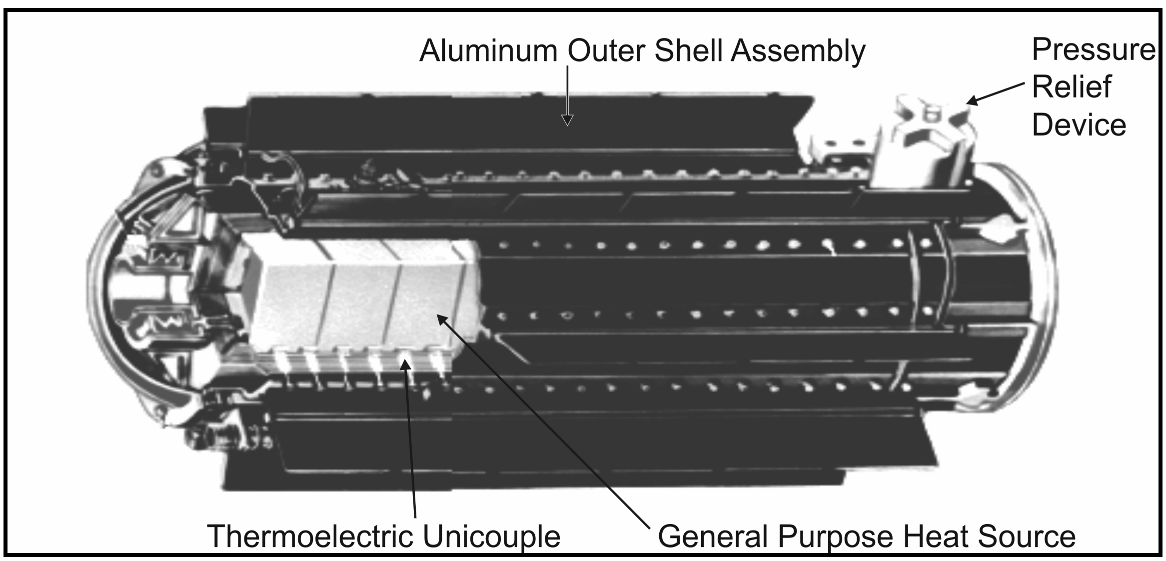
Instrument	Sensor	Function	Purpose
PERSI—Pluto Exploration Remote Sensing Instrument	MVIC—Multispectral Visible Imaging Camera	• Obtain panchromatic and four-color images • Perform optical navigation	• Study geology and morphology of the surface • Obtain geologic maps
	LEISA—Linear Etalon Imaging Spectral Array	• Obtain high-resolution infrared spectral maps • Map surface temperature	• Identify composition of the surface • Obtain temperature of the surface
	ALICE—Ultraviolet Imaging Spectrometer	• Obtain ultraviolet spectra and spatial profiles	• Study atmospheric structure and composition
REX—Radio Science Experiment	Radio signal transmitter/receiver	• Perform uplink radio occultation experiment • Measure surface brightness temperature	• Measure temperature of the atmosphere • Measure pressure profiles down to the surface • Measure density of the ionosphere • Search for an atmosphere around Charon • Refine physical parameters
Particle and Plasma Sensing Suite PEPSSI—Pluto Energetic Particle Spectrometer Science Investigation	Plasma and high-energy particle spectrometer	• Determine mass, energy spectra, directional distribution of energetic particles • Provide low-resolution, supporting measurements of the solar wind flux	• Study escape rate of Pluto's atmosphere • Study source and nature of energetic particles and plasmas
SWAP—Solar Wind Analyzer		• Measure solar wind speed and density	• Study ionosphere and solar wind interactions and bow shock
LORRI—Long Range Reconnaissance Imager	Long-focal-length telescope/camera	• Provide high-resolution panchromatic images	• Study geologic shapes and processes
SDC—Student Dust Counter		• Detect dust grains	• Measure concentration of dust particles in the outer solar system

Source: APL 2003d

To fulfill these requirements, an analysis of available electrical power systems was done to find a power source sufficiently capable of meeting the performance and operational requirements for the proposed New Horizons mission (APL 2003a). (See Section 2.3.1 below for a discussion of the alternative power systems evaluated.) The GPHS-RTG was identified as the only feasible power system with the physical and operational characteristics capable of providing the necessary power to achieve the mission. Previous performance and implementation criteria for other deep space missions have also identified radioisotope power sources as the only suitable power system, as was the case for the Galileo, Ulysses, and Cassini missions (NASA 1989, NASA 1990, NASA 1995a).

2.1.3.2 The Radioisotope Thermoelectric Generator

An RTG converts heat from the radioactive decay of plutonium (in a ceramic form called plutonium dioxide (PuO_2) consisting mostly of plutonium-238) into usable electrical power. RTGs were used on 25 previously-flown United States space missions (Table 2-2), including six Apollo flights, Pioneer, Viking, Voyager, Galileo, Ulysses, and Cassini. Radioisotope power source technology development has resulted in several models of an RTG, evolving from the Systems for Nuclear Auxiliary Power (SNAP)-RTG to the Multi-Hundred Watt (MHW)-RTG and the GPHS-RTG (Figure 2-4). The GPHS technology is the culmination of over 35 years of design evolution.



Source: DOE

FIGURE 2-4. ILLUSTRATION OF A RADIOISOTOPE THERMOELECTRIC GENERATOR

The GPHS-RTG (hereinafter referred to as the RTG) has a mass of about 56 kg (123.5 lb) and is 1.1 m (3.7 ft) long and 0.4 m (1.4 ft) in diameter. The RTG that would be used for the New Horizons mission would provide a minimum of 180 watts of electrical power at the time of the Pluto-Charon flyby, should the encounter occur in July 2015 (APL 2003d). The major components of the RTG consist of a thermoelectric

TABLE 2-2. UNITED STATES SPACE MISSIONS INVOLVING RADIOISOTOPE POWER SOURCES

Power Source (number of RTGs)	Spacecraft	Mission Type	Launch Date	Status	Activity at Launch (curies)
SNAP-3B7 (1)	TRANSIT 4A	Navigational	Jun 29, 1961	Currently in Earth orbit	1,500 – 1,600
SNAP-3B8 (1)	TRANSIT 4B	Navigational	Nov 15, 1961	Currently in Earth orbit	1,500 – 1,600
SNAP-9A (1)	TRANSIT 5BN-1	Navigational	Sep 28, 1963	Currently in Earth orbit	17,000
SNAP-9A (1)	TRANSIT 5BN-2	Navigational	Dec 5, 1963	Currently in Earth orbit	17,000
SNAP-9A (1)	TRANSIT 5BN-3	Navigational	Apr 21, 1964	Mission aborted; burned up on reentry as designed	17,000
SNAP-19B2 (2)	NIMBUS-B-1	Meteorological	May 18, 1968	Mission aborted; power source retrieved intact	34,400
SNAP-19B2 (2)	NIMBUS III	Meteorological	Apr 14, 1969	Currently in Earth orbit	37,000
SNAP-27 (1)	APOLLO 12	Lunar	Nov 14, 1969	ALSEP [a] shut down and remains on lunar surface	44,500
SNAP-27 (1)	APOLLO 13	Lunar	Apr 11, 1970	Mission aborted on way to moon; ALSEP power source fell into the Tonga Trench in the Pacific Ocean	44,500
SNAP-27 (1)	APOLLO 14	Lunar	Jan 31, 1971	ALSEP shut down and remains on lunar surface	44,500
SNAP-27 (1)	APOLLO 15	Lunar	Jul 26, 1971	ALSEP shut down and remains on lunar surface	44,500
SNAP-19 (4)	PIONEER 10	Planetary	Mar 2, 1972	Successfully operated to Jupiter and beyond	80,000
SNAP-27 (1)	APOLLO 16	Lunar	Apr 16, 1972	ALSEP shut down and remains on lunar surface	44,500
TRANSIT-RTG (1)	TRIAD-01-1X	Navigational	Sep 2, 1972	Currently in Earth orbit	24,000
SNAP-27 (1)	APOLLO 17	Lunar	Dec 7, 1972	ALSEP shut down and remains on lunar surface	44,500
SNAP-19 (4)	PIONEER 11	Planetary	Apr 5, 1973	Successfully operated to Jupiter, Saturn and beyond	80,000
SNAP-19 (2)	VIKING 1	Planetary	Aug 20, 1975	Lander shut down and remains on surface of Mars	41,000
SNAP-19 (2)	VIKING 2	Planetary	Sep 9, 1975	Lander shut down and remains on surface of Mars	41,000
MHW-RTG (2)	LES 8	Communications	Mar 14, 1976	Currently in Earth orbit	159,400
MHW-RTG (2)	LES 9	Communications	Mar 14, 1976	Currently in Earth orbit	159,400
MHW-RTG (3)	VOYAGER 2	Planetary	Aug 20, 1977	Successfully operated to Neptune and beyond	240,000
MHW-RTG (3)	VOYAGER 1	Planetary	Sep 5, 1977	Successfully operated to Saturn and beyond	240,000
GPHS-RTG (2)	GALILEO	Planetary	Oct 18, 1989	Successfully operated in Jupiter orbit; after 8 years, spacecraft purposefully entered Jupiter's atmosphere	269,000 [b]
GPHS-RTG (1)	ULYSSES	Planetary	Oct 6, 1990	Successfully operating in heliocentric flight	132,500
GPHS-RTG (3)	CASSINI	Planetary	Oct 15, 1997	Successfully operating in Saturn orbit	404,000 [b]

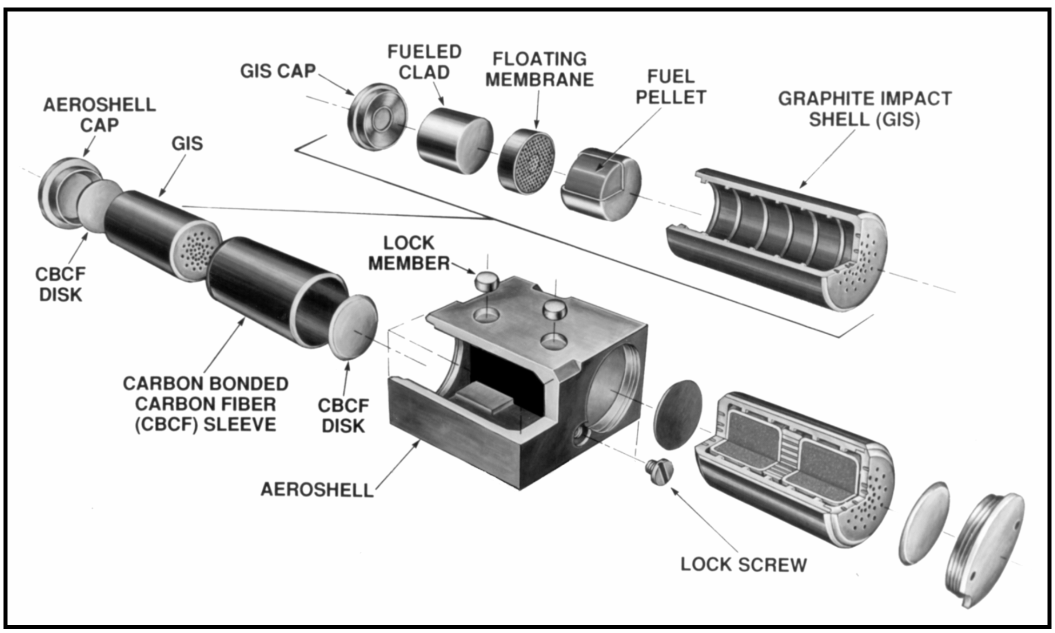
(a) Apollo Lunar Surface Experiments Package.

(b) Includes inventory from radioisotope heater units.

Note: The proposed New Horizons mission would use one GPHS-RTG with approximately 107,600 to 115,000 curies.

converter and a series of stacked GPHS aeroshell modules. The thermoelectric converter consists of an aluminum outer shell assembly, the axial and mid-span heat source supports, the thermoelectric elements, an insulation packet, and a gas management system. The thermoelectric converter contains silicon-germanium thermoelectric unicouples (Figure 2-4), which convert decay heat from the plutonium (in the form of PuO_2) directly into electricity. The unicouples are surrounded by insulation to reduce thermal losses. The converter provides the support structure for the thermoelectric elements as well as for the aeroshell modules.

The RTG consists of a stacked column of 18 aeroshell modules. Each aeroshell module (Figure 2-5) contains about 0.6 kg (1.3 lb) of PuO_2. An aeroshell module consists of a graphite aeroshell, two carbon-bonded carbon fiber insulator sleeves, two graphite impact shells (GIS), and four iridium clads, each of which contains ceramic pellets of PuO_2. The graphite (carbon-carbon composite) aeroshell has a nominal operating temperature in space of 1,060 degrees Celsius (°C) (1,940 degrees Fahrenheit (°F)) at the aeroshell surface (DOE 1990).The total radiological inventory for a typical RTG is 10.9 kg (24.0 lb) of PuO_2 with a total activity of about 132,500 curies (Ci). Plutonium (Pu) can exist in a number of different radioactive isotopic forms. The principal plutonium isotope in the fuel is Pu-238 in terms of mass and activity. Table 2-3 provides representative characteristics and the isotopic composition of the PuO_2. Plutonium dioxide has a density of 9.6 grams per cubic centimeter (5.5 ounces per cubic inch), melts at 2,400°C (4,352°F), and boils at 3,870°C (6,998°F) (DOE 1990).



Source: DOE

FIGURE 2-5. DIAGRAM OF A GENERAL PURPOSE HEAT SOURCE AEROSHELL MODULE

TABLE 2-3. TYPICAL ISOTOPIC COMPOSITION OF AN RTG

Fuel Component	Weight Percent [(a)]	Half-Life, years	Specific Activity, curies/gram of Fuel Component	Total Activity, curies
Plutonium	83.63			
Pu–236	0.0000011	2.851	531.3	0.637
Pu–238	69.294	87.7	17.12	129,308
Pu–239	12.230	24,131	0.0620	82.65
Pu–240	1.739	6,569	0.2267	42.97
Pu–241	0.270	14.4	103.0	3,031
Pu–242	0.0955	375,800	0.00393	0.0409
Actinide Impurities	4.518	NA	NA	NA
Oxygen	11.852	NA	NA	NA
Total	**100.00**	**NA**	**NA**	**132,465**

Source: DOE 2005

(a) Based on 10.9 kg (24.0 lbs) of PuO_2 fuel.
NA = Not Applicable

The U.S. Department of Energy (DOE) designed the RTG to provide for containment of the PuO_2 fuel to the extent feasible during all mission phases, including ground handling, launch, and unplanned events such as reentry, impact, and post-impact situations (Bennett 1981). Under normal, accident, and post-accident conditions the safety-related design features of the RTG to be used for the New Horizons mission are intended to:

- minimize the release and dispersion of the PuO_2 fuel, especially of biologically significant small respirable particles;
- minimize land, ocean and atmosphere contamination, particularly in populated areas; and,
- maximize long-term immobilization of the PuO_2 fuel following postulated accidents.

Safety design features of the RTG include the following.

- <u>Thermoelectric Converter</u>: The RTG is designed to release the individual aeroshell modules in case of inadvertent reentry in order to minimize module terminal velocity and the potential for fuel release on Earth impact. The converter uses an aluminum alloy to ensure melting and breakup of the converter upon reentry, resulting in release of the modules.
- <u>Aeroshell Module, GIS and related graphite components</u>: The GPHS aeroshell module is composed of a three-dimensional carbon-carbon Fine Weave Pierced Fabric, developed originally for reentry nose cone material. The module and its graphite components are designed to provide reentry and surface impact

protection to the iridium fueled clad in case of accidental sub-orbital or orbital reentry. The aeroshell has been recently modified to include additional graphite material between the GISs and strengthens which the module to enhance its performance under impact and reentry conditions.

- Iridium Fueled Clads: The iridium clad material is chemically compatible with the graphite components of the aeroshell module and the PuO_2 fuel over the operating temperature range of the RTG. The iridium has a high melting temperature (2,454°C (4,450°F)) and exhibits excellent impact response.
- PuO_2 Fuel: The fuel has a high melting temperature (2,400°C) (4,352°F), is very insoluble in water, and fractures into largely non-respirable chunks upon impact.

Formal safety tests of RTG components have established a data base that allows prediction of how these components would respond in accident environments. These safety tests have covered responses to the following environments:

- explosion overpressure;
- impact from fragments;
- other mechanical impact;
- thermal energy; and
- reentry conditions.

DOE has over 20 years experience in the engineering, fabrication, safety testing, and evaluation of GPHS aeroshell modules, building on the experience gained from previous heat source development programs and an information base that has grown since the 1950s. Test results have demonstrated the performance of the current design (LMMS 1997).

2.1.4 Space Launch Complex-41

SLC-41 is located on a 19-hectare (47-acre) site in the southernmost section of Kennedy Space Center (KSC). NASA has permitted CCAFS to use SLC-41 and the surrounding land. The launch complex consists of a launch pad, an umbilical mast, propellant and water storage areas, an exhaust flume, catch basins, security services, fences, support buildings, and facilities necessary to prepare, service, and launch Atlas V expendable launch vehicles (USAF 1998, LMILS 2001). SLC-41 was previously used to launch Titan vehicles and was modified to accommodate the Atlas V.

Security at SLC–41 is ensured by a perimeter fence, guards, and restricted access. Since all operations in the launch complex would involve or would be conducted in the vicinity of liquid or solid propellants and explosive devices, the number of personnel permitted in the area, safety clothing to be worn, the type of activity permitted, and equipment allowed would be strictly regulated. The airspace over the launch complex would be restricted at the time of launch (LMILS 2001).

2.1.5 Spacecraft Processing

The New Horizons spacecraft would be designed, fabricated, integrated and tested at APL's facilities in Laurel, Maryland. These facilities have been used extensively in the past for a broad variety of spacecraft, and no new facilities would be required for the New Horizons spacecraft. APL would deliver the spacecraft to KSC for further testing and integration with the RTG and the third stage.

The spacecraft would be received at the KSC Payload Hazardous Servicing Facility (PHSF). The spacecraft would be inspected and comprehensive tests would be performed, including flight and mission simulations. The RTG would be delivered by DOE and stored at the KSC RTG storage facility. Once the spacecraft checks are completed, the RTG would be moved from the RTG storage facility to the PHSF where it would be fitted to the spacecraft for a pre-flight systems check. After completing these checks, the RTG would be moved back to the RTG storage facility. The spacecraft would then be fueled with about 80 kg (176 lb) of hydrazine, the nominal propellant load required for the primary New Horizons mission (APL 2003d).

The third stage would also be received at the PHSF, where it would be inspected and attached to the spacecraft. A systems check and spin test would then be performed, after which the spacecraft and third stage would be enclosed within the launch vehicle payload fairing (PLF). The PLF, containing the spacecraft and third stage, would then be transported from the PHSF to the Atlas V Vertical Integration Facility (VIF) at CCAFS and would be attached to the Atlas V Centaur second stage. The aft end of the PLF would be sealed with a barrier and connected to an environmental control system to prevent contamination during transit. Transportation of the PLF from KSC to CCAFS would be by truck, limited to a speed of 8 km/h (5 mph).

Once the launch vehicle integration is completed, the RTG would be transported from the KSC RTG Facility to the CCAFS VIF where it would be installed on the spacecraft. The Atlas V launch vehicle would then be moved from the VIF to the launch pad at SLC-41.

RTG handling at KSC and CCAFS would be performed under stringent conditions following all requirements governing the use of radioactive materials. Transportation of the RTG between KSC and CCAFS would be by truck, limited to a speed of 40 km/h (25 mph), and performed in accordance with applicable U.S. Department of Transportation and other Federal, State, and local regulations (NASA 2001).

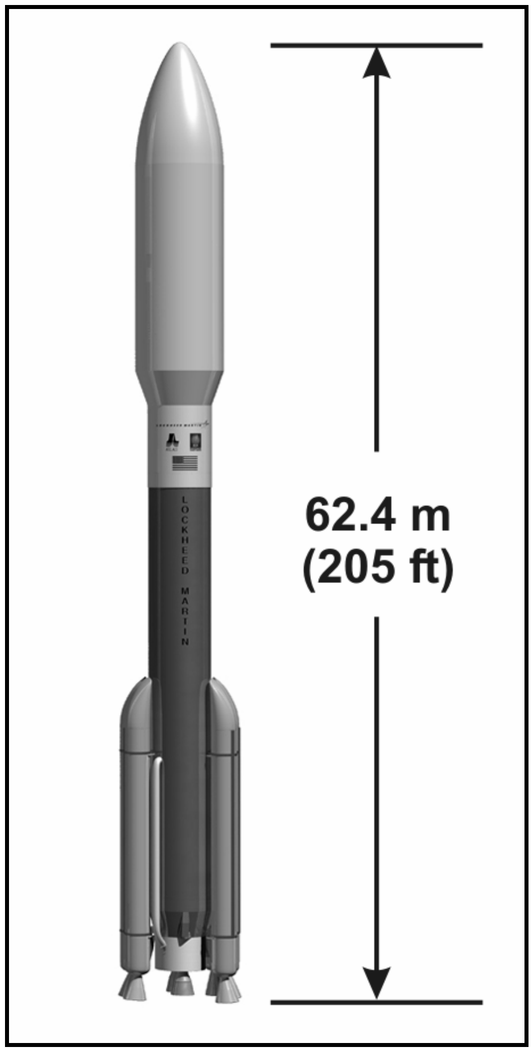
2.1.6 Description of the Atlas V Launch Vehicle

NASA maintains a contractual mechanism, the National Launch Services (NLS) contract, with all United States providers of major launch vehicle services. Early in the development process for the proposed New Horizons mission, NASA released a Request for Launch Services Proposal (RLSP) that contained a statement of work and requested that proposals be submitted to NASA for the New Horizons mission. NASA received proposals that included configurations of the Delta IV and Atlas V launch vehicles from the NLS contract holders. A NASA technical evaluation team evaluated these proposals against the evaluation criteria stated in the RLSP, including technical ability to meet the statement of work, ability to meet mission schedule, minimization of mission risk, past performance and flight history, expected launch vehicle availability, and cost/price. Upon completion of the evaluation, NASA determined that the proposal submitted by Lockheed Martin International Launch Services (LMILS) for the Atlas V 551 launch vehicle met all the specified mission requirements and was judged to present the best value to the government. LMILS was therefore awarded the launch service to provide the launch vehicle for the New Horizons mission.

The Atlas family of launch vehicles has evolved through various government and commercial programs from the first research and development flight in 1957 through the Atlas II, III, and V configurations. Versions of Atlas vehicles have been built specifically for both robotic and human space missions. The most recent version, the Atlas V, is currently available in 400 and 500 series configurations.

The Atlas V 551 launch configuration for the proposed New Horizons mission, depicted in Figure 2-6, would consist of a liquid propellant first stage, five strap-on solid rocket boosters (SRB), a liquid propellant Centaur second stage, a solid propellant third stage (procured separately from the launch vehicle contract by APL, the spacecraft provider), the New Horizons spacecraft, and the PLF. The "551" designation denotes a 5-m diameter PLF, five SRBs, and a single-engine Centaur. The SRBs are attached to the first stage, and the Centaur is mounted atop the first stage. The third stage, including the New Horizons spacecraft, would be mounted atop the Centaur. The PLF encloses and protects the third stage and the spacecraft.

Should the February 2007 backup launch opportunity be required, the launch vehicle would be nearly identical to the launch vehicle used for the January – February 2006 launch opportunity.



Source: Adapted from LMILS 2001

FIGURE 2-6. ILLUSTRATION OF AN ATLAS V 551 LAUNCH VEHICLE

2.1.6.1 First Stage

The Atlas V first stage is constructed mostly of aluminum and composite material, and is about 3.8 m (12.5 ft) in diameter and about 32.5 m (107 ft) in length. The first stage is powered by an RD-180 engine and contains about 284,089 kg (626,309 lb) of propellant. The fuel is rocket propellant-1 (RP-1), a thermally stable kerosene, and the oxidizer is liquid oxygen (LO_2). Each SRB is about 1.5 m (5 ft) in diameter, about 20 m (66 ft) in length, and is fueled with about 42,412 kg (93,500 lb) of solid propellant (consisting of ammonium perchlorate, aluminum, and hydroxyl-terminated polybutadiene (HTPB) binder) for a total mass of about 212,060 kg (467,504 lb) for the five SRBs (LMILS 2001).

2.1.6.2 Centaur Second Stage

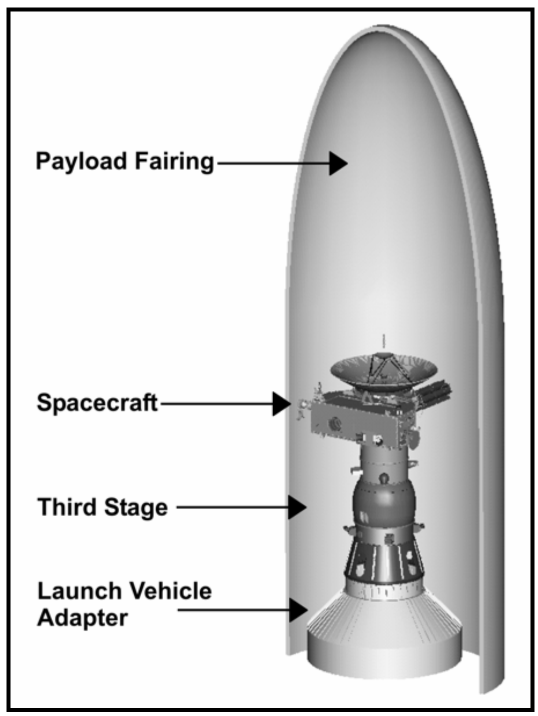
The Atlas V Centaur second stage is constructed of stainless steel and is about 3.1 m (10 ft) in diameter and about 12.7 m (42 ft) in length. The Centaur is powered by a single, cryogenic RL10A-4-2 engine, and contains about 20,672 kg (45,573 lb) of propellant, consisting of liquid hydrogen (LH_2) as the fuel and LO_2 as the oxidizer. The Centaur also uses about 127 kg (280 lb) of hydrazine for reaction control (USAF 1998).

2.1.6.3 Third Stage

The Atlas V for the New Horizons mission would require use of a third stage to provide sufficient launch energy to insert the spacecraft on its trajectory to Pluto. Because a third stage is not a typical component of an Atlas V vehicle, the third stage for the New Horizons mission would be acquired separately from the launch vehicle. This third stage would consist of a STAR® 48B[3] solid rocket motor (SRM) with a spherical titanium case containing solid propellant and an exhaust nozzle, a spin table assembly, and a payload attach fitting. The STAR® 48B is about 1.2 m (4 ft) in diameter and about 2 m (6.7 ft) in length. The STAR® 48B motor contains about 2,009 kg (4,430 lb) of solid propellant (ammonium perchlorate, powdered aluminum, and HTPB). The third stage would use about 3 kg (6 lb) of hydrazine for spin control (APL 2003d).

2.1.6.4 Payload Fairing

The PLF for the Atlas V is about 5.4 m (18 ft) in diameter and about 20.7 m (68 ft) in length and is constructed of aluminum, carbon fiber, and composite materials. The PLF encloses and protects the spacecraft from thermal, acoustic, electromagnetic, and environmental conditions during ground operations and lift-off through atmospheric ascent (LMILS 2001). Figure 2-7 depicts the New Horizons spacecraft and third stage within the PLF (APL 2003d).



Source: APL 2003d

FIGURE 2-7. ILLUSTRATION OF THE NEW HORIZONS ATLAS V PAYLOAD FAIRING

[3] STAR® is a registered trademark of Alliant Techsystems Inc.

2.1.6.5 Flight Termination System

As specified in *Eastern and Western Range Safety Requirements* (USAF 1997), Range Safety requires launch vehicles to be equipped with safety systems, collectively called the Flight Termination System (FTS), that are capable of causing destruction of the launch vehicle in the event of a major vehicle malfunction. Range Safety further specifies that for any launch vehicle the FTS reliability goal shall be a minimum of 0.999 at the 95 percent confidence level. The FTS for the New Horizons mission would provide the capability to destroy the Atlas V, if necessary, either (1) autonomously after detecting an inadvertent breakup of the vehicle or unintentional separation of vehicle stages, or (2) by commands issued via secure radio links. The FTS would consist of an Automatic Destruct System (ADS), a Centaur Automatic Destruct System (CADS), and a Command Destruct System (CDS).

If inadvertent vehicle breakup or premature stage separation occurs, the ADS would automatically initiate ordnance components that split open all first stage propellant tanks to disperse the liquid propellants and split all SRB casings to terminate solid motor thrusting. The CADS would automatically destruct the first and second stage propellant tanks and the SRBs, and activate two conical shaped charges to penetrate the aft dome of the third stage SRM to render it non-propulsive. Upon receipt of valid commands from Range Safety, the CDS would shut down the first stage or second stage main engines (depending on the timing of the event), and initiate destruction of the vehicle in the same manner as the CADS.

The CADS and CDS would also initiate the third stage SRM breakup system (BUS), an enhancement to the FTS for the New Horizons mission. The BUS adds two conical shaped charges mounted above the solid motor and directed into its upper dome. The purpose of the BUS would be to break up the large propellant dome into fragments to preclude an intact dome and attached spacecraft falling to the ground together, with potential for significant impact damage to the aeroshell modules.

The FTS would be armed 97 seconds before lift-off. Each major system of the FTS would be safed (automatically deactivated) at various times during the vehicle's ascent when the system would no longer be needed and to preclude its inadvertent activation. The BUS would be safed after the vehicle clears land and is over the Atlantic Ocean. The ADS and CADS would next be safed prior to separation of the first and second stages. Finally, the CDS would be safed immediately after completion of the first Centaur engine burn.

An Inadvertent Separation Destruct System (ISDS) would be incorporated on each of the five SRBs. In the event of an inadvertent or premature separation of an SRB, the ISDS would initiate a linear shaped charge to disable the SRB after a brief time delay to assure clearance from the Atlas V. The ISDS would be deactivated during a normal SRB separation event.

2.1.6.6 Launch Vehicle Processing

Atlas launch vehicle preparation activities and procedures during and after launch have been previously documented (USAF 1998, LMILS 2001). All NASA launches follow the current standard operating procedures.

The Atlas V launch vehicle components for the New Horizons mission would be received at CCAFS, where they would be inspected, stored, and processed at appropriate facilities. When needed for launch, the components would be moved to the VIF, where the launch vehicle would be assembled, integrated, and tested. The PLF, containing the third stage and the New Horizons spacecraft, would then be attached to the top of the Centaur second stage. The Atlas V launch vehicle would then be moved via rail on a mobile launch platform, limited to a speed of 3.2 km/h (2 mph), to the launch pad at SLC-41 for a rehearsal of loading the RP-1, LO_2 and LH_2 liquid propellants, and then unloading the LO_2 and LH_2. The vehicle (with RP-1) would then be moved back to the VIF, where hydrazine would be loaded and final vehicle processing would be performed. The RTG would then be installed on the spacecraft. The launch vehicle would then be moved back to the pad for LO_2 and LH_2 loading, final system tests, and launch (USAF 1998, USAF 2000, LMILS 2001).

Processing activities for the New Horizons Atlas V vehicle would be similar to those routinely practiced for other Atlas launches from CCAFS. Effluents and solid or hazardous wastes that may be generated by these activities are subject to Federal and State laws and regulations. NASA or its contractors would dispose of hazardous wastes. CCAFS has the necessary environmental permits and procedures for conducting launch vehicle processing activities (see Section 4.8).

2.1.6.7 Launch Profile

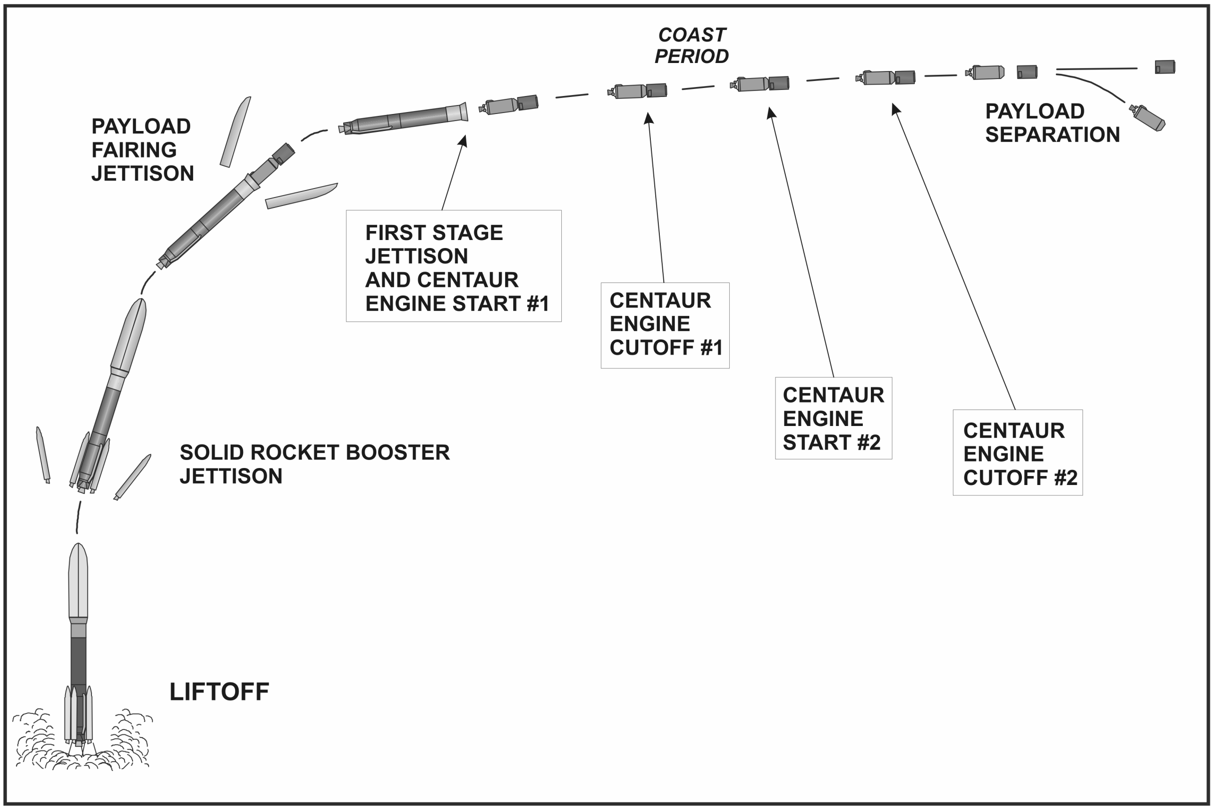
Launch of the Atlas V would begin with the ignition of the first stage main engine followed approximately 3 seconds[4] later by ignition of the five SRBs (Figure 2-8). The SRB casings would be jettisoned after propellant burnout. The first stage main engine would continue to thrust and the PLF would be jettisoned. The main engine cutoff sequence would be initiated when low propellant levels are detected by the first stage propellant sensors (LMILS 2001). The first stage would then separate from the second and third stages. The SRB casings, the PLF, and the first stage would fall into the Atlantic Ocean in predetermined drop zones and would not be recovered (USAF 2000).

The Centaur second stage would be ignited shortly after separation from the first stage. Upon achieving Earth parking orbit, the Centaur engine thrust would be cut off via a timed command. After a brief, predetermined coast period in an Earth parking orbit, the Centaur engine would restart and the vehicle would accelerate to Earth escape velocity.

After separation from the Centaur, the third stage SRM would be ignited. The third stage would provide the final thrust needed to inject the New Horizons spacecraft onto the desired trajectory toward Pluto. After third stage motor cutoff, the New Horizons

[4] The engine undergoes an automatic "health check" during this period. Should a malfunction be detected, the engine would be shutdown and the launch would be aborted.

spacecraft would be separated and continue on its trajectory. The Centaur and the third stage would each continue separately into interplanetary space.



Source: Adapted from LMILS 2001

FIGURE 2-8. TYPICAL ATLAS V ASCENT PROFILE

2.1.7 Range Safety Considerations

CCAFS has implemented range safety requirements as specified in USAF 1997. For the New Horizons mission, predetermined flight safety limits would be established for each day of the launch period. Wind criteria, impacts from fragments that could be produced in a launch accident, dispersion and reaction (e.g., toxic plumes, fire) of liquid and solid propellants, human reaction time, data delay time, and other pertinent factors would be considered when determining the flight safety limits.

Models would be used to predict launch hazards to the public and on-site personnel prior to a launch. These models calculate the risk of injury resulting from toxic exhaust gases from normal launches, and from potentially toxic concentrations due to a failed launch. The launch could be postponed if the predicted collective risk of injury from exposure to toxic gases exceeds established limits (USAF 1997).

After lift-off, the Mission Flight Control Officer would take any necessary actions, including destruction of the vehicle via the CDS, if the vehicle's trajectory indicates flight anomalies (e.g., exceeding flight safety limits) (USAF 1997).

2.1.8 Electromagnetic Environment

Launch vehicles may be subject to electromagnetic conditions such as lightning, powerful electromagnetic transmissions (e.g., radar, radio transmitters), and charging effects (i.e., electrical charges generated by friction and the resultant electrostatic discharges). NASA and the USAF address such conditions with respect to the design of the launch vehicle, as well as with ordnance (e.g., explosives, explosive detonators and fuses), fuels, exposed surfaces of the vehicle, and critical electronic systems that must have highly reliable operations. A large body of technical literature exists on these subjects and has been used by NASA and the USAF in designing safeguards (see, for example, USAF 1997). The Atlas V, third stage, the New Horizons spacecraft, and the launch support systems would be designed and tested to withstand these environments in accordance with requirements specified in USAF 1997.

2.2 DESCRIPTION OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, NASA would discontinue preparations for the New Horizons mission to Pluto. A flyby of the Pluto-Charon system or of any KBOs would not be conducted, and a unique opportunity for observing the atmosphere of Pluto would be missed. None of the close-up science investigations of Pluto, Charon, and any KBOs planned for the mission would be achieved. Observations of these bodies would remain limited to ground-based observatories or space-based observatories such as the Hubble Space Telescope.

2.3 ALTERNATIVES CONSIDERED BUT NOT EVALUATED FURTHER

This section presents alternatives that were considered for the Proposed Action but were eliminated from further evaluation for the reasons discussed below. Evaluations were performed for alternative power sources and trajectories.

2.3.1 Alternative Power Sources

An electrical power generating system consists of an energy source and an energy conversion system. The available energy sources for a space mission include the Sun, chemicals in fuel cells or batteries, heat from radioactive decay, or the combustion of fuels. The energy conversion subsystem transforms energy into electricity using, for example, photovoltaic cells, thermoelectric couples, or dynamic conversion machinery.

For the proposed New Horizons mission, the power system used must satisfy the electrical power system performance requirements discussed in Section 2.1.3. Based on these requirements, alternative power sources to the RTG were evaluated that could potentially reduce or eliminate the environmental risks associated with the PuO_2 used in the RTG. The other power systems considered include those that: (1) replace the PuO_2 in the RTG with a potentially less hazardous radioisotope; (2) implement power system designs that require less PuO_2; or (3) use a power system based on solar energy.

2.3.1.1 Other Radioisotope RTGs

The principal concern with using PuO_2 in RTGs is the potential radiation health and environmental hazards created if the PuO_2 is released into the environment following an accident. In principle, any radioisotope with a half-life long enough to provide sufficient power throughout the proposed New Horizons mission and with a high enough specific activity to provide the required power with a suitably small generator can be used. Two other radioisotopes possible for RTGs are the oxides of strontium-90 (Sr-90) and curium-244 (Cm-244). Sr-90 emits gamma radiation and Cm-244 emits both gamma and neutron radiation. PuO_2 emits much less gamma and neutron radiation than Sr-90 and Cm-244. Because gamma and neutron radiation are more penetrating than the alpha particles emitted by Pu-238, extensive shielding (not required with PuO_2) would be required during production and handling, as well as onboard the spacecraft to protect sensitive components. In addition, extensive development and safety testing would also be required, and production facilities for sufficient quantities of these radioisotopes are not available. Therefore, Sr-90 and Cm-244 oxides cannot be considered as feasible isotopic heat sources for the New Horizons spacecraft's power system.

2.3.1.2 Power Systems Requiring Less Plutonium Dioxide

The GPHS-RTG using PuO_2 is a steady-state entity that provides continuous and quantifiable amounts of heat over its lifetime. As the Pu-238 in the fuel decays, the amount of heat decreases proportionately. For example, only half the amount of heat would be available at the half-life of the radioisotope (87.7 years). The RTG uses a thermocouple/unicouple conversion mechanism, a technology used in previous missions, to convert heat energy emitted by the radioactive decay of PuO_2 into electricity. To reduce the amount of PuO_2 used for electrical power on the spacecraft, a more efficient conversion technology would need to be developed.

The thermoelectric converter on the RTG has an efficiency of at least 6.5 percent (LLMS 1997). Other conversion technologies considered include static systems (thermionic, thermophotovoltaic, and alkali metal thermoelectric converter) and dynamic systems (such as the Stirling engine).

NASA, in cooperation with DOE, is currently developing new radioisotope power systems (RPS) (the Stirling Radioisotope Generator (SRG) and the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) (DOE 2002a)) for application to a variety of deep space missions. The MMRTG would use thermocouples to convert heat from GPHS aeroshell modules directly into electricity. The SRG would use a Stirling engine to convert heat into mechanical energy, which in turn would be converted into electricity. The development and testing processes for both new systems would not result in an RPS that would be fully qualified and available by 2006 for the proposed New Horizons mission or for the 2007 backup opportunity. The first potential application of either the MMRTG or the SRG is not planned until 2009, beyond the timeframe of the Proposed Action.

The GPHS has a maximum operating temperature of 1,100°C (2,012°F). Thermionic converters are high-temperature systems operating at temperatures above 1,327°C (2,420°F), which make them incompatible with the GPHS. Thermophotovoltaic converters operate at temperatures above 1,227°C (2,240°F), again making them incompatible with the GPHS. With appropriate filters and sufficient development time, however, thermophotovoltaic converters may operate at the limiting GPHS temperatures. Development of the alkali metal thermoelectric converter has been curtailed, and would require resolution of several issues, including performance, degradation, spacecraft integration, launch environments, lifetime, and zero gravity effects, before it could be considered for space applications.

All of these power systems have technology maturity or availability issues that cannot be resolved in a timeframe consistent with the proposed New Horizons mission requirements and, therefore, are not feasible and were not evaluated further.

2.3.1.3 Solar Energy Power Systems

The encounter with Pluto and Charon would occur at a distance of about 33 AU from the Sun, where the intensity of solar illumination is about one thousand times less than at the distance of Earth's orbit at 1 AU. Extending the mission to 50 AU within the Kuiper Belt further decreases the intensity of solar illumination. Current solar energy conversion technologies cannot provide adequate electrical power to operate and heat the New Horizons spacecraft at these distances from the Sun without a large solar array (on the order of 1,000 square meters (10,700 square feet) even with technology that concentrates solar illumination onto the array to increase its efficiency). The large mass and volume of such an array would preclude the mission's ability to perform the science investigations, even if the spacecraft could be launched. There would also be adverse consequences for the spacecraft design, including impacts to structure, attitude control, and pointing. The subsequent increase in the required power level to accommodate these adverse consequences would require a further increase in the array area (APL 2003a).

Therefore, a solar-powered mission to Pluto is not feasible and was not evaluated further.

2.3.2 Alternative Trajectories

2.3.2.1 Gravity Assist Trajectories

Alternative gravity assist trajectories to Pluto were examined that could reduce launch energy requirements for the proposed New Horizons mission, and thereby possibly eliminate the need for the solid rocket third stage (APL 2003b). Eliminating the third stage would eliminate the possibility (even with the BUS) that the intact stage and attached spacecraft could impact the ground together during a launch accident, and thus eliminate the potential for significant impact damage to the aeroshell modules should the BUS fail to activate.

The analysis focused on a class of trajectories called Delta-V Earth Gravity Assist (ΔVEGA). After launch, a deep-space propulsive maneuver (designated Delta-V (ΔV), for change in velocity) would be performed to place the spacecraft on a trajectory that would return to and fly by the Earth. As the spacecraft flies past Earth it would gain additional momentum, enabling it to continue its journey toward the outer solar system. This gain in momentum is equivalent to using a more powerful launch vehicle to insert the spacecraft on a higher energy trajectory. The ∆VEGA trajectories are further classified as 2+ years, 3+ years, and 4+ years, denoting the amount of time for the Earth flyby portion of the trajectory. In general, as the flight time to Earth flyby increases, the magnitude of the deep-space maneuver decreases (thus requiring less propellant onboard the spacecraft) but the launch energy requirement increases (thus requiring a more powerful launch vehicle).

Several ∆VEGA trajectories to Pluto were examined with launch opportunities in January 2006 and January 2007 and with arrival at Pluto in 2015, 2016, and 2020. Jupiter would not be in position near the flight paths of these ∆VEGA trajectories toward Pluto to provide an additional gravity assist. In all cases the flyby altitude at Earth was constrained to be 300 km (187 mi) since the lowest possible flyby altitude yields the highest possible momentum gain. Even at this low flyby altitude the Earth would not provide sufficient change in momentum for the spacecraft to reach Pluto. More energy would therefore need to be added to the trajectory by a propulsive maneuver (powered flyby) during the closest approach at Earth.

A large chemical propulsion system would need to be added to the baseline New Horizons spacecraft to accommodate the combination of the deep-space maneuver and the powered flyby at Earth. Except for two trajectories, the ∆VEGA cases analyzed had combined ∆V requirements that were judged to be too large to warrant further study. The two most efficient of the ∆VEGA trajectories examined for the proposed New Horizons mission are the 3+ years and 4+ years trajectories launching in January 2006 and arriving at Pluto in 2020. These would have the lowest combined ∆V: 3,012 meters per second (m/s) (9,882 feet per second (ft/s)) and 2,587 m/s (8,487 ft/s), respectively.

The size of a new propulsion system, which would be added to the baseline New Horizons spacecraft, was estimated for these two cases. The total mass at launch of the New Horizons spacecraft with this new propulsion system was estimated to be approximately 2,580 kg (5,690 lb) for the 2006 3+ years ∆VEGA trajectory, and approximately 1,920 kg (4,235 lb) for the 2006 4+ years ∆VEGA trajectory. Each mass is beyond the launch capability of the Atlas V without a solid rocket third stage, thus making elimination of the third stage not feasible.

2.3.2.2 Low Thrust Trajectories

A low thrust trajectory requires the use of a propulsion system with a thrust acceleration level typically less than one ten-thousandth of the Earth's gravity, and with a specific impulse that is typically two orders of magnitude higher than that of a conventional high thrust chemical propulsion system. However, large-scale low thrust propulsion systems for deep-space mission applications are not yet available and would require significant development. Two types of low thrust propulsion systems were considered: solar-electric propulsion and nuclear-electric propulsion.

Solar-electric propulsion (SEP), the most mature and best understood of the two types of systems, would use large solar arrays to provide electrical power to a number of ion thrusters that would typically use xenon as the propellant. A SEP system could operate efficiently only near the Sun, to solar distances not greater than about 4 AU. SEP low thrust trajectory alternatives to the proposed New Horizons mission were assessed (APL 2002). While examining several possible scenarios, the assessment focused on a solar-electric low thrust trajectory to Pluto that includes a Venus Gravity Assist. The launch for such a mission would occur in February 2008 with arrival at Pluto in 2019. For this mission scenario, the New Horizons spacecraft would be attached to a separate SEP module having an estimated mass of 1,125 kg (2,480 lb), including 560 kg (1,235 lb) of xenon propellant. The New Horizons spacecraft would need to be modified to accommodate the increased thermal environment near 0.7 AU during the Venus flyby. The SEP module would generate 15.3 kilowatts of electrical power at 1 AU, and would be jettisoned after reaching a distance of about 4 AU from the Sun, when solar energy diminishes below the level needed to maintain adequate power to the thrusters. Because the SEP module would be jettisoned, the New Horizons spacecraft would still require a separate chemical propulsion system for trajectory and attitude control maneuvers beyond 4 AU and a separate source, such as an RTG, for electrical power and heat. Therefore, a solar-electric low thrust trajectory alternative would offer no advantages to the proposed New Horizons mission, and was not evaluated further.

Nuclear-electric propulsion (NEP) would use a small nuclear reactor to provide electrical power to the ion thrusters. A NEP system would provide propulsive capability to and beyond Pluto and could provide electrical power and heat to a spacecraft. However, the major components of a NEP system still require significant development and testing, and would not be qualified in time for the proposed New Horizons mission. Therefore, a nuclear-electric low thrust trajectory alternative to the proposed New Horizons mission was not evaluated further.

2.4 COMPARISON OF ALTERNATIVES INCLUDING THE PROPOSED ACTION

This section summarizes and compares the potential environmental impacts of the Proposed Action and the No Action Alternative. The anticipated impacts associated with nominal or normal implementation of the Proposed Action are considered first, followed by a summary and comparison of the potential radiological consequences and risks from an accident associated with the Proposed Action. No such impacts would be associated with the No Action Alternative. Details of the results summarized in this section can be found in Chapter 4.

2.4.1 Environmental Impacts of a Normal Launch

Table 2-4 provides a summary comparison of the anticipated environmental impacts associated with normal implementation of the Proposed Action and the No Action Alternative.

Proposed Action. The environmental impacts associated with implementing the Proposed Action would center largely on the exhaust products emitted from the Atlas V launch vehicle's SRBs and the short-term impacts of those emissions. High concentrations of solid rocket motor exhaust products, principally aluminum oxide (Al_2O_3) particulates, carbon monoxide (CO), hydrogen chloride (HCl), nitrogen (N_2), and

TABLE 2-4. SUMMARY COMPARISON OF THE NEW HORIZONS MISSION ALTERNATIVES

Impact Category	New Horizons Mission Alternatives	
	Normal Implementation of the Proposed Action	**No Action**
Land Use	No adverse impacts on non-launch-related land uses at CCAFS would be anticipated.	No change in baseline condition.
Air Quality	High levels of solid propellant combustion products could occur within the exhaust cloud. The exhaust cloud would rise and disperse near the launch complex. No long-term adverse air quality impacts would be anticipated in off-site areas.	No change in baseline condition.
Noise and Sonic Boom	Sound levels estimated at the nearest communities would be in the moderate range. Exposure levels are estimated to be within federal guidelines for affected workers and the public.	No change in baseline condition.
Geology and Soils	Some deposition of aluminum oxide particulates and hydrogen chloride near the launch complex would be anticipated.	No change in baseline condition.
Hydrology and Water Quality	Water used for pre-launch fire protection, heat suppression and acoustic damping during launch, and post-launch wash down would be collected and treated, if necessary, prior to being released to grade. A potential short-term increase in the acidity of nearby surface waters could occur following launch, however, no adverse long-term impacts to groundwater or surface waters would be anticipated.	No change in baseline condition.
Biological Resources	Biota in the launch complex could be damaged or killed during launch. Possible acidification of nearby surface waters could cause some mortality of aquatic biota. No long-term adverse effects would be anticipated. No short-term or long-term impacts to threatened or endangered species or to essential fish habitat would be anticipated.	No change in baseline condition.
Socioeconomics	No impacts would be anticipated.	No change in baseline condition.
Environmental Justice	No disproportionate impacts would be anticipated.	No change in baseline condition.
Cultural/Historical/ Archaeological Resources	No impacts would be anticipated.	No change in baseline condition.
Global Environment	Not anticipated to adversely affect global climate. Temporary localized decrease in ozone would be anticipated along the flight path with rapid recovery to pre-launch conditions.	No change in baseline condition.

water (H_2O), would occur in the exhaust cloud that would form at the launch complex. CO would be quickly oxidized to carbon dioxide (CO_2), and N_2 may react with oxygen to form nitrogen oxides (NO_X). Due to the relatively high gas temperatures, this exhaust cloud would be buoyant and would rise quickly and begin to disperse near the launch pad. High concentrations of HCl would not be expected, and long-term damage to vegetation and prolonged acidification of nearby water bodies should not occur. No adverse impacts to air quality in offsite areas would be expected.

If rain were to occur shortly after launch, some short-term acidification of nearby water bodies could occur with the accompanying potential for some mortality of aquatic biota. Biota that happened to be in the path of the exhaust could be damaged or killed. Threatened or endangered species would not be jeopardized nor would critical habitats be affected at CCAFS. As the launch vehicle gains altitude, a portion of the solid rocket motor exhaust (specifically HCl, Al_2O_3, and NO_X) would be deposited in the stratosphere, resulting in a short-term reduction in ozone along the launch vehicle's flight path. Recovery, however, would be rapid.

Noise and sonic booms would be associated with the launch. However, neither launch site workers nor the public would be adversely affected. No impacts to cultural, historical or archaeological resources would be expected from the launch. The New Horizons mission launch would not be expected to disproportionately impact either minority or low-income populations.

No Action Alternative. Under the No Action Alternative, NASA would discontinue preparations for the New Horizons mission to Pluto, and the spacecraft would not be launched. Spacecraft and launch vehicle components would be recycled. Thus, none of the anticipated impacts associated with a normal launch would occur.

2.4.2 Environmental Impacts of Potential Nonradiological Launch Accidents

Proposed Action. Nonradiological accidents could occur during preparation for and launch of the New Horizons spacecraft at CCAFS. The two nonradiological accidents of greatest concern would be a liquid propellant spill and a launch vehicle failure.

The potential for environmental consequences would be limited primarily to liquid propellant spills of RP-1, LH_2, LO_2, and hydrazine during fueling operations of the Atlas V, and a launch failure at or near the launch pad. USAF safety requirements (USAF 1997) specify detailed policies and procedures to be followed to ensure worker and public safety during liquid propellant fueling operations. Propellant spills or releases of RP-1, LH_2, and LO_2 would be minimized through remotely operated actions that close applicable valves and safe the propellant loading system. Workers performing propellant loading (e.g., RP-1 and hydrazine) would be equipped with protective clothing and breathing apparatus and uninvolved workers would be excluded from the area during propellant loading. Propellant loading would occur only shortly before launch, further minimizing the potential for accidents.

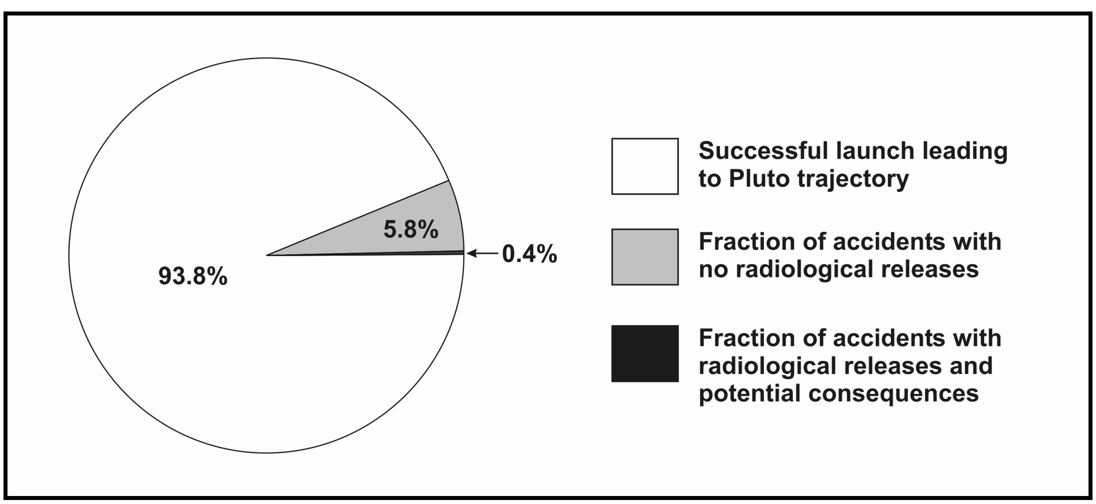
A launch vehicle failure on or near the launch area during the first few seconds of flight could result in the release of the propellants (solid and liquid) onboard the Atlas V and the spacecraft. The resulting emissions would resemble those from a normal launch, consisting principally of CO, CO_2, HCl, NO_X, and Al_2O_3 from the combusted propellants. A launch vehicle failure would result in the prompt combustion of a portion of the liquid propellants, depending on the degree of mixing and ignition sources associated with the accident, and somewhat slower burning of the solid propellant fragments. Falling debris would be expected to land on or near the launch pad resulting in potential secondary ground-level explosions and localized fires. After the launch vehicle clears land, debris from an accident would be expected to fall over the ocean. Modeling of accident consequences with meteorological parameters that would result in the greatest concentrations of emissions over land areas indicates that the emissions would not reach levels threatening public health. Some burning solid and liquid propellants could enter surface water bodies and the ocean resulting in short-term, localized degradation of water quality and toxic conditions to aquatic life. Such chemicals entering the ocean would be rapidly dispersed and buffered, resulting in little long-term impact on water quality and resident biota.

No Action Alternative. Under the No Action Alternative a launch would not occur, therefore there would be no potential for either type of accident to occur.

2.4.3 Environmental Impacts of Potential Radiological Launch Accidents

This section presents a summary of the nuclear risk assessment (DOE 2005) performed for the Proposed Action described in this DEIS. A more detailed presentation can be found in Section 4.1.4.

As shown in Figure 2-9, the most likely outcome of implementing the New Horizons mission, about 94 percent probability, is a successful launch to Pluto. Should an accident occur during launch (about 6 percent probability), most such accidents would not result in environments that could damage the RTG and release some of the PuO_2. About 0.4 percent of the time a launch accident could result in a release of PuO_2, but not in a large enough quantity to result in discernible health consequences (see Section 2.4.3.2 below).



Source: Adapted from DOE 2005

FIGURE 2-9. LAUNCH-RELATED PROBABILITIES

NASA and DOE and its contractors have conducted several safety assessments of launching and operating spacecraft using RTGs (i.e., the Galileo mission in 1989, the Ulysses mission in 1990, and the Cassini mission in 1997). In developing the nuclear risk assessment for this DEIS, NASA and DOE have built upon an extensive experience base that involves:

- testing and analysis of the heat source modules and RTGs under simulated launch accident environments;
- evaluating the probability of launch-related accidents based on evaluations of launch histories, including extensive studies of the January 1997 Delta II accident at CCAFS, and system designs; and
- estimating the outcomes of the RTG responses to the launch accident environments.

Several technical issues that could impact the results presented in this DEIS are under continuing evaluation. These issues could not be fully addressed in the risk assessment; best engineering judgment was used to address these issues and their impact on the risk estimate for the New Horizons mission. The important issues that were addressed in this manner and that are the subject of continuing evaluation include:

- the severity of the solid propellant fire environment and its potential effect on the release of PuO_2 from the RTG;
- the dispersal of solid propellant within the on-pad accident environment;
- the behavior of solid PuO_2 and PuO_2 vapor in the fire environment and the potential for PuO_2 vapor to permeate the graphite components in the RTG; and,
- the fragment environment associated with activation of the third stage SRM BUS and its potential impact on the RTG.

Under Presidential Directive/National Security Council Memorandum 25 (PD/NSC-25), a separate nuclear launch safety review of the New Horizons mission is being conducted by NASA and DOE. As part of this process DOE is preparing a Final Safety Analysis Report (FSAR) that will include a complete, detailed risk analysis. In preparing the FSAR, DOE is following procedures and using techniques similar to those used in the risk analyses performed for earlier NASA missions using radioisotope devices. An Interagency Nuclear Safety Review Panel (INSRP) has been formed for the New Horizon mission, and will review this safety analysis. Should the FSAR present risk estimates that differ significantly from those presented in this EIS, NASA would consider the new information, and determine the need for additional environmental documentation.

2.4.3.1 The EIS Nuclear Risk Assessment

The nuclear risk assessment for the New Horizons mission considers (1) potential accidents associated with the launch, and their probabilities and accident environments; (2) the response of the RTG to such accidents in terms of the amount of radioactive materials released and their probabilities; and (3) the radiological consequences and mission risks associated with such releases. The risk assessment was based on a typical radioactive material inventory of 132,500 Ci of primarily plutonium-238 (an alpha-emitter with a half life of 87.7 years). The PuO_2 in the RTG to be used on the New Horizons spacecraft would consist of a mixture of fuel of differing ages, yet to be finalized. Based on the latest information, the inventory in the RTG is estimated to be in the range of 108,000 to 124,000 Ci. A reduction in the assumed inventory from 132,500 Ci would lead to an estimated proportional decrease in the results reported in DOE 2005 and summarized in this DEIS.

The risk assessment for the New Horizons mission began with the identification of the initial launch vehicle system malfunctions or failures and the subsequent chain of accident events that could ultimately lead to the accident environments (e.g., explosive overpressures, fragments, fire) that could threaten the RTG. These launch vehicle system failures were based on Atlas V system reliabilities and estimated failure probabilities (ASCA 2005).

Failure of the launch vehicle has the potential to create accident environments that could damage the RTG and result in the release of PuO_2. Based on analyses performed for earlier missions that carried radioisotope devices (RTGs and radioisotope heater units), DOE identified the specific accident environments that could potentially threaten the RTG.

DOE determined the response of the RTG and RTG components to these accident environments and estimated the amount of radioactive material that could potentially be released. Results of DOE's RTG testing and analyses were used to determine if a release of PuO_2 from the RTG could potentially occur. The amount of PuO_2 that could be released to the environment was determined based upon scaling of selected results from previous missions and additional analyses, where appropriate, to reflect conditions specific to the Atlas V and the New Horizons mission. Several factors, including population growth, Atlas V specific dispersion (vertical plume) configurations, the launch complex location, the amount of PuO_2 in the mission, the amount of solid propellant and its configuration, and the physical characteristics of the released PuO_2 were considered.

For this risk assessment, the New Horizons mission was divided into mission phases which reflect principal launch events.

- Phase 0 (Pre-Launch) and Phase 1 (Early Launch): A launch-related accident during these periods could result in ground impact in the launch area with some release of PuO_2 from the RTG. The results for Phases 0 and 1 are discussed below in combination because both deal with accidents that could occur in and directly affect the launch area. The results presented are probability-weighted averages of the mean estimates for both Phases. Each Phase is discussed separately in more detail in Chapter 4.

- Phase 2 (Late Launch): A launch accident during this period would lead to impact of debris in the Atlantic Ocean with no release of PuO_2 since undamaged aeroshell modules would survive water impact at terminal velocity.

- Phase 3 (Pre-Orbit): A launch accident during this period prior to reaching Earth parking orbit could lead to prompt sub-orbital reentry within minutes. Breakup of the spacecraft during reentry could result in impacts of individual aeroshell modules along the vehicle flight path over the Atlantic Ocean and southern Africa. Should the aeroshell modules impact hard surfaces (e.g., rock), small releases of PuO_2 are possible at ground level.
- Phase 4 (Orbit): A launch accident which occurs after attaining parking orbit could result in orbital decay reentries from minutes to years after the accident, affecting Earth surfaces between approximately 28° North Latitude and 28° South Latitude. Post-reentry impact releases would be similar to those in Phase 3, except more aeroshell modules could impact hard surfaces due to differences in the probability of impact on hard surfaces within these latitude bands.
- Phase 5 (Escape): A launch accident which leads to Earth escape conditions would not result in a release of PuO_2.

2.4.3.2 Accident Consequences

The radiological consequences of a given accident that results in a release of radioactive material have been calculated in terms of maximum individual dose, collective dose, health effects, and land area contaminated at or above specified levels. The radiological consequences have been determined from atmospheric transport and dispersion simulations incorporating both worldwide and launch-site specific meteorological and population data. Biological effects models, based on methods prescribed by the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP), were applied to predict the number of health effects following a New Horizons launch accident that results in a release of PuO_2.

Risk estimates were generated for each mission phase by combining the probabilities and consequences for each relevant accident environment. The risk estimates for all mission phases were combined to produce an overall mission risk estimate.

The analyses conducted by DOE for this DEIS are described in greater detail in Chapter 4, with the results presented for both mean and 99-th percentile values. For the purposes of this summary, the accident consequences and associated risks are presented only in terms of the mean. The 99-th percentile value reflects the potential for higher radiological consequences to the exposed population at lower probabilities than could occur for all accidents involving a release to the environment. The 99-th percentile consequences are typically a factor of 5 to 15 higher but at probabilities 100 times lower than the mean consequences.

Human Health Consequences

Human health consequences are expressed in terms of maximum individual dose, collective dose to the potentially exposed population, and the associated health effects. The maximum individual dose is the maximum dose, expressed in units of rem, delivered to a single individual for each accident. Collective dose is the sum of the radiation dose received by all individuals exposed to radiation from a given release, expressed in units of person-rem. Health effects represent statistically estimated additional latent cancer fatalities resulting from an exposure over a 50 year period to a release of radioactive material, and are determined using ICRP-60 health effects estimators (ICRP 1990). The estimated radiological consequences by mission phase and for the overall mission are summarized below.

Chapter 4 provides a detailed quantitative discussion of the accident probabilities for the New Horizons mission. For this summary discussion, the total probabilities of an accident with a release of PuO_2 are grouped into categories that allow for a descriptive characterization of the likelihood of each accident. The categories and their associated probability ranges are:

- unlikely: 10^{-2} to 10^{-4} (1 in 100 to 1 in 10 thousand);
- very unlikely: 10^{-4} to 10^{-6} (1 in 10 thousand to 1 in 1 million); and
- extremely unlikely: less than 10^{-6} (less than 1 in 1 million).

Qualitatively, unlikely accidents are events that will probably not occur during this mission. Both the very unlikely and extremely unlikely accidents are highly improbable events that would probably not occur even during a series of several missions.

Accidents Within the Launch Area (within 100 km (62 mi) of the launch site)

- Phases 0 and 1 (Pre-Launch and Early Launch): Prior to launch, the most likely result of a launch vehicle problem would be a safe hold or termination of the launch. After lift-off, most significant launch vehicle problems would lead to the automatic or commanded activation of on-board safety systems resulting in destruction of the launch vehicle. For both Phases combined, the total probability of an accident resulting in a release is considered to be unlikely, about 1 in 620. The maximum dose received by an individual within the exposed population would vary and would have a mean value of about 0.3 rem, which is the equivalent of about 80 percent of the normal annual background dose received by each member of the U.S. population during a year[5]. The collective dose that would be received by all individuals within the potentially exposed local and global populations would be about 718 person-rem, which would result in about 0.4 health effects within the entire group of potentially exposed individuals. A portion of the PuO_2 released in an accident during either of these phases would be transported beyond 100 km (62 mi). In this event, about two-thirds of the estimated radiological consequences would occur within the global population.

[5] An average of about 0.36 rem per year for an individual in the United States, including both natural sources and other sources such as medical X-rays; see Section 3.2.5 for further information.

Accidents Beyond the Launch Area

- Phase 2 (Late Launch): A launch accident occurring during this phase would not result in a release of PuO_2 since undamaged aeroshell modules would survive water impact at terminal velocity. There would be no health consequences.
- Phase 3 (Pre-Orbit): The total probability of an accident resulting in a release during this phase is considered to be unlikely, about 1 in 1,300. The maximum (mean value) dose received by an individual within the exposed global population would be about 0.1 rem, or the equivalent of about 30 percent of the normal annual background dose received by each member of the U.S. population during a year. The collective dose received by all individuals within the potentially exposed global population would be about 3 person-rem, which would result in about 0.002 health effects within the exposed population.
- Phase 4 (Orbit): The total probability of an accident resulting in a release during this phase is considered to be unlikely, about 1 in 1,100. The maximum (mean value) dose received by an individual within the potentially exposed global population would be about 0.4 rem, or the equivalent of about 110 percent of the normal annual background dose received by each member of the U.S. population during a year. The collective dose received by all individuals within the potentially exposed global population would be about 34 person-rem, resulting in about 0.02 health effects within the exposed population.
- Phase 5 (Escape): No accidents were identified that would result in a release of PuO_2 from the RTG. There would be no health consequences.

Overall Mission

- The total probability of an accident resulting in a release across the entire mission is considered to be very unlikely, about 1 in 300. The maximum dose received by an individual within the potentially exposed population would be about 0.3 rem, or about 80 percent of the normal background dose received by each member of the U.S. population annually. The collective dose received by all individuals within the potentially exposed population (both within 100 km (62 mi) of the launch site and globally) would be about 352 person-rem, resulting in about 0.2 health effects within the exposed population.

For the unlikely accidents in and near the launch area (Phases 0 and 1), as well as pre-orbit (Phase 3) and orbit (Phase 4) accidents, the mean health effects (i.e., additional latent cancer fatalities) are estimated to be small (0.002 to 0.4) within the potentially exposed population.

The predicted maximum radiological dose to an individual within the exposed population (i.e., the maximally exposed individual) ranges from very small to less than a rem for the very unlikely launch area (Phases 0 and 1) accidents. Assuming no interdiction, such as sheltering and exclusion of people from contaminated land areas, the potentially exposed population is estimated to inhale enough material to result in 0.4 health effects.

There is a range of accidents that have different probabilities of occurrence and consequences. Included are a number of accidents evaluated in the risk assessment for this DEIS that could occur at much lower total probabilities but result in higher consequences. For Phases 0 and 1, most of these accidents were determined to range from very unlikely to extremely unlikely, that is, having total probabilities of release in the range of 1 in 10,000 to 1 in 1 million or less. These postulated accidents could result in higher releases of the RTG inventory (ranging from 0.02 percent to 2 percent), with the potential for mean consequences 10 to 100 times greater than those summarized above. With extremely unlikely events, such as an intact ground impact of the entire Atlas V vehicle[6] with a total probability of release of 1 in 1.4 million, the maximally exposed off-site individual could receive a dose of 10 to 50 rem, and, assuming no mitigation actions such as sheltering and exclusion of people from contaminated land areas, the potentially exposed population could incur approximately 100 health effects.

The specific probability values presented in this DEIS are estimates and will likely differ from those presented in the more detailed FSAR being prepared by DOE for the New Horizons mission. Some probabilities will likely increase while others may decrease. However, NASA expects the overall probability of an accidental release of radioactive material will not vary substantially from the values presented in this DEIS.

Impacts of Radiological Releases on the Environment

In addition to the potential human health consequences of launch accidents that could result in a release of PuO_2, environmental impacts could also include contamination of natural vegetation, wetlands, agricultural land, cultural, archaeological and historic sites, urban areas, inland water, and the ocean.

Potential environmental contamination was evaluated in terms of areas exceeding various screening levels and dose-rate related criteria considered in evaluating the need for land cleanup following radioactive contamination. In the risk assessment for this DEIS, land areas contaminated at or above a level of 0.2 microcuries per square meter ($\mu Ci/m^2$) have been identified. This is a screening level used in prior NASA environmental documentation (e.g., NASA 1989, NASA 1997, NASA 2003) to identify areas potentially needing further action, such as monitoring or cleanup. The results for the mean land area contaminated at or above a level of $0.2 \mu Ci/m^2$ are summarized below.

- <u>Phases 0 and 1 (Pre-Launch and Early Launch)</u>: 1.8 square kilometers (km^2) (0.7 square miles (mi^2)).
- <u>Phase 2 (Late Launch)</u>: none.
- <u>Phase 3 (Pre-Orbit)</u>: 0.009 km^2 (0.003 mi^2).
- <u>Phase 4 (Orbit)</u>: 0.02 km^2 (0.008 mi^2).
- <u>Phase 5 (Escape)</u>: none.

[6] Referred to as Full Stack Intact Impact (FSII) in Chapter 4.

The risk assessment indicates that the unlikely launch area accident (involving the intentional destruction of all launch vehicle stages freeing the RTG to fall to the ground) would result in about 1.6 km^2 (0.6 mi^2) being contaminated above 0.2 $\mu Ci/m^2$. The risk assessment also indicates that in the extremely unlikely event that the on-board safety systems fail (involving ground impact of the entire launch vehicle), nearly 300 km^2 (about 115 mi^2) might be contaminated above 0.2 $\mu Ci/m^2$.

The area of land contaminated above the U.S. Environmental Protection Agency's (EPA) lifetime-risk criterion, associated with an average annual dose rate criterion of 15 millirem per year (mrem/yr), is estimated to range from 3 to 6 times higher than the land area contaminated above the 0.2 $\mu Ci/m^2$ level in the first year following a release. This is due in part to the resuspension contribution to dose. Following the first year, the areas contaminated above the 15 mrem/yr criterion would be expected to decrease to values comparable to that associated with the 0.2 $\mu Ci/m^2$ level.

Costs associated with potential characterization and cleanup, should decontamination be required, could vary widely ($93 million to $520 million per km^2 or about $241 million to $1.3 billion per mi^2) depending upon the characteristics and size of the contaminated area. The Price-Anderson Act, as amended (42 U.S.C. 2210), governs liability and compensation in the event of a nuclear incident arising out of the activities of the DOE. In the case of the New Horizons mission, DOE retains title to the RTG. The RTG would, therefore, be subject to Price-Anderson Act provisions. In the unlikely event that an accident were to occur resulting in release of PuO_2, affected property owners would be eligible for reimbursement for loss of property due to contamination.

In addition to the potential direct costs of radiological surveys, monitoring, and potential cleanup following an accident, there are potential secondary societal costs associated with the decontamination and mitigation activities due to launch area accidents. Those costs may include:

- temporary or longer term relocation of residents;
- temporary or longer term loss of employment;
- destruction or quarantine of agricultural products, including citrus crops;
- land use restrictions (which could affect real estate values, tourism and recreational activities);
- restriction or bans on commercial fishing; and
- public health effects and medical care.

2.4.3.3 Mission Risks

To place the estimates of potential health effects due to launch accidents for the proposed New Horizons mission into a perspective that can be compared with other human undertakings and events, it is useful to use the concept of risk. Risk is commonly viewed as the possibility of harm or damage. For the New Horizons mission, public risk is characterized in terms of the expectation of health effects in a statistical sense. The risk for each mission phase and for the overall mission is estimated by multiplying the total probability of a release by the health effects resulting from that release. Risk calculated in this manner can also be interpreted as the probability of one health effect occurring in the exposed population. The risks are estimated for the exposed population and for individuals within the exposed population.

Population Risks

Population risk can be interpreted as the probability of one health effect occurring in the exposed population. For the New Horizons mission, overall population health effects risk (i.e., the probability of a health effect occurring as a result of the launch) is estimated to be 1 in 1,700. For accidents that may occur in the launch area (during the Pre-Launch and Early Launch Phases), only a portion of the total population within 100 km (62 mi) of the launch site would be exposed. The total probability of a health effect within the regional population is about 1 in 5,300, or about one third of the total risk for the overall mission. For the global population (excluding those exposed in the launch area region) the risk would be due to the potential for accidental release occurring from Pre-Launch through Pluto trajectory insertion and was estimated to be about 1 in 2,600, or about two thirds of the total risk.

Individual Risks

Individual risk can be interpreted as the probability of an individual in the exposed population incurring a fatal cancer. The average individual risk is defined as the population risk divided by the number of persons exposed. For an accident near the launch site, not everyone within the regional area would be expected to receive a dose as a result of the accident. Due to meteorological conditions prevailing at the time of launch, only a portion of the total regional population is estimated to receive some radiological exposure. The average individual risk, therefore, is estimated to be about 1 in 2 billion in the potentially exposed population near the launch site and less than 1 in 2 trillion in the potentially exposed global population. This means, for example, that an individual within 100 km (62 mi) of the launch site has less than a 1 in 2 billion chance of incurring a health effect associated with implementation of the New Horizons mission.

While some individuals within the population, such as those very close to the launch area, would face higher risks, those risks are predicted to be very small. The highest risk to the maximally exposed individual within the regional population is estimated to be less than a 1 in 1 million for the New Horizons mission.

These risk estimates are small compared to other risks. For example, Table 2-5 presents information on annual individual fatality risks to residents of the United States due to various types of hazards. This data indicates that in 2000 the average individual risk of accidental death in the U.S. was about 1 in 3,000 per year, while the average individual risk of death due to any disease, including cancer, was about 1 in 130.

TABLE 2-5. CALCULATED INDIVIDUAL RISK AND PROBABILITY OF FATALITY BY VARIOUS CAUSES IN THE UNITED STATES IN 2000

Accident Type	Number of Fatalities	Approximate Individual Risk Per Year	Probability
Railway	25	8.88×10^{-8}	1 in 11 million
Floods	38	1.35×10^{-7}	1 in 7 million
Tornadoes	41	1.46×10^{-7}	1 in 6.8 million
Lightning	51	1.81×10^{-7}	1 in 6 million
Extreme Heat	158	5.61×10^{-7}	1 in 2 million
Legal Intervention	345	1.23×10^{-6}	1 in 800,000
All Weather	476	1.69×10^{-6}	1 in 600,000
Manufacturing	668	2.37×10^{-6}	1 in 400,000
Accidental Discharge of Firearms	808	2.87×10^{-6}	1 in 300,000
Water, Air and Space Transport Accidents (includes unspecified transport accidents)	1,786	6.35×10^{-6}	1 in 200,000
Accidental Exposure to Smoke, Fires and Flames	3,265	1.16×10^{-5}	1 in 90,000
Accidental Drowning and Submersion	3,343	1.19×10^{-5}	1 in 80,000
All Injuries at Work	5,291	1.88×10^{-5}	1 in 50,000
Accidental Poisoning and Exposure to Noxious Substances	9,893	3.52×10^{-5}	1 in 30,000
Falls	12,604	4.48×10^{-5}	1 in 20,000
Drug-induced deaths	15,852	5.63×10^{-5}	1 in 18,000
Assault (Homicide)	16,137	5.73×10^{-5}	1 in 17,000
Alcohol-induced deaths	18,539	6.59×10^{-5}	1 in 15,000
Suicide	28,332	1.01×10^{-4}	1 in 10,000
Motor Vehicle	41,804	1.49×10^{-4}	1 in 7,000
All Accidents	93,592	3.33×10^{-4}	1 in 3,000
All Diseases	2,192,094	7.79×10^{-3}	1 in 130
All Causes	**2,404,598**	$\mathbf{8.54 \times 10^{-3}}$	**1 in 100**

Sources: USBC 2000, BLS 2000, NOAA 2001, HHS 2001

Note: The population of the United States for the year 2000 was 281,421,906.

2.4.4 Radiological Contingency Response Planning

Prior to launch of the New Horizons mission, a comprehensive set of plans would be developed by NASA to ensure that any launch accident could be met with a well-developed and tested response. NASA's plans would be developed in accordance with the National Response Plan (NRP) and the NRP Radiological Incident Annex with the combined efforts of the U.S. Department of Homeland Security (DHS), the DHS's Federal Emergency Management Agency, DOE, the U.S. Department of Defense

(DOD), the U.S. Department of State (DOS), the EPA, the State of Florida, Brevard County, and local organizations involved in an emergency response.

The plans would be tested prior to launch in exercises designed to verify the response interfaces, command channels, and field responses to ensure that the various organizations would be prepared to respond in the unlikely event of a launch accident. NASA would be the Principal Technical Agency, working with the DHS to coordinate the entire federal response for launch accidents occurring within United States jurisdiction. Should a release of radioactive material occur in the launch area, the State of Florida, Brevard County, and local governments would determine an appropriate course of action for any off-site plans (such as sheltering in place, evacuation, exclusion of people from contaminated land areas, or no action required) and have full access to the DHS-coordinated federal response. For accidents outside United States jurisdiction, NASA would assist the DOS in coordinating the United States' response via diplomatic channels and using federal resources as requested.

To manage the radiological contingency response, NASA would establish a Radiological Control Center (RADCC) at KSC prior to and during the mission launch. The RADCC would be where NASA's and DHS's coordination efforts would be managed. The RADCC would also be used to coordinate the initial federal response to a radiological contingency once the vehicle has left the launch site area until the New Horizons spacecraft has left Earth orbit. Participation in the RADCC would include NASA, DHS, DOE, DOD, DOS, the EPA, USAF, the National Oceanic and Atmospheric Administration, the State of Florida, and Brevard County. An additional off-site location would be established from which radiological monitoring and assessment could be conducted.

If impact occurs in the ocean, NASA would work with the DHS, the DHS's U.S. Coast Guard, the U.S. Navy, and DOE to initiate security measures and search and retrieval operations. Efforts to recover the RTG or its components would be based on technological feasibility and any potential health hazard presented to recovery personnel and the environment.

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