

RECORD OF DECISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARS SCIENCE LABORATORY MISSION

A. Background (Purpose and Need for the Proposed Mission)

NASA's Mars Exploration Program (MEP) is currently being implemented as a sustained series of flight missions to Mars, each of which will provide important, focused scientific return. Taking advantage of launch opportunities available approximately every 26 months, the MEP is undertaking a set of flight missions extending into the next decade, including surface-focused missions such as possible return of samples to Earth and astrobiological field laboratories. Surface reconnaissance from orbiting missions (*e.g.*, Mars Global Surveyor, Mars Odyssey, and Mars Reconnaissance Orbiter) would provide the primary means for selecting the best sites for surface exploration, in addition to forming the basis for understanding the processes that have formed and modified the Mars environment.

The MEP is fundamentally a science driven program focused on understanding and characterizing Mars as a dynamic system and ultimately addressing whether life is or was ever a part of that system. The MEP further embraces the challenges associated with the development of a predictive capability for Martian climate and how the role of water and other factors, such as variations in the tilt of the planet's polar axis, may have influenced the environmental history of Mars. One of the foundational elements of the scientific strategy for the MEP is referred to as "*follow the water.*" This strategy connects fundamental program goals pertaining to biological potential, climate, the evolution of the solid planet, and the development of knowledge and technologies applicable to the eventual exploration of Mars by humans.

The purpose of the Mars Science Laboratory mission is to both conduct comprehensive science on the surface of Mars and demonstrate technological advancements in the exploration of Mars. The mission's overall scientific goals are: (1) assess the biological potential of at least one selected site on Mars; (2) characterize the geology and geochemistry of the landing region at all appropriate spatial scales; (3) investigate planetary processes of relevance to past habitability; and (4) characterize the broad spectrum of the Martian surface radiation environment. The following specific objectives are planned for the mission to address these goals:

- determine the nature and inventory of organic carbon compounds;
- inventory the chemical building blocks of life (carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur);
- identify features that may represent the effects of biological processes;
- investigate the chemical, isotopic, and mineralogical composition of Martian surface and near-surface geological materials;
- interpret the processes that have formed and modified rocks and regolith;
- assess long-timescale (*i.e.*, 4-billion-year) atmospheric evolution processes; and
- determine the present state, distribution, and cycling of water and carbon dioxide.

The MSL mission, with its planned capability to “*follow the water*” from a potential landing site within a broad range of latitudes, would utilize a mobile science laboratory (rover) with advanced instrumentation to acquire significant detailed information regarding the habitability of Mars from a scientifically promising location. The MSL mission would allow NASA to substantially advance its technological and operational capabilities to deliver a large, mobile science payload safely and precisely to a selected location on the surface of Mars, to expand access to higher and lower latitudes, to increase traverse capability to distances on the order of several kilometers, to conduct comprehensive science investigations on the surface for an extensive period of time, and to transmit large volumes of scientific data to Earth.

B. The Environmental Impact Statement

B.1 Introduction to the EIS

NASA prepared an environmental impact statement (EIS) to analyze the potential environmental impacts of the planned MSL mission. The U.S. Department of Energy (DOE) was a cooperating agency in the EIS because the Proposed Action (Alternative 1) (see subsection **B.2** below) would use a DOE-developed and owned radioisotope power system (RPS), specifically a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), to provide electrical power for the MSL rover.

On March 10, 2006, NASA published a Notice of Intent in the *Federal Register* (71 FR 12402) to prepare an EIS and conduct scoping for the Mars Science Laboratory mission. Public input and comments on alternatives, potential environmental impacts and concerns associated with the proposed MSL mission were requested. The scoping period ended on April 24, 2006. One scoping comment was received during this period from a Federal agency expressing concerns regarding habitat management of threatened and endangered species near the MSL launch site at Cape Canaveral Air Force Station (CCAFS), Florida. These concerns were addressed in the Draft EIS (DEIS).

NASA published a Notice of Availability (NOA) of the DEIS for the MSL mission in the *Federal Register* on September 5, 2006 (71 FR 52347). The DEIS was mailed by NASA to 59 potentially interested Federal, State and local agencies, organizations and individuals. In addition, the DEIS was publicly available in electronic format on NASA’s web site. The U.S. Environmental Protection Agency (EPA) published its NOA for the DEIS in the *Federal Register* on September 8, 2006 (71 FR 53093), initiating the 45-day review and comment period.

The public review and comment period closed on October 23, 2006. NASA received ten comment submissions (letters and other written comments) from three Federal agencies, one State agency, one private organization, and five individuals. The comments received included “no comment”, requests for clarification of specific sections of text, and objections to the use of nuclear material for space missions. The EPA had no objection to the proposed action discussed in the DEIS. In addition, NASA received a total of 34 comment submissions via electronic mail (e-mail) from 32 individuals. These comment submissions include objections to the use of nuclear material for space missions, and general support for the proposed MSL mission. These comments were considered in developing the Final EIS (FEIS), and responses to these comments were prepared and included in the FEIS at Appendix D.

In addition to soliciting comments for submittal by letter and e-mail, NASA held three meetings during which the public was invited to provide both oral and written comments on the MSL

DEIS. Two meetings were held on September 27, 2006, at the Florida Solar Energy Center in Cocoa, Florida, and one meeting was held on October 10, 2006, at the Hyatt Regency Hotel in Washington, DC. NASA placed paid advertisements announcing the dates, times, and purpose of the public meetings in local and regional newspapers together with the full text of NASA's NOA in the legal notices section of each newspaper. Members of the public attending each meeting were asked to register their attendance at the meeting. However, registration was not a requirement for anyone wishing to present either oral or written comments. Eleven members of the public registered for the 1 p.m. meeting and seven registered for the 6 p.m. meeting on September 27. Eleven members of the public registered for the meeting on October 10.

Excerpts of the official transcripts taken by a court reporter during the September 27 meetings, during which three members of the public presented oral comments, are included in the FEIS at Appendix E; no oral comments were presented during the October 10 meeting.

The EPA published a finding of no objection (*i.e.*, LO – Lack of Objection) to the Proposed Action regarding NASA's DEIS in the *Federal Register* on November 3, 2006 (71 FR 64701).

NASA published its NOA for the FEIS in the *Federal Register* on November 21, 2006 (71 FR 67389), and mailed copies to 119 Federal, State and local agencies, organizations, and individuals. In addition, NASA made the FEIS available in electronic format on its web site. NASA sent e-mail notifications to 23 individuals who had submitted comments on the DEIS via e-mail or had previously expressed interest in the MSL mission. The EPA published its NOA in the *Federal Register* on November 24, 2006 (71 FR 67863), initiating the 30-day waiting period, which ended on December 26, 2006. The EPA issued a finding of no objection to the Proposed Action in the FEIS on December 21, 2006. No additional comments were received by NASA during this period.

On December 6, 2006, NASA issued a Record of Decision for Advanced Radioisotope Power System Development. The decision was to pursue development of such RPSs, specifically the MMRTG and the Sterling Radioisotope Generator (SRG).

B.2 Alternatives Considered

The reasonable alternatives considered in the FEIS are:

1. The Proposed Action (Alternative 1), which would consist of continuing preparations for and implementing the MSL mission to Mars. The proposed MSL spacecraft would be launched on board an expendable launch vehicle from CCAFS, Florida, during September – November 2009, and would be inserted into a trajectory toward Mars. The proposed MSL rover would utilize a MMRTG as its primary source of electrical power to operate and conduct science on the surface of Mars. The next launch opportunity for a landed mission to Mars would occur during November – December 2011.

The Proposed Action (Alternative 1) is the alternative that would best accomplish the goals and objectives established for the MSL mission. The Proposed Action (Alternative 1) was designated NASA's preferred alternative in the FEIS.

2. Alternative 2, in which NASA would discontinue preparations for the Proposed Action (Alternative 1) and implement an alternative MSL mission to Mars. The alternative MSL spacecraft would be launched on board an expendable launch vehicle from CCAFS, Florida, during September – November 2009, and would be inserted into a trajectory toward Mars. The alternative MSL rover would utilize solar energy as its primary source of electrical

power to operate and conduct science on the surface of Mars. The next launch opportunity for a landed mission to Mars would occur during November – December 2011.

3. The No Action Alternative, in which NASA would discontinue preparations for the 2009 MSL mission and the spacecraft would not be launched.

B.3 Alternatives Considered But Not Evaluated Further

Alternatives to the Proposed Action (Alternative 1) that were considered but were not evaluated further include alternative power sources and additional heat sources for the mission.

Alternative power sources to the MMRTG were evaluated that could potentially reduce or eliminate the environmental risks associated with the plutonium dioxide (PuO_2) used in the MMRTG. The alternative power systems considered include those that either replace the PuO_2 in the MMRTG with a potentially less hazardous radioisotope, or implement power system designs that require less PuO_2 .

The principal concern with using PuO_2 in RPSs 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 MSL rover's surface mission and with a high enough specific activity to provide the required power with a suitably small generator can be used. For example, two other radioisotopes possible for RPSs 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 plutonium-238 (the principal radioisotope in PuO_2), extensive shielding (not required with PuO_2) would be required during production and handling, as well as on the spacecraft to protect sensitive components. Therefore, Sr-90 and Cm-244 oxides are not considered feasible isotopic heat sources for space missions.

NASA, in cooperation with DOE, is currently developing a SRG for application to a variety of deep space missions. The SRG would use a Stirling engine to convert heat into mechanical energy, which in turn would be converted into electricity. The SRG could be four times more efficient than the MMRTG, and therefore could require one-fourth as much PuO_2 for the same power output. However, the Stirling conversion technology has not yet been demonstrated in space for production of electricity from heat since its development is not complete, and the first potential application of the SRG would not occur before 2010 or later, beyond the timeframe of the Proposed Action (Alternative 1).

An alternative rover design was considered for which a solar-powered MSL rover would utilize up to 30 radioisotope heater units (RHUs) to provide additional heat. A RHU is a passive device that provides about one (1) watt of heat derived from the radioactive decay of about 2.7 grams (0.1 ounces) of PuO_2 with an activity of approximately 33.2 curies. The additional heat would help maintain the solar-powered rover's health and functionality during extreme cold temperature conditions. This alternative showed only small improvement in operational capability when compared to the capability of a solar-powered rover without RHUs. Furthermore, this small improvement in operational capability would only occur during MSL mission arrival dates for which high data rate communication would not be available during

entry, descent, and landing operations. For these reasons this alternative was not evaluated further.

B.4 Key Environmental Issues Evaluated

The key environmental issues of implementing either the Proposed Action (Alternative 1) or Alternative 2 are those associated with the air emissions which would accompany normal launch of the MSL spacecraft, and the environmental consequences (both nonradiological and radiological) associated with potential launch accidents.

Consideration of launch accidents involving radiological consequences under the Proposed Action (Alternative 1) was a principal focus of the MSL EIS. The proposed MSL spacecraft would have one MMRTG which uses PuO₂ to provide electrical power. The total PuO₂ inventory would be 4.8 kilograms (10.6 pounds), with up to about 58,700 curies at the time of launch. Depending upon the sequence of events, some launch accidents could result in release of some of the PuO₂, which could have adverse impacts on human health and the environment. For either the Proposed Action (Alternative 1) or Alternative 2, two of the science instruments on the rover would use small quantities of radioactive material, totaling approximately two curies, for instrument calibration or science experiments.

There would be no environmental impacts associated with the No Action Alternative.

B.5 Environmental Consequences of the Alternatives

B.5.1 Normal Launch

The environmental impacts of a normal launch of the MSL spacecraft under either the Proposed Action (Alternative 1) or Alternative 2 would consist principally of short-term impacts associated with the exhaust emissions from the Atlas V expendable launch vehicle.

The primary environmental impacts of a normal mission launch would be associated with airborne emissions from the strap-on solid rocket boosters that would be used on the Atlas V launch vehicle. Air emissions from the liquid propellant engines on the core vehicle, although large in magnitude, would be relatively inconsequential in terms of environmental effects. The effects of a normal launch would include short-term adverse impacts on air quality within the exhaust cloud at and near the launch pad, and the potential for acidic deposition from the solid booster exhaust on the vegetation and surface water bodies at and near the launch complex. Shortly after lift-off, the exhaust cloud would be transported downwind and upward, eventually dissipating to background concentrations. However, because launches from CCAFS are relatively infrequent events and winds rapidly disperse and dilute the launch emissions to background concentrations, no long-term adverse impacts to air quality in offsite areas would be anticipated. Surface waters in the immediate area of the exhaust cloud would temporarily acidify from deposition of hydrogen chloride, but no prolonged acidification or other long-term adverse effects would be anticipated. Biota in the immediate vicinity of the launch pad could be damaged or killed by intense heat following ignition and hydrogen chloride deposition from the exhaust cloud, but no long-term adverse effects to biota would be anticipated. Neither short-term nor long-term adverse impacts to threatened or endangered species would be expected. No significant socioeconomic impacts would be expected on nearby communities, and no impacts would be expected to cultural, historical, or archeological resources as a result of the MSL mission launch.

Some short-term ozone degradation would occur along the flight path as the Atlas V launch vehicle passes through the stratosphere and deposits ozone-depleting chemicals from the exhaust products of the solid rocket boosters. However, the depletion trail from a launch vehicle has been estimated to be largely temporary, and is self-healing within a few hours of the vehicle's passage. The total contribution to the average annual depletion of ozone from the launch of large expendable launch vehicles with solid rocket boosters in a given year has been estimated to be small (approximately 0.014 percent per year). Because launches at CCAFS are always separated by at least a few days, combined impacts in the sense of holes in the ozone layer combining or reinforcing one another cannot occur.

Launch of the Atlas V for the MSL mission would produce a very small fraction (less than 0.00001 percent) of the annual net greenhouse gases emitted by the United States. Therefore, launch of the mission would not be anticipated to substantially contribute to the accumulation of greenhouse gases.

Under the No Action Alternative, NASA would discontinue preparations for the MSL mission, and the spacecraft would not be launched. Thus, none of the anticipated impacts associated with a normal launch would occur.

B.5.2 Potential Accidents

Nonradiological accidents could occur during preparation for and launch of the MSL spacecraft at CCAFS under either the Proposed Action (Alternative 1) or Alternative 2. The two nonradiological accidents of greatest concern would be a liquid propellant spill during fueling operations and a launch vehicle failure. Under the No Action Alternative a launch would not occur, therefore there would be no potential for any accident to occur.

A liquid propellant spill during fueling operations would not be expected to result in any public health impacts or any long-term environmental consequences. Fueling operations for the Atlas V involve rocket propellant-1 (a form of kerosene), liquid hydrogen, liquid oxygen, and hydrazine. Launch preparation activities at CCAFS are subject to environmental regulations, including spill prevention and response requirements, and U.S. Air Force (USAF) and launch service contractor safety requirements specify detailed policies and procedures to be followed to ensure worker and public safety during all liquid propellant fueling operations. Workers performing propellant loading are 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. Any propellant spills or releases that did occur would be minimized and contained by remotely operated actions that close applicable valves and make safe the propellant loading system. Spill containment would be in place prior to any propellant transfer to capture any potential release.

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 carbon monoxide, carbon dioxide, hydrogen chloride, oxides of nitrogen, and aluminum oxide from the combusted propellants. A launch vehicle failure would result in the prompt combustion of a portion of the released 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 Atlantic 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 conditions toxic to aquatic life. Such chemicals entering the ocean would be rapidly dispersed and buffered, resulting in little long-term adverse impact on water quality and resident biota.

One of the primary issues addressed in the MSL EIS for the Proposed Action (Alternative 1) was the possible radiological consequences of mission accidents. DOE prepared a nuclear risk assessment to support the EIS. The risk assessment is based on a combination of scaling the results of risk assessments for past missions (*e.g.*, the Cassini, Mars Exploration Rover and New Horizons missions) on a per-curie inventory basis for specific accident configurations and environments, coupled with additional analyses where considered appropriate. The nuclear risk assessment for the MSL mission considers: (1) potential accidents associated with the launch, and their probabilities and accident environments; (2) the response of the MMRTG to such accidents in terms of the estimated amounts of radioactive material released and the release probabilities; and (3) the radiological consequences and risks associated with such releases.

DOE's risk assessment was developed during the time when the candidate launch vehicles being considered by NASA for the MSL mission were the Atlas V 541 and the Delta IV Heavy, prior to NASA's selection of the Atlas V 541. A composite approach was taken in the risk assessment in which results for representative configurations of the Atlas V 541 and Delta IV Heavy launch vehicles were combined in a probability-weighted manner to derive accident probabilities, potential releases of PuO₂ in case of an accident, radiological consequences, and mission risks. Differences in the two launch vehicles in terms of design, accident probabilities and accident environments were taken into account in developing composite results. NASA continues to evaluate the reliability of the selected Atlas V 541 launch vehicle (see section E. below).

The radiological impacts or consequences for each postulated accident were calculated in terms of: (1) impacts to individuals in terms of the maximum individual dose (the largest expected dose that any person could receive for a particular accident); (2) impacts to the exposed portion of the population in terms of the potential for additional latent cancer fatalities due to a radioactive release (*i.e.*, cancer fatalities that are in excess of those latent cancer fatalities which the general population would normally experience from all causes over a long-term period following the release); and (3) impacts to the environment in terms of land area contaminated at or above specified levels.

Results of the DOE risk assessment show that the most likely outcome of implementing the Proposed Action (Alternative 1) would be a successful launch with no release of radioactive materials. For most launch-related problems that could occur prior to launch, the most likely result would be a safe hold or termination of the launch countdown.

The risk assessment did, however, identify potential launch accidents that could result in a release of PuO₂ in the launch area, southern Africa following suborbital reentry, and other global locations following orbital reentry. However, in each of these regions an accident resulting in a release of PuO₂ is unlikely (*i.e.*, the estimated probability of such an accident in each region ranges from 1 in 100 to 1 in 10 thousand, with the data and analysis of the risk assessment indicating mean probabilities on the order of 1 in several hundred for each region). Accidents

which could occur either during ascent over the Atlantic Ocean or after the spacecraft escapes the Earth's gravity field would not result in a release of PuO₂.

A major vehicle malfunction after lift-off would lead to activation of safety systems that would result in destruction of the launch vehicle. Destruction of the launch vehicle by these safety systems would minimize potential damage to the MMRTG. However, the MMRTG or its components would fall to the ground where they could be subject to mechanical damage and exposure to solid propellant fires. This unlikely situation, with an estimated mean probability of approximately 1 in 480, could result in a release of about 0.02 percent of the PuO₂ in the MMRTG (about 1 gram (0.04 ounce)).

For the unlikely accidents with a release which could occur in and near the launch area, the predicted mean radiological dose to the maximally exposed individual is about 0.14 rem, which is the equivalent of about 40 percent of the normal annual background dose received by each member of the U.S. population during a year. No short-term radiological effects would be expected from any of these exposures. Each exposure would, however, increase the statistical likelihood of a cancer fatality over the long term.

For such unlikely accidents with a release, additional latent cancer fatalities are predicted to be small (*i.e.*, a mean of 0.4 additional latent cancer fatalities among the potentially exposed members of the local population near the launch area, and a mean of 0.2 additional latent cancer fatalities among potentially exposed members of the global population). These estimates of health consequences assume no mitigation actions, such as sheltering and exclusion of people from contaminated land areas.

Potential environmental contamination was evaluated in terms of areas exceeding various screening levels and dose-rate related criteria. Land areas estimated to be contaminated above a screening level of 0.2 microcuries per square meter ($\mu\text{Ci}/\text{m}^2$) (used by NASA in the evaluations of previous missions) have been identified for the purpose of evaluating the need for potential characterization and cleanup. Costs associated with these efforts, should decontamination be required, could vary widely (\$101 million to \$562 million per square kilometer or about \$261 million to \$1.5 billion per square mile, adjusted for inflation to 2009) depending upon the characteristics and size of the contaminated area.

Results of the risk assessment indicate that the unlikely launch area accident, involving the intentional destruction of all launch vehicle stages freeing the MMRTG to fall to the ground, could result in about six square kilometers (about two square miles) potentially contaminated above the 0.2 $\mu\text{Ci}/\text{m}^2$ screening level.

Less likely launch accidents were also assessed. These events were postulated for cases in which an accident occurs in the launch area and the safety systems fail to destroy the launch vehicle. The mean probabilities of these events are estimated to range from 1 in 8,000 to 1 in 800,000. These less likely accidents could, however, expose the MMRTG to severe accident environments, including mechanical damage, fragments, and solid propellant fires, and could result in higher releases of PuO₂ (up to 2 percent of the MMRTG inventory) with the corresponding potential for higher consequences.

The maximally exposed individual could receive a mean dose ranging from a fraction of one rem up to about 30 rem following the more severe types of less likely accidents, such as ground impact of the entire launch vehicle, which are considered to be very unlikely (*i.e.*, probabilities

ranging from 1 in 10,000 to 1 in 1 million). It should be noted that there are very large variations and uncertainties in the prediction of close-in doses due to the large variations and uncertainties in dispersion modeling for such complicated accident situations. Assuming no mitigation actions, such as sheltering and exclusion of people from contaminated land areas, radiation doses to the potentially exposed members of the population from a very unlikely launch accident could result in up to 60 mean additional cancer fatalities over the long term.

For the very unlikely accident that involves ground impact of the entire launch vehicle, roughly 90 square kilometers (about 35 square miles) of land area could be contaminated above the 0.2 $\mu\text{Ci}/\text{m}^2$ screening level. Contamination at this level could necessitate radiological surveys and potential mitigation and cleanup actions.

In summary, considering the unlikely launch accidents assessed in this EIS, the maximally exposed individual within the launch-area and global populations would face a less than 1 in 1 million chance of incurring a latent cancer due to a catastrophic failure of the MSL mission under the Proposed Action (Alternative 1).

Under Alternative 2, the MSL rover would utilize solar energy as its primary source of electrical power. Alternative 2 would not involve any MMRTG-associated radiological risks as a MMRTG would not be used for this mission alternative. The small quantities of radioactive materials in two science instruments on the rover are negligible compared to that contained in the MMRTG planned for use in the Proposed Action (Alternative 1). In a launch accident, these small quantities would result in contributions to mission risks and related radiological consequences of nominally less than 0.01 percent of those associated with the MMRTG under the Proposed Action (Alternative 1). Alternative 2 is the environmentally preferable alternative that in some measure meets the purpose and need.

Under the No Action Alternative, NASA would not complete preparations for and implement the MSL mission. The No Action Alternative would, therefore, not involve any of the radiological risks associated with potential launch accidents.

C. Assessment of the Analysis

The environmental impacts of a normal launch of the MSL spacecraft under either the Proposed Action (Alternative 1) or Alternative 2 would consist principally of short-term impacts associated with the exhaust emissions from the Atlas V expendable launch vehicle. Such impacts of Atlas launches from CCAFS have been previously addressed and fully characterized in USAF and NASA environmental documentation. A normal launch of the MSL mission is within the scope of operations analyzed in that previous documentation and would not be expected to cause any environmental impacts beyond those of routine CCAFS launch operations.

The DOE's risk assessment for the Proposed Action (Alternative 1) shows that in most launch accidents there would be no release of nuclear material. The environmental impacts of a launch accident with no release of nuclear material would consist principally of emissions from burning propellants and from falling debris. Emissions from a launch accident would resemble the emissions from a normal launch and would not be anticipated to reach levels threatening public health. Debris from a launch accident would be expected to fall in the launch site area or over the Atlantic Ocean.

In the unlikely event of an accident resulting in release of nuclear material, the risk assessment indicates that, in the mean, no additional latent cancer fatalities would be expected among

potentially exposed members of the population. For certain potential launch accidents in which the launch vehicle safety systems fail to operate, there could be, in the mean, about 60 additional latent cancer fatalities among potentially exposed members of the population; however, such accidents are considered very unlikely.

D. Choice of Alternatives

In view of the small risks associated with the MSL mission's use of an MMRTG as the primary electrical power source to operate and conduct science on the surface of Mars, it is my intention to select the Proposed Action (Alternative 1) (see subsection **B.2** above), based on the following.

The Proposed Action (Alternative 1) enables the best return of scientific and technical information, and makes most effective use of fiscal, human, and material resources.

NASA established target operational capabilities for the proposed MSL mission to meet the goals and objectives summarized above (see section **A.**). Both full and minimum operational capabilities have been established. Achieving the full capabilities (*e.g.*, operating on the surface for at least one Mars year) would maximize the potential for the mission to be most responsive to real-time discoveries and fulfill its comprehensive science objectives. Achieving the minimum capabilities (*e.g.*, operating on the surface for at least one-half of a Mars year) would be necessary to assure that the mission addresses its objectives with a reasonable confidence of success. The full operational capabilities (with the corresponding minimum capabilities shown in square brackets) include, but are not limited to, the following:

- be capable of landing on the surface of Mars within a circular target area with a radius of 10 kilometers (km) (6 miles (mi)) [20 km (12 mi)];
- be capable of landing between 60° North and 60° South latitudes [between 45° North and 45° South latitudes];
- be capable of landing at an elevation of up to 2 km (about 1¼ mi) [up to 1½ km (about 1 mi)] above the mean surface of Mars;
- be designed to operate at least one Mars year [at least one-half of a Mars year];
- be capable of adequate mobility to ensure representative measurement of diverse sites, at distances of at least 20 km (12 mi) [at least 10 km (6 mi)];
- accommodate the NASA-selected science payload, capable of definitively analyzing the mineralogy, chemistry, and isotopic composition of surface and near-surface materials, and assessing the biological potential of the landing site; and
- be able to select, acquire, process, distribute, and analyze at least 74 samples [at least 28 samples] of rock, rock fragments, and soil.

The exact landing site for the MSL mission will be selected in 2008, about one year before the planned launch. The site selection process will include a consensus recommendation by mission scientists, utilizing very detailed, high resolution images expected from the Mars Reconnaissance Orbiter and other available science data, on the most scientifically worthy location to land the rover. The selection process will also include NASA's engineering assessment of the rover's capabilities at the proposed site. NASA will then approve the selected site.

Both the MMRTG-powered rover under the Proposed Action (Alternative 1) and the solar-powered rover under Alternative 2 could accommodate the NASA-selected science payload. The MMRTG-powered rover would be capable of performing all the science experiments planned for the mission for an entire Mars year over a wide latitude range on Mars (60° North latitude to 60° South latitude). The solar-powered rover would be capable of performing all the science experiments planned for the mission for a full Mars year only at 15° North latitude. Such a rover could accomplish only the minimum science objectives over a latitude range of approximately 5° North to about 20° North latitude. At other latitudes, a solar-powered rover would be unable to generate sufficient power for the rover to survive the extreme cold temperatures, and thus would not be able to survive for an entire Mars year.

In terms of operational capabilities, the major difference between the Proposed Action (Alternative 1) and Alternative 2 is the length of time the rovers would be expected to survive and successfully operate and conduct science experiments at a selected landing site. The capability to operate the rover within a broad range of latitudes is important because doing so maintains NASA's flexibility to select the most scientifically interesting location on the surface and fulfill the purpose and need for the MSL mission defined in the FEIS.

The No Action Alternative is the environmentally preferable alternative because there would be no launch of the MSL spacecraft. However, under the No Action Alternative NASA would need to reevaluate its programmatic options for the 2009 launch opportunity to Mars and beyond. Without development and implementation of a large mobile science platform such as the rover planned for the MSL mission, NASA's ability to acquire detailed scientific information on the habitability of Mars would be severely limited, and the advancements in technological and operational capabilities necessary for the future exploration of Mars may not be achieved. In summary, the No Action Alternative does not satisfy the purpose and need for the MSL mission defined in the FEIS.

The selection of the Proposed Action (Alternative 1) is fully consistent with the mandate of the National Aeronautics and Space Act to contribute to the expansion of human knowledge of phenomena in space.

E. Additional Information

In addition to the requirements under the National Environmental Policy Act (NEPA) and NASA policy and procedures, there is a separate and distinct Executive Branch interagency process for evaluating the nuclear launch safety of the proposed MSL mission. Pursuant to paragraph 9 of Presidential Directive/National Security Council Memorandum #25 (PD/NSC-25) a nuclear Safety Analysis Report (SAR), including an uncertainty analysis, will be prepared by DOE and will be based on detailed reliability data for the selected Atlas V 541 launch vehicle. The SAR will be reviewed by an *ad hoc* Interagency Nuclear Safety Review Panel (INSRP), who will then prepare a Safety Evaluation Report (SER) for the mission. The PD/NSC-25 process is ongoing, and I will receive briefings on the results of the analyses presented in the SAR and SER. While there may be some differences in mission phase risk estimates contained in the SAR, SER, and the FEIS, the differences are not, at this time, expected to be significant with regard to potential public health consequences and are not expected to change the overall nuclear launch safety mission risk, but to reasonably bound that risk. The DOE and the INSRP will provide NASA a formal briefing on the SAR and SER analyses prior to NASA's decision on whether or not to

request launch approval from the White House Office of Science and Technology Policy in accordance with PD/NSC-25.

F. Mitigation

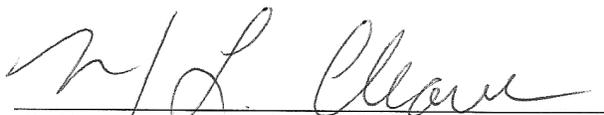
The only expected or immediate environmental impacts of launching the MSL mission are the same as those for the launch of every currently-available Delta and Atlas class vehicle, and mitigation will accordingly be the same. Range Safety at CCAFS monitors launch surveillance areas to ensure that risks to people, aircraft, and surface vessels are within acceptable limits. Models which take into account current meteorological conditions, the probability of a launch failure, and emergency preparedness procedures, are used to predict launch hazards. Launches are postponed if the predicted public risks of injury from toxic gases, debris, or blast overpressure exceed acceptable limits.

This EIS primarily addressed possible radiological consequences of mission accidents. Regarding such possible radiological impacts, for any launch of radioactive materials a comprehensive set of radiological contingency response plans are developed by NASA in coordination with Federal, State and local representatives. Such plans are put in place prior to launch to ensure that any launch accident can be met with a well-developed and thoroughly tested response. NASA's plans are developed in accordance with the National Response Plan and applicable State and county emergency plans, and in coordination with the Federal agencies participating in the National Response Plan, the State of Florida, Brevard County, and local launch site response organizations. At the time of launch, emergency response personnel and equipment would be pre-deployed both within the launch area and in the surrounding communities to continuously monitor for a potential release of radioactive material in the unlikely event of a launch accident. Post-accident mitigation activities, if required, would be based upon detailed monitoring information and assessments. The selection of the types and capabilities of response personnel and equipment would be based on the radiological contingency planning effort that is in the early planning stages at this time.

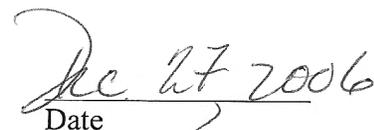
I am confident that all practicable means to avoid or minimize environmental harm from the MSL mission have been adopted or are in the process of development. The radiological contingency response plan for the MSL mission will be very similar to the one put in place for the recently launched New Horizons mission.

Decision

Based upon all of the foregoing, it is my decision to complete preparations for launch of the proposed MSL mission during September – November 2009, and to operate the mission using an MMRTG as the primary power source for the rover.



Mary L. Cleave
Associate Administrator
Science Mission Directorate



Date