National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

January 13, 2014

Reply to Attn of: 460

MEMORANDUM FOR THE RECORD

The National Environmental Policy Act Compliance for Solar Probe Plus

1.0 Introduction

The National Environmental Policy Act (NEPA) of 1969, (42 USC 4321, *et seq.*) requires Federal agencies to consider the environmental impacts of a project in their decision making process. To comply with NEPA, associated regulations (the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA [40 CFR Parts 1500-1508], and NASA policy and procedures [14 CFR, Part 1216, Subpart 1216.3]), NASA has prepared an Environmental Assessment (EA) for routine payloads launched on expendable launch vehicles (Ref: *Environmental Assessment for Launch of NASA Routine Payloads*, November 2011). The 2011 NASA Routine Payload Environmental Assessment (NRPEA) assesses the environmental impacts of missions launched with spacecraft that are considered routine payloads from existing launch facilities at Cape Canaveral Air Force Station (CCAFS), Florida, Vandenberg Air Force Base (VAFB), California, the United States Army Kwajalein Atoll/Reagan Test Site (USAKA/RTS), Republic of the Marshall Islands, Wallops Flight Facility (WFF), Virginia, and the Kodiak Launch Complex (KLC), Alaska.

Spacecraft defined as routine payloads utilize materials, quantities of materials, launch vehicles, launch sites, and operational characteristics that are consistent with normal and routine spacecraft preparation and flight activities at CCAFS, VAFB, USAKA/RTS, WFF, KLC, and Kennedy Space Center. The environmental impacts of launching routine payloads from these sites fall within the range of routine, ongoing, and previously documented impacts that have been determined not to be significant. Spacecraft within the scope of this EA meet specific criteria ensuring that the spacecraft, operation, and decommissioning, do not present any new or substantial environmental or safety concerns.

To determine the applicability of a routine payload classification for a mission, the mission is evaluated against the criteria (Envelope Payload Characteristics) defined in the EA using the Routine Payload Checklist.

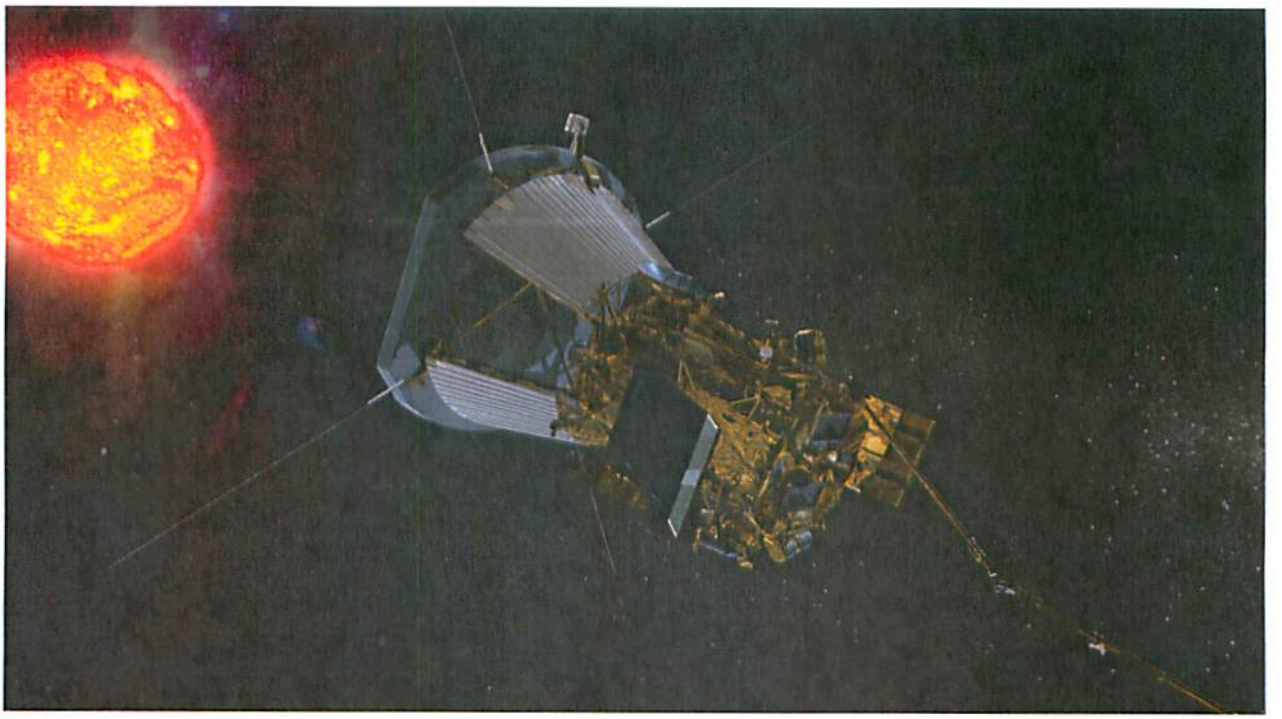
2.0 Mission Description

Solar Probe Plus (SPP) is part of NASA's Living with a Star (LWS) program, created to gather more information about the Sun and its effects on planetary systems and human activities. NASA

Goddard Space Flight Center in Greenbelt, Maryland, manages the LWS program for the Science Mission Directorate at NASA Headquarters, Washington, DC. The Johns Hopkins University Applied Physics Laboratory in Laurel, MD, is designing and building the spacecraft.

SPP will be a historic mission, as it will fly into the Sun's atmosphere (or corona) for the first time. SPP will come closer to the Sun than any previous spacecraft. The purpose of the mission is to gather data on the processes that heat the corona and accelerate the solar wind to answer critical questions that have been top goals in heliophysics for decades. SPP will employ a combination of in situ measurements and imaging to achieve the mission's primary scientific goal of understanding these processes. SPP will revolutionize our knowledge and understanding of coronal heating and of the origin and evolution of solar wind. This mission will transform our understanding of the Sun and stars like it, and enable further exploration through our own solar system. By making direct in situ measurements of the region, where some of the most hazardous solar energetic particles are energized, SPP will make a fundamental contribution to our ability to characterize and forecast the radiation environment in which future space explorers will work and live.

SPP will study the streams of charged particles the Sun hurls into space from where the processes that produce the solar wind actually occur. At closest approach, SPP will pass the Sun at 125 miles per second, protected by a heat shield that must withstand up to 2,600° Fahrenheit and survive blasts of radiation and energized dust at levels not experienced by any previous spacecraft.



The solar-powered probe will weigh about 1,350 pounds. The design includes an 8-foot-diameter, 4.5-inch-thick, carbon-composite heat shield atop the spacecraft body. The solar arrays will retract and extend as the spacecraft swings toward or away from the Sun. Summary tables of the science instruments and spacecraft characteristics are provided below. SPP is schedule to launch in 2018 from CCAFS on an Atlas V551 rocket with a Star-48GXV solid-fuel third stage "kick" motor to achieve the required launch energy.

INSTRUMENT	FUNCTION
Solar Wind Electrons, Alphas, and Protons	Count and measure properties of the primary particles in the solar wind
Widefield Imager for Solar Probe	Image the solar corona
Fields	Measure electric and magnetic fields
Integrated Science Investigation of the Sun	Monitor high-energy electrons, protons, and ions

Spacecraft Characteristics

- Three-axis stabilized, using guidance and control sensors and attitude control thrusters to keep the solar shield pointed toward the Sun.
- A hexagonal bus (or six-sided body) with a central propellant tank.
- Science instruments mounted on the front and rear-facing panels, and extending from the lower deck.
- The Thermal Protection System (TPS), or solar shield, is attached to the spacecraft body through a transition structure, which includes the radiators for the solar array cooling system.
- Solar powered, with up to 343 watts at closest approach, delivered through actively cooled solar arrays. At closest approach, only the tip of the array extends into the partial shadow (or penumbra) created by the TPS; this provides power while minimizing solar array temperatures and thermal load into the cooling system. The remainder of the array is completely shadowed. As the spacecraft moves away from the Sun the array extends from the spacecraft, exposing more of the array to the Sun and providing the required power.
- X/KA-band telecommunications system provides high-speed downlink through a high-gain antenna when the spacecraft is away from the Sun (farther than .25 astronomical units, or ¼ the distance between Earth and the Sun) and low-speed command uplink and "health and status" downlink through low-gain antennas during solar encounters.
- Block-redundant processor suite with 256-gigabit solid state recorders and internally redundant power control and distribution systems.

SPP spacecraft shown with solar array panels in stowed position

3.0 Special Considerations

The SPP mission will utilize a modified Star 48 third stage with a solid propellant load of 3,056 kg (6,737 lbs.). This is 56 kg (123 lbs.) more than the quantity listed in the Envelope Payload Characteristics of the 2011 NRPEA, 3,000kg (6,614 lbs.). The NRPEA requires additional environmental review if characteristics are outside the envelope. The additional review is presented below.

Under normal operation, the Star 48 third stage would not ignite and operate until well above the stratosphere, at which point it would already be on an earth-escape trajectory. There would be no potential substantial environmental impacts expected on local air quality from the Star 48 during normal launch. Potential impacts could only occur from a launch failure.

The New Horizons Environmental Impact Statement (EIS) analyzed the impacts of the addition of a third stage solid rocket motor to the Atlas V during a launch failure. Previous analysis for an accident during an Atlas V launch showed that estimated concentration of combustion products resulting from an accident would not be expected to exceed any of the applicable standards, and would not create adverse impacts to air quality in the region. The New Horizons EIS concluded that because the solid propellant in the third stage motor would account for less than one percent of

the total inventory of solid propellant aboard the Atlas V, the combustion products from this motor would not be expected to significantly factor into the previously estimated concentration of combustion products. (Ref: *Final Environmental Impact Statement for the New Horizons Mission, July 2005*)

The modified Star 48 would account for less than 1.5 percent of the total inventory of solid propellant aboard the Atlas V for the SPP mission. The combustion products from this motor would also not be expected to significantly factor into the previously estimated concentrations. The modified Star 48 would not create new or substantially increase impacts to the environment.

4.0 NASA Routine Payload Determination

The components utilized in the SPP mission are made of materials normally encountered in the space industry. Materials and operations to provide power, propulsion, and communications for the spacecraft and instruments will not pose substantial risks to human health and safety. SPP will not utilize radioactive sources or lasers, will not carry pathogenic organisms, and will not return samples to Earth. No reentry is planned for the SPP.

The SPP mission has been evaluated against the NRPEA, using the Routine Payload Checklist (see enclosed Evaluation Recommendation Package). The mission does not present any unique or unusual circumstances that could result in new or substantial environmental impacts. Based on the analyses set forth in the 2011 NRPEA and the additional review, NASA has determined that the environmental impacts associated with SPP will not individually or cumulatively have a significant impact on the quality of the human environment and that a routine payload classification for the SPP is applicable. No additional NEPA action or documentation is required.

George W. Morrow
Director, Flight Projects

1/9/14
Date

Christopher J. Scolese
Director

13 January 2014
Date

Enclosure

Reference
http://solarprobe.jhuapl.edu/

EVALUATION RECOMMENDATION PACKAGE

Record of Environmental Consideration
Routine Payload Checklist
Flight Project Environmental Checklist

Enclosure

RECORD OF ENVIRONMENTAL CONSIDERATION

1. Project Name: Solar Probe Plus (SPP)

2. Description/location of proposed action: The purpose of the SPP mission is to study the streams of charged particles the Sun hurls into space from an unprecedented vantage point: inside the Sun's corona (its outer atmosphere) where the processes that heat the corona and produce solar wind occur. SPP will employ a combination of in situ measurements and imaging to achieve the mission's primary scientific goal: to understand how the Sun's corona is heated and how the solar wind is accelerated.

Date and/or Duration of project: Launch – Summer 2018

3. It has been determined that the above action:

☒ a. Is adequately covered in an existing EA or EIS.
Title: *Environmental Assessment for Launch of NASA Routine Payloads*
Date: November 2011

☐ b. Qualifies for Categorical Exclusion and has no extraordinary circumstances which would suggest a need for an Environmental Assessment.
Categorical Exclusion: _____

☐ c. Is exempt from NEPA requirements under the provisions of: _____

☐ d. Is covered under EO 12114, not NEPA.

☐ e. Has no significant environmental impacts as indicated by the results of an environmental checklist and/or detailed environmental analysis.
(Attach checklist or analysis as applicable)

☐ f. Will require the preparation of an Environmental Assessment.

☐ g. Will require the preparation of an Environmental Impact Statement.

☐ h. Is not federalized sufficiently to qualify as a major federal action.

Beth Montgomery NEPA Program Manager, Code 250 — 10/23/13 Date

Mark Goans Project Manager, Code 460 — 11/21/13 Date

NASA Routine Payload Checklist (1 of 3)

PROJECT NAME: SOLAR PROBE PLUS (SPP) DATE OF LAUNCH: 7/2018
PROJECT CONTACT: MARK GOANS PHONE NUMBER: 6-9763 MAILSTOP: 460
PROJECT START DATE: 2008 PROJECT LOCATION: JHU/APL, LAUREL, MD.
PROJECT DESCRIPTION: SPP IS AN EXTRAORDINARY AND HISTORIC MISSION, TRAVELING CLOSER TO THE SUN (9.86 RS) THAN ANY OTHER SPACECRAFT, THAT WILL REPEATEDLY OBTAIN DIRECT IN-SITU CORONAL MAGNETIC FIELD AND PLASMA OBSERVATIONS IN THE REGION OF THE SUN THAT ACCELERATES THE SOLAR WIND AND CREATES SPACE WEATHER.

A. SAMPLE RETURN:	YES	NO
1. Would the candidate mission return a sample from an extraterrestrial body?		X
B. RADIOACTIVE MATERIALS:	**YES**	**NO**
1. Would the candidate spacecraft carry radioactive materials in quantities that produce an A2 mission multiple value of 10 or more?		X
Provide a copy of the Radioactive Materials On Board Report as per NPR 8715.3 with the ERP submittal		
C. LAUNCH AND LAUNCH VEHICLES:	**YES**	**NO**
1. Would the candidate spacecraft be launched on a vehicle and launch site combination other than those listed in Table C–1 below?		X
2. Would launch of the proposed mission exceed the approved or permitted annual launch rate for the particular launch vehicle or launch site?		X
Comments:		
D. FACILITIES:	**YES**	**NO**
1. Would the candidate mission require the construction of any new facilities or substantial modification of existing facilities?		X
Provide a brief description of the construction or modification required, including whether ground disturbance and/or excavation would occur:		
E. HEALTH AND SAFETY:	**YES**	**NO**
1. Would the candidate spacecraft utilize batteries, ordnance, hazardous propellant, radiofrequency transmitter power, or other subsystem components in quantities or levels exceeding the EPCs in Table C–2 below?	X	
2. Would the expected risk of human casualty from spacecraft planned orbital reentry exceed the criteria specified by NASA Standard 8719.14?		X
3. Would the candidate spacecraft utilize any potentially hazardous material as part of a flight system whose type or amount precludes acquisition of the necessary permits prior to its use or is not included within the definition of the Envelope Payload Characteristics?		X
4. Would the candidate mission, under nominal conditions, release material other than propulsion system exhaust or inert gases into the Earth's atmosphere or space?		X
5. Are there changes in the preparation, launch or operation of the candidate spacecraft from the standard practices described in Chapter 3 of this EA?		X
6. Would the candidate spacecraft utilize an Earth-pointing laser system that does not meet the requirements for safe operation (ANSI Z136.1-2007 and ANSI Z136.6-2005)?		X
7. Would the candidate spacecraft contain, by design (e.g., a scientific payload) pathogenic microorganisms (including bacteria, protozoa, and viruses) which can produce disease or toxins hazardous to human health or the environment beyond Biosafety Level 1 (BSL 1)[1]?		X
Comments: Health & Safety: 1. Spacecraft upper stage (treated as part of the payload) solid propellant mass 6737 lb 2. Spacecraft will be in solar orbit, not earth orbit, hence no planned re-entry.		

[1] The use of biological agents on payloads is limited to materials with a safety rating of "Biosafety Level 1." This classification includes defined and characterized strains of viable microorganisms not known to consistently cause disease in healthy human adults. Personnel working with Biosafety Level 1 agents follow standard microbiological practices including the use of mechanical pipetting devices, no eating drinking, or smoking in the laboratory, and required hand-washing after working with agents or leaving a lab where agents are stored. Personal protective equipment such as gloves and eye protection is also recommended when working with biological agents.

NASA Routine Payload Checklist (2 of 3)

PROJECT NAME: SPP | DATE OF LAUNCH:
PROJECT CONTACT: | PHONE NUMBER: | MAILSTOP:
PROJECT START DATE: | PROJECT LOCATION:
PROJECT DESCRIPTION:

F. OTHER ENVIRONMENTAL ISSUES:	YES	NO
1. Would the candidate spacecraft have the potential for substantial effects on the environment outside the United States?		X
2. Would launch and operation of the candidate spacecraft have the potential to create substantial public controversy related to environmental issues?		X
3. Would any aspect of the candidate spacecraft that is not addressed by the EPCs have the potential for substantial effects on the environment (i.e., previously unused materials, configurations or material not included in the checklist)?		X
Comments:		

Table C–1. Launch Vehicles and Launch Sites

Launch Vehicle and Launch Vehicle Family	Space Launch Complexes and Pads				
	Eastern Range (CCAFS)	Western Range (VAFB)	USAKA/RTS	WFF	KLC
Athena I, IIc, III[a]	LC-46	CA Spaceport (SLC-8)	N/A	Pad 0	LP-1[a]
Atlas V Family	LC-41	SLC-3	N/A	N/A	N/A
Delta II Family	LC-17	SLC-2	N/A	N/A	N/A
Delta IV Family	LC-37	SLC-6	N/A	N/A	N/A
Falcon 1/1e	LC-36	SLC-4W	Omelek Island	Pad 0	LP-3[b]
Falcon 9	LC-40	SLC-4E	Omelek	Pad 0	LP-3[b]
Minotaur I	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Minotaur II-III	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Minotaur IV	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Minotaur V	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Pegasus XL	CCAFS skidstrip KSC SLF	VAFB Airfield	Kwajalein Island	WFF Airfield	N/A
Taurus	LC-46 and/or LC-20	SLC-576E	N/A	Pad 0	LP-1
Taurus II	NA	NA	N/A	Pad 0	LP-3[b]
Any other launch vehicle/launch site combination for which NASA has completed or cooperated on the NEPA compliance					

a. Athena III and LP-3 are currently under design.

b While not explicitly listed in this table, the Minotaur IV includes all configurations of this launch vehicle, including the Minotaur IV+, which is a Minotaur IV with a Star 48V 4th stage.

Key: CA=California; CCAFS=Cape Canaveral Air Force Station; KSC=Kennedy Space Center; LC=Launch Complex; LP=Launch Pad; MARS=Mid-Atlantic Regional Spaceport; SLC=Space Launch Complex; SLF=Shuttle Landing Facility; USAKA/RTS=United States Army Kwajalein Atoll/Reagan Test Site; VAFB=Vandenberg Air Force Base; WFF=Wallops Flight Facility.

Table C–2. Summary of Envelope Payload Characteristics by Spacecraft Subsystems

Structure	• Unlimited: aluminum, beryllium, carbon resin composites, magnesium, titanium, and other materials unless specified as limited.
Propulsion[a]	• Liquid propellant(s); 3,200 kg (7,055 lb) combined hydrazine, monomethyhydrazine and/or nitrogen tetroxide. • Solid Rocket Motor (SRM) propellant; 3,000 kg (6,614 lb) Ammonium Perchlorate (AP)-based solid propellant (examples of SRM propellant that might be on a spacecraft are a Star-48 kick stage, descent engines, an extra-terrestrial ascent vehicle, etc.)
Communications	• Various 10-100 Watt (RF) transmitters
Power	• Unlimited Solar cells; 5 kilowatt-Hour (kW-hr) Nickel-Hydrogen (NiH_2) or Lithium ion (Li-ion) battery, 300 Ampere-hour (A-hr) Lithium-Thionyl Chloride (LiSOCl), or 150 A-hr Hydrogen, Nickel-Cadmium (NiCd), or Nickel-hydrogen ($Ni-H_2$) battery.
Science Instruments	• 10 kilowatt radar • American National Standards Institute safe lasers (see Section 4.1.2.1)
Other	• U. S. Department of Transportation (DoT) Class 1.4 Electro-Explosive Devices (EEDs) for mechanical systems deployment • Radioactive materials in quantities that produce an A2 mission multiple value of less than 10 • Propulsion system exhaust and inert gas venting • Sample returns are considered outside of the scope of this environmental assessment

[a] Propellant limits are subject to range safety requirements.

Key: kg=kilograms; lb=pounds.

Goddard Space Flight Center
FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

1. PROJECT/PROGRAM	Date:
Solar Probe Plus	October 25, 2013

2. SCHEDULE

PDR/CDR:	Launch Date:
PDR January 2014, CDR March 2015	July 2018

3. CURRENT STATUS

Mid- Phase B Formulation.

4. PROJECT DESCRIPTION

a. Purpose:
SPP is an extraordinary and historic mission, traveling closer to the Sun (9.86 Rs) than any other spacecraft, that will repeatedly obtain direct in-situ coronal magnetic field and plasma observations in the region of the Sun that accelerates the solar wind and creates space weather.

b. Spacecraft:
Custom spacecraft produced and integrated by JHU/APL. Small spacecraft bus shaded by a carbon foam thermal protection system. The spacecraft implementer will also supply a modified ATK Star 48 solid fuel upper stage for increased launch energy.

c. Instruments:
Fields - Measures electric and magnetic fields - University of California, Berkeley
ISIS - Monitor high energy electrons, protons, and ions - Southwest Research Institute.
SWEAP - Count and measure properties of the primary particles of the solar wind - Smithsonian Astrophysical Observatory
WISPR - Image the solar corona - Naval Research Laboratory.

d. Launch Vehicle:
Not selected yet. Designing to an Atlas 551 with previously mentioned, payload supplied ATK Star 48 solid fuel upper stage.

e. Launch Site:
Eastern Test Range.

f. NASAs Involvement/Responsibility:
Program office and technical authority oversight at GSFC. GSFC manufactures magnetometers for Fields. MSFC builds some electronics for SWEAP. JPL provides some components for WISPR. GSFC, GRC, MSFC, and JSC provide some test facilities for SPP.

g. Participants/Locations:
JHU/APL - Laurel, MD - Project Office, manufacturer, and integrator for SPP.

h. End-of-Mission Plan: Planned Re-entry (controlled/uncontrolled?)
SPP will be in a near-sun solar orbit. No planned re-entry necessary.

5. Is there anything controversial or unique about the mission, spacecraft or instruments? If yes, Explain. Yes ☐ No ☑

6. Is the mission compliant with NASA requirements for limiting orbital debris (NPR 8715.6, and NASA Standard 8719.14? Explain non-compliances. Yes ☑ No ☐

7. During any phase, does the mission/project include or involve: Check yes for all that apply. If uncertain, check the corresponding box. *For all that apply, provide an explanation. Use the additional space below if needed.*	Yes	No	Uncertain
A. Fuels	☑	☐	☐
B. Ionizing Radiation Devices/Sources	☐	☑	☐
C. Explosives	☐	☑	☐
D. Hazardous Materials/Substances/Chemicals	☐	☑	☐
E. Lasers (Class, Earth Pointing)	☐	☑	☐
F. Disease Producing Pathogenic Microorganisms/Biological Agents	☐	☑	☐
G. Discharges/Venting of any Substances into Air, Water, or Soil	☐	☑	☐
H. Hazardous Waste Generation	☐	☑	☐
I. High Noise Levels	☐	☑	☐
J. Sample Return to Earth	☐	☑	☐
K. Radio Frequency Communications	☑	☐	☐
L. Construction/Modification/Demolition of a Facility/Lab (onsite - offsite)	☐	☑	☐
M. Land Disturbance, Tree Clearing, Removal of Vegetation	☐	☑	☐
N. Impact on Threatened or Endangered Species	☐	☑	☐
O. Impact/Destruction of Sensitive Wildlife Habitat	☐	☑	☐
P. Impact on/near Areas of Cultural Significance	☐	☑	☐
Q. Impact on Local Social or Economic Conditions (Increase in Traffic, Employment, etc.)	☐	☑	☐
R. Impact on Minority or Low Income Populations	☐	☑	☐
S. New or Foreign Launch Vehicle	☐	☑	☐
T. Other Issues of Potential Environmental Impact	☐	☑	☐
U. Environmental Permits	☐	☑	☐

Additional Information
A. Spacecraft liquid propellant 60 kG hydrazine, upper stage (treated as part of payload) 6737 lb solid propellant.
K. X-Band transmitter 33W, Ka Band transmitter 80W.

8. What Safety hazards are associated with the mission?

Safety hazards are still in the definition stage. Obvious ones are hydrazine propellant, solid propellant, and RF transmitters. No safety hazards are expected to be out-of-family with other spacecraft.

9. Summary of Subsystem Components

Propulsion (Include fuel type, amount, tank size, materials, dimensions	Spacecraft - Approx 60 kG monopropellant hydrazine in a 22.14" ID spherical COTS titanium tank (ATK-PSI P/N 80259) with AF-E-332 diaphragm. Upper stage - 6737 lb Class 1.3 solid propellant in a composite case.
Communications	Ka band 35W transmitter for science data (downlinked while orbiting between the Sun and Venus). X band 13W transmitter for operations.
Structural Materials	Bus primary structure is aluminum honeycomb. Additional materials are titanium, composites, and carbon foam. Upper stage will be composite.
Power	25 amp-hour Li-Ion battery. Two solar arrays with water-cooled backplane providing approx 400W power.
Science Instruments	See above.
Hazardous Components (radioactive materials, lasers, chemicals, etc.)	Previously mentioned hydrazine and solid propellants. No radioactive materials or lasers.
Other (include dimensions and weight of s/c)	Spacecraft: mass < 665 kG. ~2.9 m overall length, ~2.2 m diameter across thermal protection shield. Upper stage: mass ~ 7522lb, approx 6737 of which is propellant. ~3.2 m long by 1.25 m diameter.

Goddard Space Flight Center

FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

Project Manager Printed Name:	Project Manager Signature:		
Mark Goans/Deputy Program Manager for APL Projects			
Project Name:	**Date:**	**Phone Number:**	**Org. Code:**
Solar Probe Plus	October 25, 2013	6-9763	460

Comments:

Solar Probe Plus will spend a fraction of an orbit in an Earth parking orbit, then will be propelled on an escape trajectory toward solar orbit. After that, it will approach the Earth no closer than the orbit of Venus (10's of millions of miles).