National Aeronautics and
Space Administration
Goddard Space Flight Center
Greenbelt, MD 20771

December 14, 2009

Reply to Attn of: 461

MEMORANDUM FOR THE RECORD

The National Environmental Policy Act (NEPA) Compliance for Magnetospheric Multiscale Mission (MMS)

1.0 Introduction

The NEPA of 1969, as amended (42 U.S.C. 4321, *et seq.*), requires Federal agencies to consider the environmental impacts of a project in their decision making process. To comply with NEPA and associated regulations (the Council on Environmental Quality (CEQ) 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 (ELVs) from Cape Canaveral Air Force Station (CCAFS) and Vandenberg Air Force Base (VAFB) (Ref: *Final Environmental Assessment for Launch of NASA Routine Payloads on Expendable Launch Vehicles from Cape Canaveral Air Force Station, Florida, and Vandenberg Air Force Base, California*, June 2002). The EA assesses the environmental impacts of missions launched from CCAFS and VAFB with spacecraft that are considered routine payloads.

Spacecraft defined as routine payloads utilize materials, quantities of materials, launch vehicles and operational characteristics that are consistent with normal and routine spacecraft preparation and flight activities at VAFB, CCAFS, and the Kennedy Space Center. The environmental impacts of launching routine payloads from VAFB and CCAFS fall within the range of routine, ongoing and previously documented impacts that have been determined not to be significant. Spacecraft covered by this EA meet specific criteria ensuring that the spacecraft, its 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 launched from VAFB and CCAFS and coverage under the NASA Routine Payload EA (NRP EA), the mission is evaluated against the criteria defined in the EA using the Routine Payload Checklist (RPC).

2.0 Mission Description

MMS is a NASA Science Mission Directorate Heliophysics mission in the Solar Terrestrial Probes Program. The mission is being designed to investigate one of the most fundamental and explosive physical processes in the universe - magnetic reconnection.[1]

MMS consists of four identical satellites that will fly in a tetrahedron formation through Earth's magnetosphere to discover how magnetic reconnection works. When magnetic fields become tangled, as they often do in the magnetosphere, they can merge together creating an explosive release of energy, whereby magnetic energy is converted directly into heat and charged-particle kinetic energy. Magnetic reconnection sparks solar flares, powers auroras, and even pops up in nuclear fusion chambers (tokamaks) on Earth. It is the ultimate driver of space weather impacting human technologies such as communications, navigation, and power grids.[1]

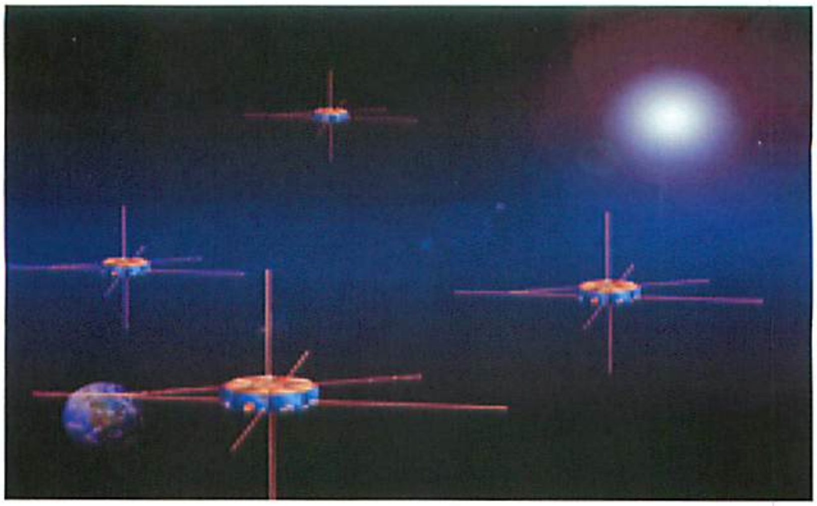
In addition to seeking to solve the mystery of the small-scale physics of the reconnection process, MMS will also investigate how the energy conversion that occurs in magnetic reconnection accelerates particles to high energies and what role plasma turbulence plays in reconnection events. These processes -- magnetic reconnection, particle acceleration, turbulence -- occur in all astrophysical plasma systems but can be studied in situ only in our solar system and most efficiently only in Earth's magnetosphere, where they control the dynamics of the geospace environment and play an important role in the phenomena known as "space weather." [2]

MMS is being managed by NASA's Goddard Space Flight Center, Greenbelt, Maryland. Goddard will build all four spacecraft and integrate four sets of instruments into the four MMS observatories.[1]

Goddard will conduct environmental testing, and support launch vehicle integration and operations. Goddard is also developing the Mission Operations Center that will monitor and control the satellites and provide all the flight dynamics support for the extensive maneuvering and orbit raising required for the mission. Scientists and engineers at Goddard are building the Fast Plasma Investigation (FPI), which is part of the instrument suite.[1]

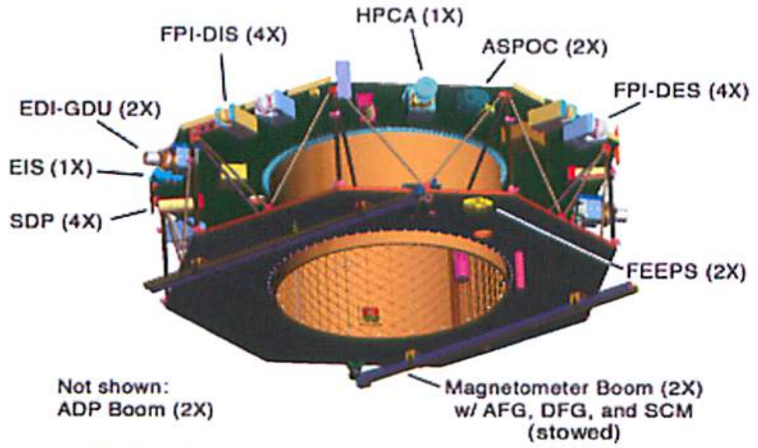
The MMS instruments are being provided as a suite from Southwest Research Institute (SwRI), San Antonio, Texas. Under contract to Goddard, SwRI is responsible for the mission science, development of the instruments for the four observatories, science operations, data analysis, theory and modeling, and education and public outreach. Kennedy Space Center is providing launch services. Launch of all four observatories in an Atlas V launch vehicle is scheduled for August 2014.[1]

Science team members and instrument development are being provided by the University of New Hampshire; Johns Hopkins University Applied Physics Laboratory; NASA Goddard; University of Colorado; Lockheed Martin Advanced Technology Center; Rice University; the University of Iowa; Aerospace Corporation; and the University of California-Los Angeles. International contributions to the MMS instrument suite are provided by the Austrian Academy of Sciences; Sweden's Royal Institute of Technology and Institute of Space Physics; France's Plasma Physics Laboratory and Toulouse Space Center; and Japan's Institute of Space and Astronautical Science.[1]



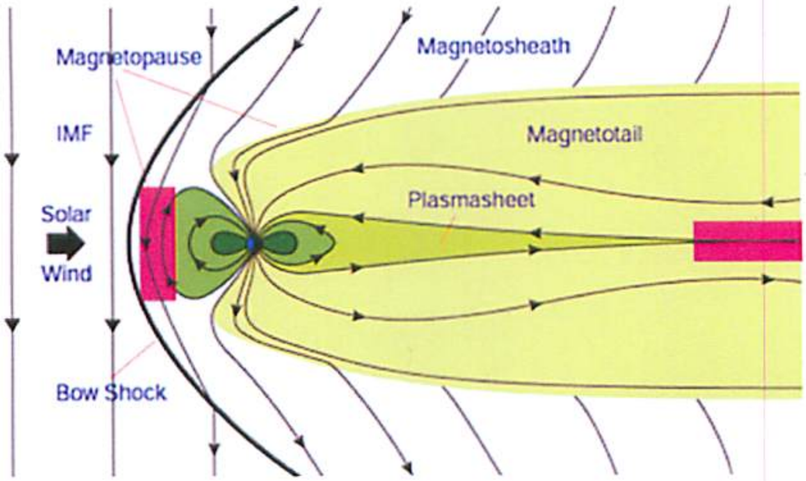
The Magnetospheric Multiscale mission will use four identical spacecraft, variably spaced in Earth orbit, to make three-dimensional measurements of magnetospheric boundary regions and examine the process of magnetic reconnection. **Credit:** Southwest Research Institute [1]

The four MMS spacecraft will carry identical suites of plasma analyzers, energetic particle detectors, magnetometers, and electric field instruments as well as a device to prevent spacecraft charging from interfering with the highly sensitive measurements required in and around the diffusion regions. The plasma and fields instruments will measure the ion and electron distributions and the electric and magnetic fields with unprecedentedly high (millisecond) time resolution and accuracy. These measurements will enable MMS to locate and identify the small (1-10 km) and rapidly moving (10-100 km/s) diffusion regions, to determine their size and structure, and to discover the mechanism(s) by which the frozen-in condition is broken, the ions and electrons become demagnetized, and the magnetic field is re-configured. MMS will make the first unambiguous measurements of plasma composition at reconnection sites, while energetic particle detectors will remotely sense the regions where reconnection occurs and determine how reconnection processes produce such large numbers of energetic particles.[2]



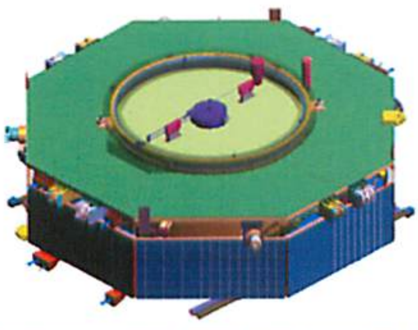
FPI = Fast Plasma Instrument; DIS = Dual Ion Sensors; DES = Dual Electron Sensors; HPCA = Hot Plasma Composition Analyzer; ASPOC = Active Spacecraft Potential Control Device; FEEPS = Fly's Eye Energetic Particle Sensor; EIS = Energetic Ion Spectrometer; EDI = Electron Drift Instrument; GDU = Gun Detector Unit; SDP = Spin-plane Double Probe; ADP = Axial Double Probe; AFG = Analog Fluxgate Magnetometer; DFG = Digital Fluxgate Magnetometer; SCM = Search Coil Magnetometer [2]

Magnetic reconnection occurs in two main regions of Earth's magnetosphere: (1) the dayside magnetopause and (2) the nightside magnetotail. MMS will employ a two-phase orbit strategy to explore each of these regions in turn.[2]



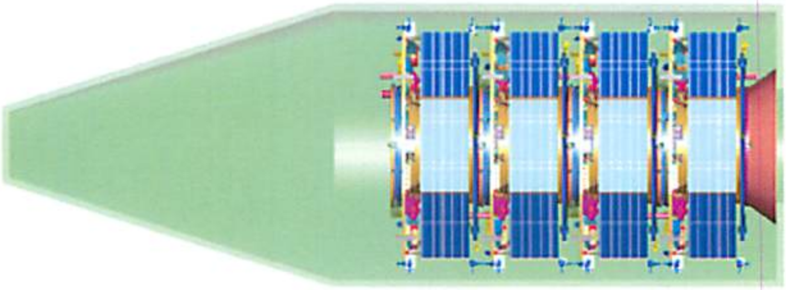
In Phase 1, MMS will probe reconnection sites at the mid-latitude dayside magnetopause. Here the interplanetary magnetic field (IMF) merges with the geomagnetic field, transferring mass, momentum, and energy to the magnetosphere. The solar wind flow transports the merged IMF/geomagnetic field lines toward the nightside, causing a build up of magnetic flux in the magnetotail. In Phase 2, the MMS constellation will investigate reconnection sites in the nightside magnetotail, where reconnection releases the magnetic energy stored in the tail in explosive events known as magnetospheric substorms and allows the magnetic flux stripped away from the dayside magnetopause by the solar wind/magnetosphere interaction to return to the dayside.[2]

Each spacecraft consists of an eight-sided bus, roughly 11 feet across and 4 feet high, built around a central cylindrical thrust tube. The majority of the instruments and associated electronics are mounted on the underside of the octagonal top deck. The two magnetometer booms and one of the two fly's eye energetic particle spectrometers (FEEPS) are mounted on the underside of the bottom deck; the second FEEPS is mounted on top of the top deck. The two 12.5-meter Axial Double Probe booms are stored in the thrust tube and will be deployed in the +Z and -Z directions once on orbit.[2]



The MMS spacecraft viewed from above (left) and below (right). The double-probe and magnetometer booms are stowed.[2]

Primary power is provided by eight body-mounted solar array panels, with a secondary battery for energy storage. The propulsion system consists of four hydrazine propellant tanks located within the thrust tube and four axial and eight radial thrusters. The MMS spacecraft are spin-stabilized, with a nominal spin rate of 3 rpm. Attitude knowledge is provided by 2 star cameras, 2 three-axis accelerometers, and 2 sun sensors, with the thrusters being used for attitude and orbit adjustment maneuvers. A Global Positioning System (GPS) receiver on board each spacecraft provides absolute position information.[2]



The four MMS spacecraft will be launched in a stacked configuration on a single launch vehicle and inserted sequentially into orbit. [2]

NASA Routine Payload Determination

The components utilized in the MMS spacecraft are made of materials normally encountered in the space industry. MMS will not use any radioactive materials or lasers. MMS will not carry any pathogenic organisms, nor will MMS return samples to Earth.

The MMS mission has been evaluated against the NASA Routine Payload EA for launches from CCAFS and VAFB, using the RPC (see enclosed Evaluation Recommendation Package). The evaluation indicates that the mission meets the criteria for a routine payload with the exception of the propellant fuel load. The MMS mission will utilize 1,492 kg (3,282 lbs) of hydrazine (four spacecraft with 373 kg (821 lbs) of hydrazine each). The threshold limit of hydrazine for a payload in the current NRP EA is 1,000 kg (2,200 lbs). However, propellant loads for certain NRP EA approved launch vehicles, such as the Delta II which carries 2064 kg (4550 lb) of Aerozine-50 hydrazine, well exceed the 1492 kg propellant load planned for MMS. To evaluate impacts in the NRP EA, the Delta II was used as the bounding case for the largest hypergolic load from CCAFS. The NRP EA and other NEPA documentation concluded that these quantities of hydrazine do not create a substantial impact. The launch vehicle for the MMS mission is the Atlas V which utilizes no hydrazine. The MMS launch vehicle/spacecraft combination is less than the amount of hydrazine on the Delta II and is within the bounds that were considered for assessing the environmental impacts in the NRP EA. No new or additional impacts are anticipated beyond what was considered in the NRP EA.

Based on this review, it is determined that the MMS mission qualifies as a routine payload and falls within the scope of the reference Routine Payload EA.

At this point no additional NEPA action or documentation is required. However, NASA is in the process of updating the NASA Routine Payload EA. Once the Agency issues the final updated EA, NASA will review the potential environmental impacts of the proposed MMS mission in the context of the new analysis and information contained in the updated EA. If NASA determines that there are substantial new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts, NASA will formally reopen the NEPA process for this mission.

12/2/09

George W. Morrow — Date
Director of Flight Projects

12/14/09

Robert Strain — Date
Director

Enclosure

References

[1] http://www.nasa.gov/centers/goddard/news/topstory/2009/mms_magnetic.html
[2] http://mms.space.swri.edu/index.html

EVALUATION RECOMMENDATION PACKAGE

Record of Environmental Consideration
Routine Payload Checklist
NEPA Environmental Checklist

Enclosure

RECORD OF ENVIRONMENTAL CONSIDERATION

1. Project Name: Magnetospheric Multiscale Mission (MMS)

2. Description/location of proposed action: Mission to study magnetic reconnection in the Earth's Magnetopause.

   Date and/or Duration of project: August 2014

3. It has been determined that the above action:

X a. Is adequately covered in an existing EA or EIS.
Title: *Final Environmental Assessment for Launch of NASA Routine Payloads on ELVs from CCAFS, Florida and VAFB, California*
Date: June 2002

___ b. Qualifies for Categorical Exclusion and has no special circumstances which would suggest a need for and 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 (signature) 11/18/2009
Beth Montgomery NEPA Program Manager, Code 250 Date

Karen Halterman (signature) 11/19/09
Karen Halterman Project Manager, Code 461 Date

GSFC Routine Payload Checklist

PROJECT NAME: MMS		DATE OF LAUNCH: August 2014
PROJECT CONTACT: Karen Halterman	PHONE NUMBER: x6-1511	MAILSTOP: 461
PROJECT START DATE: May 2002 (Phase A Start)	PROJECT LOCATION: B12 N021 Suite	
PROJECT DESCRIPTION: Constellation of 4 spacecraft to study magnetic reconnection in the Earths Magnetopause		

A. SAMPLE RETURN:	YES	NO
1. Would the candidate mission return a sample from an extraterrestrial body?	☐	☑

B. RADIOACTIVE SOURCES:	YES	NO
1. Would the candidate spacecraft carry radioactive materials?	☐	☑
2. If yes, would the amount of radioactive sources require launch approval at the NASA Associate Administrator level or higher according to NPG 8715.3 (NASA Safety Manual)?	☐	☐
Provide a copy of the Radioactive Materials Report as per NPG 8715.3 Section 5.5.2.		

C. LAUNCH AND LAUNCH VEHICLES:	YES	NO
1. Would the candidate spacecraft be launched using a launch vehicle/launch complex combination other than those indicated in Table 1 below?	☐	☑
2. Would the proposed mission cause the annual launch rate for a particular launch vehicle to exceed the launch rate approved or permitted for the affected launch site?	☐	☑
Comments:		

D. FACILITIES:	YES	NO
1. Would the candidate mission require the construction of any new facilities or substantial modification of existing facilities?	☐	☑
2. If yes, has the facility to be modified been listed as eligible or listed as historically significant?	☐	☐
Provide a brief description of the construction or modification required:		

E. HEALTH AND SAFETY:	YES	NO
1. Would the candidate spacecraft utilize any hazardous propellants, batteries, ordnance, radio frequency transmitter power, or other subsystem components in quantities or levels exceeding the Envelope Payload Characteristics (EPC's) in Table 2 below?	☑	☐
2. 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 (EP)?	☐	☑
3. Would the candidate mission release material other than propulsion system exhaust or inert gases into the Earth's atmosphere or space?	☐	☑
4. Would launch of the candidate spacecraft suggest the potential for any substantial impact on public health and safety?	☐	☑
5. Would the candidate spacecraft utilize a laser system that does not meet the requirements for safe operation (ANSI Z136.1-2000 and ANSI Z136.6-2000)? For Class III-B and IV laser operations, provide a copy of the hazard evaluation and written safety precautions (NPG	☐	☑

	YES	NO
8715.3).		
6. Would the candidate spacecraft contain pathogenic microorganisms (including bacteria, protozoa, and viruses) which can produce disease or toxins hazardous to human health?	☐	☑
Comments:		
F. OTHER ENVIRONMENTAL ISSUES:	**YES**	**NO**
1. Would the candidate spacecraft have the potential for substantial effects on the environment outside the United States?	☐	✓
2. Would launch and operation of the candidate spacecraft have the potential to create substantial public controversy related to environmental issues?	☐	☑
Comments: ~370kg of hydrazine per spacecraft; ~1480kg of hydrazine total		

Table 1: Launch Vehicles and Launch Pads

Launch Vehicle	Eastern Range (CCAFS Launch Complexes)	Western Range (VAFB Space Launch Complexes)
Atlas IIA & AS	LC-36	SLC-3
Atlas IIIA & B	LC-36	SLC-3
Atlas V Family	LC-41	SLC-3
Delta II Family	LC-17	SLC-2
Delta III	LC-17	N/A
Delta IV Family	LC-37	SLC-6
Athena I & II	LC-46 or -20	California Spaceport
Taurus	LC-46 Or -20	SLC-576E
Titan II	N/A	SLC-4W
Pegasus XL	CCAFS skidstrip KSC SLF	VAFB airfield

Table 2: Summary of Envelope Spacecraft Subsystems and Envelope Payload Characteristics (EPC)

Structure	**Unlimited:** aluminum, magnesium, carbon resin composites, and titanium **Limited:** beryllium [50 kg (110 lb)]
Propulsion	Mono- and bipropellant fuel; 1000 kg (2200 lb) (hydrazine); 1000 kg (2200 lb) (monomethyhydrazine) Bipropellant oxidizer; 1200 kg (2640 lb) (nitrogen tetroxide) Ion-electric fuel; 500 kg (1100 lb) (Xenon) SRM; 600 kg (1320 lb) (AP)-based solid propellant
Communications	Various 10-100 W (RF) transmitters
Power	Solar cells; 150 A-Hr (Ni-H_2) battery; 300 A-Hr (LiSOC) battery; 150 A-Hr (NiCd) battery
Science instruments	10 kW radar ANSI safe lasers (Section 4.1.2.1.3)
Other	Class C EEDs for mechanical systems deployment Radioisotopes limited to quantities that are approved for launch by NASA Nuclear Flight Safety Assurance Manager Propulsion system exhaust and inert gas venting

GODDARD SPACE FLIGHT CENTER
ENVIRONMENTAL CHECKLIST
FOR FLIGHT PROJECTS

1. PROJECT/PROGRAM Magnetospheric Multiscale Mission, MMS

2. POINTS OF CONTACT

Name: Karen Halterman	Code: 461	Phone No.: 6-1511

3. SCHEDULE

PDR/CDR: PDR/NAR May 2008 CR June 2009	Launch Date: August 2014

4. CURRENT STATUS

~~Completing Phase B~~ Approved for implementation KH.

5. PROJECT DESCRIPTION

a. Purpose: Space physics science mission to study the phenomena of Magnetic reconnection in the Earth's Magnetopause

b. Spacecraft: 4 Spacecraft developed in-house at Goddard

c. Instruments: Procured via Contract with South West Research Institute. Each instrument suite is composed of 28 assorted component

d. Launch Vehicle: Atlas 421

e. Launch Site: Cape Canaveral

f. NASA's Involvement/Responsibility: NASA has total mission responsibility. GSFC is performing Project Management, Mission Systems Engineering, SR &OA, In-House Spacecraft Development, Mission Operations

g. Participants/Locations: South West Research Institute, San Antonio, TX

h. End of Mission, Re-entry: Natural orbital decay within 25 years

6. Is there anything controversial about the mission?

No

7. Is there anything unique, unusual, or exotic about the mission, spacecraft, and instruments?

No

8. Is there any environmental documentation for spacecraft, launch vehicle (NEPA or EO12114)?

No

9. Is the mission (s/c and LV) compliant with NASA policy and guidelines for orbital debris (NPD 8710.3 and NSS 1740.14)? Explain non –compliances.

S/C - Yes

LV - No; waiver against casualty probability will be required - SMD & OSF aware of this

10. Has an Air Force Form 813 been completed? ☐ YES
(Please attach copy) ☑ NO

	11. During any phase, does the mission/project include or involve: Check all that apply. If uncertain, indicate with a "?" For all that apply, provide an explanation. Use the additional space below if needed.
✓	A. Fuels MMS uses hydrazine MMH/NTO, fueling only at Launch site
	B. Ionizing Radiation Devices/Sources
✓	C. Explosives NASA Standard Initiators for Separation System
	D. Hazardous Materials/Substances/Chemicals
	E. Lasers (Class, Earth Pointing)
	F. Disease Producing Pathogenic Microorganisms
	G. Discharges of any Substances into Air, Water, or Soil
	H. Hazardous Wastes
	I. High Noise Levels
	J. Sample Return to Earth
	K. Radio Frequency Communications
	L. Construction/Modification/Demolition of a Facility
	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 (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. Require any Environmental Permit
	Additional Information

12. What Safety hazards are associated with the mission?

Inadvertant activation of the RF transmitter, Li-ion cell rupture, damage due to EMC/EMI, software hazards, ground support equipment (MGSE) failure, improper use of EGSE

13. Summary of Subsystem Components

Structural Materials	Aluminum Structure
Propulsion	4 Titanium propellant tanks (per spacecraft) 12 Thrusters (per spacecraft) ~370kg of hydrazine per spacecraft; ~1480kg of hydrazine total
Communications	Two 8 watts, (RF output) S-Band transponders (per spacecraft); GPS Receivers
Power	60 Ah Lithium-Ion, 20 kg battery; Eight triple junction Ga As solar array panels (per spacecraft)
Science Instruments	E and b field sensors, Fast Plasma ion and electron sensors, Hot plasma Composition sensors, Energetic Particle sensors
Hazardous Components (radioactive materials, tasers, chemicals, etc.)	None
Other (*include dimensions and weight of s/c*)	Stack Total mass (5100kg); 3.4 m dia; 4.9 m tall

Project Manager Name	Karen Halterman	Date
Project Manager Signature	Karen Halterman	11/19/09

GSFC 23-74 (07/08) PREVIOUS EDITIONS OBSOLETE