National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

January 12, 2012

Reply to Attn of: 463

MEMORANDUM FOR THE RECORD

Subject: The National Environmental Policy Act (NEPA) Compliance for Gravity and Extreme Magnetism (GEMS)

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 (Ref: *Environmental Assessment (Final) for Launch of NASA Routine Payloads*, November 2011). The 2011 NASA Routine Payload EA (2011 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) in the Republic of the Marshall Islands, NASA's 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 VAFB, CCAFS, USAKA/RTS, WFF, KLC, and the 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, 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, the mission is evaluated against the criteria defined in the EA using the Routine Payload Checklist (RPC).

2.0 Mission Description

The GEMS mission will use an X-ray telescope to explore the shape of space that has been distorted by a spinning black hole's gravity and probe the structure and effects of the

magnetic field around magnetars, dead stars with magnetic fields trillions of times stronger than Earth's. GEMS will use a new technique to accomplish what has been impossible until now. It will build up a picture indirectly by measuring the polarization of X-rays. [1]

GEMS will reveal:

- How spinning black holes affect space-time and matter as it is drawn in and compressed by strong gravitational fields.
- What happens in the super strong magnetic fields near pulsars and magnetars.
- How cosmic rays are accelerated by shocks in supernova remnants.

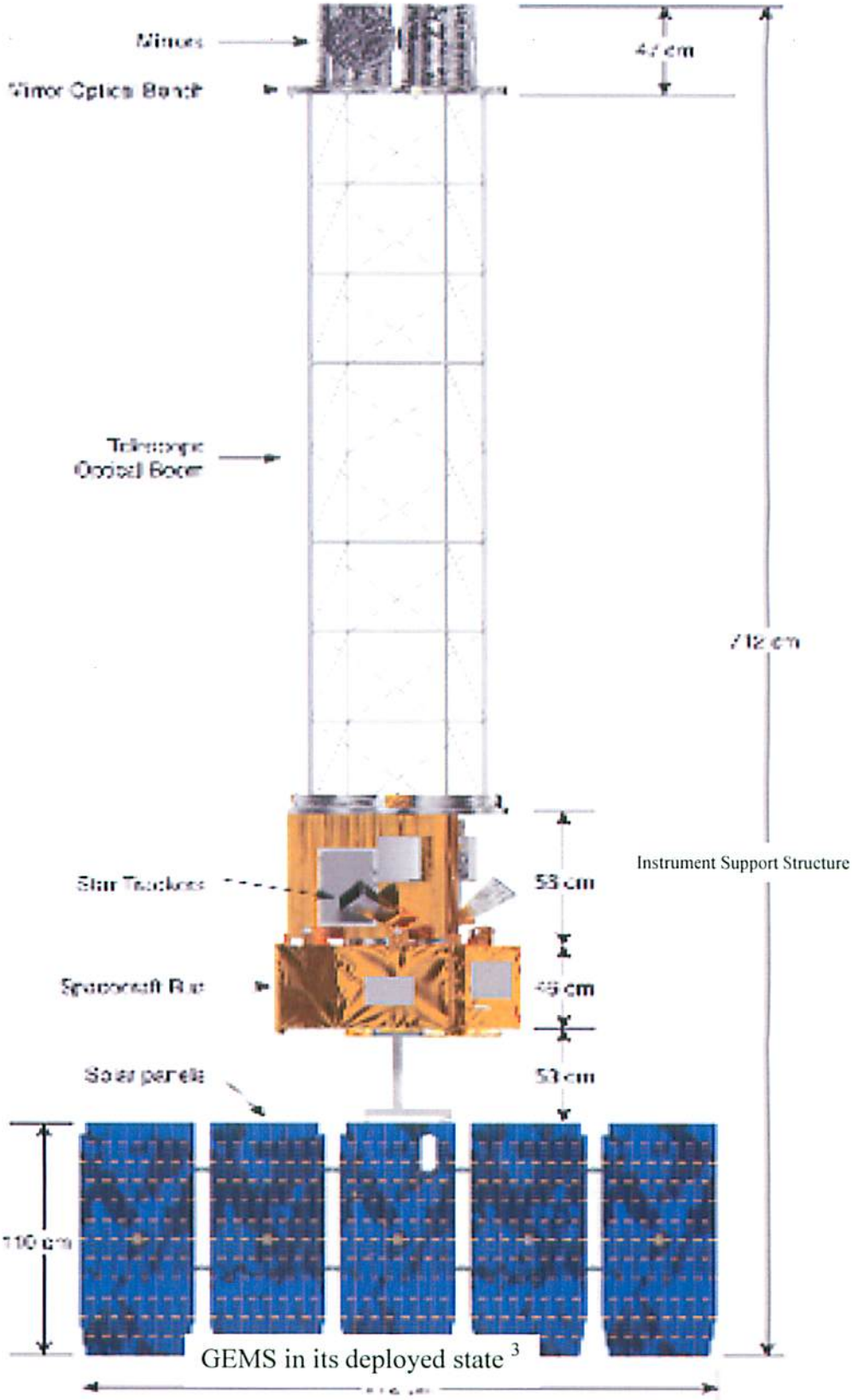
GEMS will be able to tell the shape of the X-ray-emitting matter near black holes better than existing missions can, in particular, whether matter around a black hole is confined to a flat disk or puffed into a sphere or squirting out in a jet. The paths of X-rays, and their polarization, are bent by the strong gravity near a spinning black hole. GEMS will therefore, also provide a method of determining black hole spin independent of other techniques. [1]

GEMS will take measurements of the 23 prime targets, including stellar black holes, seyfert galaxies and quasars, blazars, a variety of neutron star pulsars, shell supernova remnants and pulsar wind nebulae. GEMS polarimetry information will provide a key piece that has been missing from the puzzle, and narrow the search for the true model. GEMS' results will enrich the value of much larger current and future missions. [2]

NASA Goddard is responsible for the GEMS instrument and the overall program management. Orbital Sciences Corporation, Dulles, Virginia is responsible for building the spacecraft and mission operations. ATK Space, Goleta, California, is building a boom to place the X-ray telescopes the proper distance from the detectors. The University of Iowa is providing instrument calibration assistance and will have students prepare an experiment that will be part of the mission. GEMS includes collaborators from universities including Massachusetts Institute of Technology, Johns Hopkins University, Cornell University, Rice University, the University of Oulu (Finland), North Carolina State University and Washington University. [1]

The GEMS main science payload, the X-ray Polarimeter Instrument, consists of two co-aligned telescopes. Each telescope has a high throughput, high heritage, grazing incidence mirror that focuses x-rays onto a high efficiency polarimeter that measures the polarization-dependant direction of the initial photoelectron using a time projection technique. The two mirrors are mounted on a common Mirror Optical Bench (MOB), and the two polarimeter detectors are mounted on an Instrument Support Structure (ISS). The Telescope Optical Boom (TOB) connects the MOB and ISS. The TOB, which is stowed for launch, undergoes a one-time on-orbit deployment that places the mirrors 4.5 m in front of the detector mid-points. The Bragg Reflection Polarimeter (BRP) is the University of Iowa student experiment. [3]

GEMS will be launched on a Pegasus-class or similar launch vehicle no earlier than November 2014. The launch vehicle will insert the observatory into a 565 km, 28.5 degree inclination, circular, LEO orbit.



GEMS in its deployed state [3]

3.0 Routine Payload Determination

The components utilized in the GEMS spacecraft are made of materials normally encountered in the space industry. The GEMS mission will utilize a small radioactive source for calibration of the BRP. GEMS will not carry any pathogenic organisms nor will it return samples to Earth. There is a planned uncontrolled reentry for the GEMS spacecraft, which meets the NASA requirements for uncontrolled reentry.

The GEMS mission has been evaluated against the 2011 NRPEA, using the RPC (see enclosed Evaluation Recommendation Package). The site specific impacts of the GEMS launch vehicle/launch site combination are addressed in EA. The GEMS mission qualifies as a routine payload and falls within the scope of the reference EA. Based on the analyses set forth in the 2011 NRPEA and the launch vehicle NEPA documents referenced in the EA, NASA has determined that the environmental impacts associated with the GEMS mission will not individually or cumulatively have a significant impact on the quality of the human environment. No new or additional impacts are anticipated beyond what was considered in the 2011 NRPEA.

1/12/12

George W. Morrow Date
Director of Flight Projects

1/24/12

Robert Strain Date
Director

Enclosure

References
[1] http://heasarc.nasa.gov/docs/gems/
[2] http://gems.gsfc.nasa.gov/launch.html
[3] http://gems.gsfc.nasa.gov/sc_inst.html

EVALUATION RECOMMENDATION PACKAGE

Record of Environmental Consideration
Routine Payload Checklist
NEPA Environmental Checklist

Enclosure

RECORD OF ENVIRONMENTAL CONSIDERATION

1. Project Name: Gravity and Extreme Magnetism (GEMS)

2. Description/location of proposed action: GEMS will use an X-ray telescope to explore the shape of space that has been distorted by a spinning black hole's gravity, and probe the structure and effects of the formidable magnetic field around magnetars.

   Date and/or Duration of project: Launch - NET November 2014

3. It has been determined that the above action:

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

___ 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 — NEPA Program Manager, Code 250 — 1/5/2012 Date

Greg Frazier — Project Manager, Code 463 — 1/9/2012 Date

NASA Routine Payload Checklist (1 of 2)

PROJECT NAME: GEMS (GRAVITY AND EXTREME MAGNETISM SMEX) DATE OF LAUNCH: NET NOVEMBER 2014

PROJECT CONTACT:GREGORY V. FRAZIER PHONE NUMBER: 301-286-6619 MAILSTOP:463

PROJECT START DATE:JUNE 2008 PROJECT LOCATION:GSFC,GREENBELT,MD/ORBITAL,DULLES,VA

PROJECT DESCRIPTION:GEMS WILL USE X-RAY POLARIZATION FOR A NEW PERSPECTIVE ON BLACK HOLES AND MAGETARS

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:		

Continued on next page

[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 2)

PROJECT NAME: GEMS (GRAVITY AND EXTREME MAGNETISM SMEX) DATE OF LAUNCH: NET NOVEMBER 2014

PROJECT CONTACT: GREGORY V. FRAZIER PHONE NUMBER: 301-286-6619 MAILSTOP:463

PROJECT START DATE: JUNE 2008 PROJECT LOCATION: GSFC,GREENBELT,MD/ORBITAL,DULLES,VA

PROJECT DESCRIPTION: GEMS WILL USE X-RAY POLARIZATION FOR A NEW PERSPECTIVE ON BLACK HOLES AND MAGETARS

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:
GEMS (Gravity and Extreme Magnetism)/Explorer Program Office	October 14, 2011

2. SCHEDULE

PDR/CDR:	Launch Date:
November 2011/May 2012 (Under Review)	NET November 2014

3. CURRENT STATUS

Completing Phase B

4. PROJECT DESCRIPTION

a. Purpose:

GEMS will use X-Ray polarization for a new perspective of black holes and magnetars

b. Spacecraft:

Will be the LeoStar-2/750 provided by Orbital

c. Instruments:

1) X-ray Polarimeter Instrument (XPI) built in house at GSFC
2) Student experiment, the Bragg Reflection Polarimeter (BRP) built by University of Iowa

d. Launch Vehicle:

Pegasus XL or compatible

e. Launch Site:

KSC, Florida

f. NASAs Involvement/Responsibility:

Principal Investigator, Project Management, Mission System Engineering, Safety and Mission Assurance

g. Participants/Locations:

GSFC/Greenbelt MD and Orbital Dulles VA

h. End-of-Mission Plan: Planned Re-entry (controlled/uncontrolled?)

Mission duration is 10 months. Orbital debris analysis shows compliance. At EOM, GEMS will be passivated and let to re-enter uncontrolled. Re-entry will occur within 8 yrs of launch.

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

The Instrument has a deployable telescope boom.

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
7D.
X-ray Polarimeter Instrument (XPI) will fly with dimethyl ether (DME) gas sealed in the instrument.
Bragg Reflector Polarimeter (BRP) will fly with a sealed radioactive source of 3.7 MBq Fe55.
Beryllium (Be) is present in the X-ray Polarimeter Instrument (XPI). Weight of 0.31 grams.
Lithium Ion Battery (24A-hr): Note: All Lithium Ion batteries are classified by the federal government as non-hazardous waste and are safe for disposal in the normal municipal waste stream.
Other:
Testing with compatibility test van for GN and TDRSS

8. What Safety hazards are associated with the mission?

Deployment testing of Solar Array and Deployable Boom. Handling of the battery will be controlled.

9. Summary of Subsystem Components

Propulsion (Include fuel type, amount, tank size, materials, dimensions	N/A
Communications	OMNI antenna.
Structural Materials	Composite\Aluminum Honeycomb panels.
Power	Lithium-Ion battery, 24A-hr Deployable solar arrays.
Science Instruments	X-ray Polarimeter Instrument (XPI) Bragg Reflector Polarimeter (BRP)
Hazardous Components (radioactive materials, lasers, chemicals, etc.)	About 36 gms. total of DME (dimethyl ether) in the XPI. XPI windows contain a total of 0.31 grams of Beryllium. 3.7 MBq Fe55 of sealed radioactive source will fly with the Bragg Reflector Polarimeter (BRP).
Other (include dimensions and weight of s/c)	Spacecraft: 1.05 m x 5.134 m deployed. Solar Arrays: 2.72 m x 1.1 m deployed. Spacecraft mass: 261 kg

Goddard Space Flight Center

FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

Project Manager Printed Name:	Project Manager Signature:		
Gregory V. Frazier			
Project Name:	**Date:**	**Phone Number:**	**Org. Code:**
Gravity and Extreme Magnetism SMEX (GEMS)	October 14, 2011	301-286-6619	463

Comments:

9. Summary of Subsystem Components (continued)

The Fe55 calibration source allows for the energy calibration of the BRP, and thus helps the BRP team determine the appropriate detector voltage levels in order to achieve a gain appropriate for the detection of 515 eV events.

GEMS
10/2011

Select up to Ten Isotopic Symbols	Enter Source Activity (Ci)	A_2 Value (Ci)	A_2 Multiplier for Each Source
Fe-55	1.00E-04	1.00E+03	1.00E-07

INSTRUCTIONS FOR USE OF THIS CALCULATOR

In accordance with NPR 8715.3C, Chapter 6, this calculator is used to assist in the preparation of a report to the Nuclear Flight Safety Assurance Manager (NFSAM) at NASA Headquarters whenever it becomes known that radioactive sources will be launched on GSFC managed missions. The RSO will work with the Project Manager to obtain information regarding the sources and prepare the report. We then determine an A2 Mission Multiple for each launch. The result of this calculation will determine the internal NASA nuclear launch safety review process. Table 6.1 lists the required levels of review and reports. This calculator will display the relevant review requirements based on the mission multiple. The last 3 rows of this spreadsheet are cut and pasted into the radioactive materials report required in NPR 8715.3C, Para 6.4.2 (NOTE: The calculator uses Column E of the A1A2 workbook on Tab 1. If an isotope cannot be found in the dropdown list it must be added to Column E prior to use of the calculator.)

A_2 Mission Multiple (Sum of Column D)= **1.00E-07**

Nuclear Launch Safety Approval Summary (Table 6.1, NPG 8715.3B, Chapter 6)					
A_2 Mission Multiple	**Launch Reported to NFSAM**	**Launch Concurrence/ Approval by**	**Launch Reported to OSTP**	**Required Level of Review and Reports**	**Approval/ Concurrence**
Less than 0.001	Yes	NFSAM	No	Paragraph 6.3.3	Concurrence letter from NFSAM