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

October 11, 2017

Reply to Attn of:

483

RECORD OF ENVIRONMENTAL CONSIDERATION

Restore-L National Environmental Policy Act Compliance

1.0 Introduction

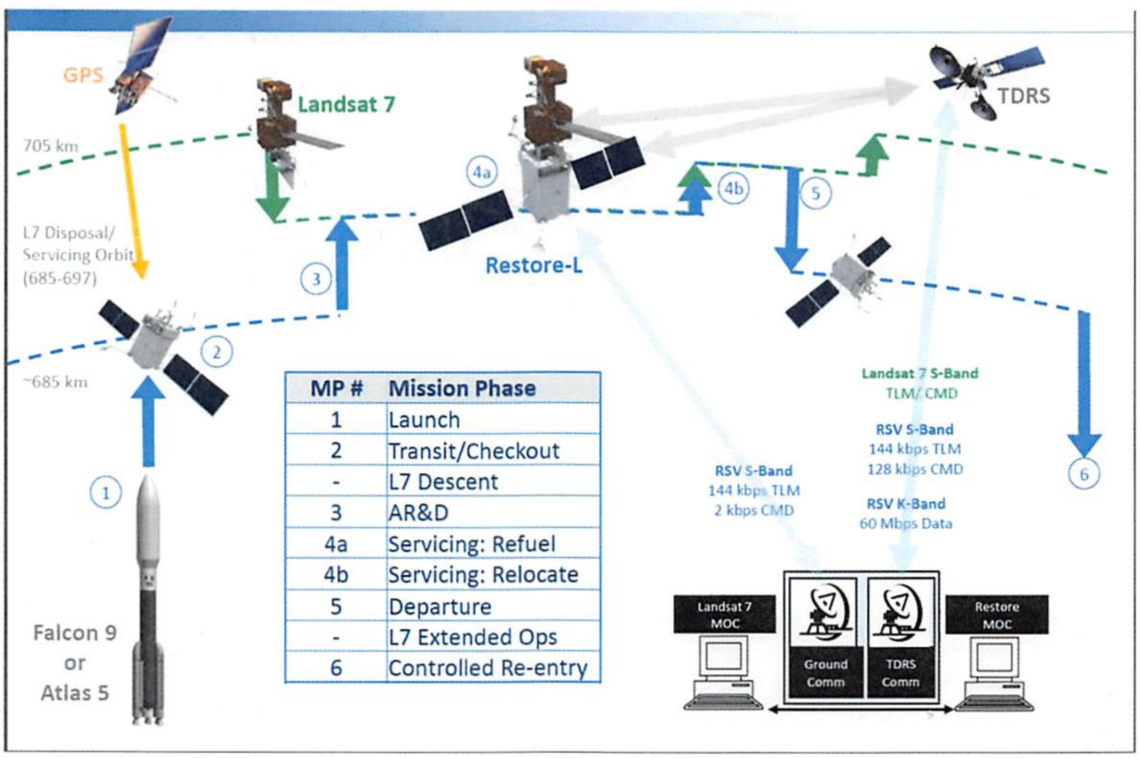
The National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321, et seq.), requires Federal agencies to consider the project's environmental impacts in its decision making process. To comply with NEPA and associated regulations (the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA [40 CFR Parts 1500-1508] and NASA policy and procedures [14 CFR, Part 1216, Subpart 1216.3]), NASA prepared the "Final Environmental Assessment for Launch of NASA Routine Payloads on Expendable Launch Vehicles," 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) 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 (KSC). 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 environmental assessment (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, it is evaluated against the criteria defined in the EA using the routine payload checklist (RPC).

2.0 Mission Description

The Restore-L mission is a technology demonstration mission that will provide robotic on-orbit servicing capability to an operational satellite located in low Earth orbit (LEO). The mission will provide refueling and a relocation demonstration service to the Landsat 7 satellite. Restore-L will launch to a nominal (LEO) altitude of 680 km and conduct its on-orbit checkout. Landsat 7 will descend to a servicing altitude of 685 km and enter a stable, solar-inertial attitude. Restore-L will then use both ground-generated and on-board navigation solutions to rendezvous with Landsat 7, and perform an autonomous capture. After client capture, the refueling tasks will be performed by ground operators. When all refueling tasks are complete, Restore-L will modify Landsat 7's orbit to demonstrate relocation capability then release the spacecraft and depart to its own transit orbit. At the end of the Restore-L mission, the spacecraft will be maneuvered into a controlled de-orbit trajectory.

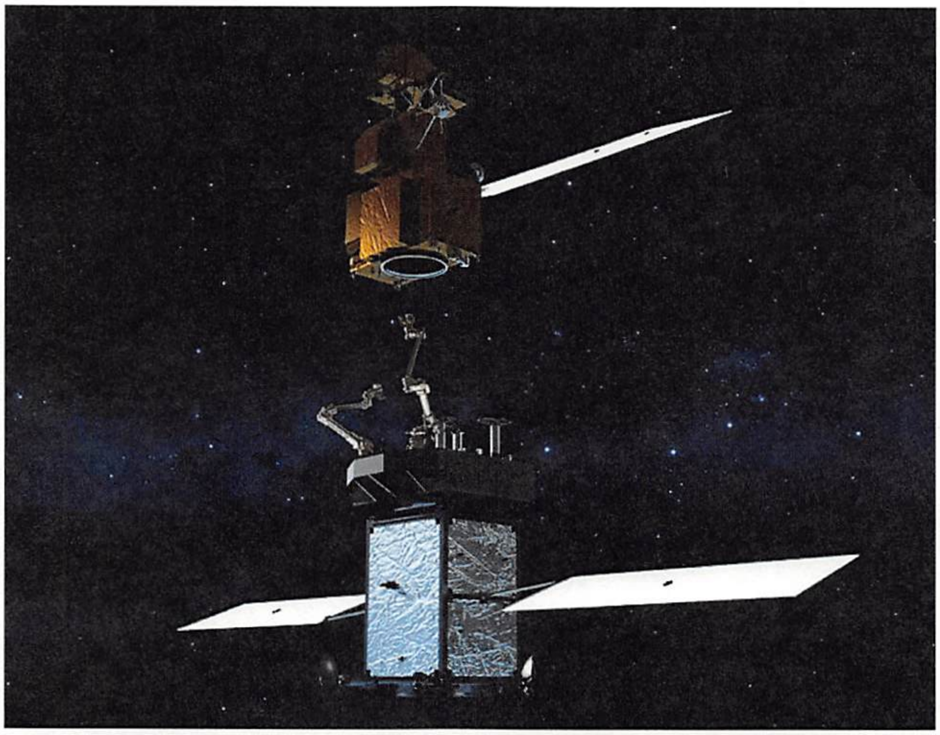


Restore-L Mission Functional Block Diagram

The Restore-L servicing vehicle consists of a spacecraft bus, and a servicing payload module. The servicing payload module includes all the additional subsystems (the robotics and tools, the autonomous rendezvous and cocking sensors and support avionics, and the propellant transfer subsystem) necessary to convert a spacecraft bus into a servicing platform. To optimize cost and support the launch readiness date, the Restore-L spacecraft bus will be a commercial spacecraft bus with the required mission unique equipment to support the servicing payload and launch vehicle interface. GSFC will provide overall project management, systems engineering, and mission integration services. KSC will provide the payload propellant and transfer system. NASA's Johnson Space Center will provide analysis and support for reviews.

Restore-L's capabilities can give satellite operators new ways to manage their fleets more efficiently, and derive more value from their initial investment. These capabilities could even help mitigate the looming problem of orbital debris. Successfully completing the Restore-L mission will demonstrate that servicing technologies are ready for incorporation into other NASA missions, including exploration and science ventures. NASA also plans to transfer Restore-L's technologies to commercial entities to help jumpstart a new domestic servicing industry.

Restore-L will launch aboard an expendable launch vehicle that will insert the spacecraft into LEO at an optimal location to service the client satellite. The launch is planned for late-2020 from VAFB. At this time, launch vehicle selection has not been made.



Restore-L servicing a satellite

3.0 NASA Routine Payload Determination

The components utilized in the Restore-L spacecraft are made of materials normally encountered in the space industry. The Restore-L mission will not utilize radioactive sources, will not carry any pathogenic organisms, and will not return samples to Earth. The mission will utilize two lasers, one 3D Lidar and one laser range finder. During certain operations (roughly 700 km) the lasers may point toward Earth, however, they present no eye hazard at this distance. A controlled reentry is planned consistent with NASA-STD-8719.14, Process for Limiting Orbital Debris and NPR 8715.6B, NASA Procedural Requirements for Limiting Orbital Debris.

The 2011 NRPEA, using the RPC (see enclosed evaluation recommendation package), was used to evaluate the Restore-L mission. A positive response was indicated on the routine payload checklist for Question E.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?" When the refueling tool disconnects from the client spacecraft there will be residual hydrazine (~16 cc) that escapes in space in LEO (680-700 kilometers). In addition, at end of mission any remaining hydrazine will be vented prior to a controlled reentry. Per the NRPEA, positive responses on the routine payload checklist require further analysis or clarification. As this release of hydrazine will occur in space and will not be affecting the earth or its atmosphere, it does not become an environmental issue under NEPA.

A positive response was also indicated for Question E.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?" The Restore-L lithium-ion battery will have a capacity of ~12.3 kW-hr, which is above the bounding level (5 kW-hr) established in the 2011 NRPEA. The bounding levels in the NRPEA were established based on quantities and types of materials commonly used in NASA spacecraft at the time. Lithium-ion batteries are widely used in consumer electronics, electric vehicles and space flight systems. Many commercial geosynchronous Earth orbit (GEO) satellites fly battery configurations with higher capacity than 12.3 kW-hr. The Restore-L battery capacity is on the low end of the range for these commercial GEO satellites, which require much higher capacities for radio frequency operations.

The battery capacity for Restore-L would not create impacts beyond those already analyzed and documented in existing NEPA analyses. Analysis in the NRPEA indicates that environmental impacts from batteries would be minimal, especially when compared to propellant impacts. The Restore-L battery would not change this conclusion.

The launch vehicle has yet to be selected; however, the candidate launch vehicle/launch site combinations fall within the scope of the EA. The site-specific impacts of these combinations are addressed in the NRPEA. The Restore-L 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, NASA has determined that the environmental impacts associated with the Restore-L mission will not individually or cumulatively have a significant impact on the quality of the human environment and that a routine payload classification for the mission is applicable. No additional NEPA action or documentation is required at this time. Once launch vehicle selection has occurred, the mission will be reviewed to ensure that a routine payload classification is still valid.

David F. Mitchell
9/22/17

David F. Mitchell
Director of Flight Projects

Date

C.J.S.

6 OCTOBER 2017

Christopher J. Scolese
Director

Date

Enclosure

cc:
480/B. Reed
483/R. Smith

EVALUATION RECOMMENDATION PACKAGE

Record of Environmental Consideration
Routine Payload Checklist
Flight Project Environmental Checklist

Enclosure

NASA Goddard Space Flight Center
RECORD OF ENVIRONMENTAL CONSIDERATION (REC)

PROJECT NAME: Restore-L

1. **Description of proposed action:** The Restore-L Mission is a technology demonstration mission that will provide robotic on-orbit servicing capability to an operational satellite located in Low Earth Orbit (LEO). The Restore-L Mission will provide refueling and a relocation demonstration service to the Landsat 7 satellite.

   Date and/or Duration of project: Launch - November 2020

2. **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 per 14 CFR 1216.304 (c) which would suggest a need for an Environmental Assessment.

Categorical Exclusion: ____________________

☐ c. Has no significant environmental impacts as indicated by the results of an environmental checklist and/or detailed environmental analysis.

☐ d. Is exempt from NEPA requirements under the provisions of: ____________________

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

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

☐ g. Is addressed under EO12114.

- ☐ Is exempt from EO12114 requirements under the provisions of: ____________________
- ☐ Action not included under EO12114: ____________________
- ☐ Qualifies for an EO12114 categorical exclusion: ____________________
- ☐ Is adequately covered in existing documentation: ____________________
- ☐ Requires an environmental summary document: ____________________
- ☐ Requires EO documentation IAW 2-4. (a) i, ii, iii: ____________________

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

Beth Montgomery [signature]

Beth Montgomery NEPA Manager, Code 250 — Date: 9/6/17

[signature]

Robert C. Smith Project Manager, Code 483 — Date: 9/8/17

NASA Routine Payload Evaluation and Determination Process and Checklist

After a proposed spacecraft mission is sufficiently well formulated (usually the Phase B design study), the Sponsoring Entity, in coordination with the local Environmental Management Office (EMO), will prepare an environmental evaluation. An environmental evaluation is a preliminary review that determines what aspects of the proposal are of potential environmental concern. The environmental evaluation also assists in determining the appropriate level of National Environmental Policy Act (NEPA) documentation (i.e., environmental assessment [EA], or environmental impact statement [IEIS]) for the proposal. The local EMO uses a comprehensive checklist to provide a level of rigor to this early evaluation of the proposal, helping to ensure that pertinent considerations are not overlooked. Local EMO review of the Routine Payload Checklist (RPC, below) forms the basis for evaluating the applicability of a NASA Routine Payload (NRP) spacecraft classification for a proposed mission.

The local EMO uses the completed RPC (and required attachments) to evaluate the proposed mission against the NRP EA criteria. If the EMO evaluation of the RPC indicates that a NRP categorization may be appropriate, the Sponsoring Entity documents this in an Evaluation Recommendation Package (ERP). The ERP is then processed for review and approval in accordance with established National Aeronautics and Space Administration (NASA) procedures and guidelines. If approved, the ERP would be attached to a Record of Environmental Consideration (REC).

The Sponsoring Entity can then proceed with the proposal while monitoring the project activities, for changes or circumstances during implementation that could affect classification of the proposed mission as a NRP spacecraft. If a NRP spacecraft categorization is determined to be inappropriate, the local EMO will initiate plans for preparation of additional NEPA documentation.

NASA Routine Payload Checklist

Project Name: Restore-L (Low Earth Orbit)		Date of Launch: November 2020
Project Contact: Robert C. Smith	Phone Number: 301-286-9065	Mailstop: 483
Project Start Date: October 2015	Project Location: GSFC	

Project Description:
Technology demonstration of autonomous capture, perform tele-operated robotic servicing tasks, refuel Government-owned satellite, and demonstrate relocation of client satellite.

A. Sample Return:	Yes	No
1. Would the candidate mission return a sample from an extraterrestrial body?	☐	☒

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?	☐	☒
Provide a copy of the Radioactive Materials On Board Report as per NPR 8715.3 with the ERP submittal.	Attachment	

C. Launch and Launch Vehicles:	Yes	No
1. Would the candidate spacecraft be launched on a vehicle and launch site combination other than those indicated in Table C-1 on Page 2?	☐	☒
2. Would the proposed mission exceed the approved or permitted annual launch rate for the particular launch vehicle or 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?	☐	☒

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 EPC's in Table C-2 below? See Note below on page 4	☒	☐
2. Would the expected risk of human casualty from spacecraft planned orbital reentry exceed the criteria specified by NASA Standard 8719.14?	☐	☒
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?	☐	☒
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? See Note below on page 4	☒	☐
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?	☐	☒
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)?	☐	☒
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]?	☐	☒

Comments:
When our tool disconnects from the client S/C there will be residual hydrazine (~16cc) that escapes in space. All hydrazine vented for EOL.

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 (continuation)

Project Name: Restore-L (Low Earth Orbit)			Date of Launch November 2020
Project Contact: Robert C. Smith		Phone Number: 301-286-9065	Mailstop: 483
Project Start Date: October 2015	Project Location: GSFC		

Project Description:
Technology demonstration of autonomous capture, perform tele-operated robotic servicing tasks, refuel Government-owned satellite, and demonstrate relocation of client satellite.

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?	☐	☒
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)?	☐	☒

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)	NA	Pad 0	LP-1[a]
Atlas V Family	LC-41	SLC-3	NA	NA	NA
Delta II Family	LC-17	SLC-2	NA	NA	NA
Delta IV Family	LC-37	SLC-6	NA	NA	NA
Falcon I/Ie	LC-36	SLC-4W	Omelek Island	Pad 0	LP-3[b]
Falcon 9	LC-40	SLC-4E	Omelek	Pad 0	LP-1
Minotaur I	LC-20 and/or LC-46	SLC-8	NA	Pad 0	LP-1
Minotaur II-III	LC-20 and/or LC-46	SLC-8	NA	Pad 0	LP-1
Minotaur IV[c]	LC-20 and/or LC-46	SLC-8	NA	Pad 0	LP-1
Minotaur V	LC-20 and/or LC-46	SLC-8	NA	Pad 0	NA
Pegasus XL	CCAFS skidstrip KSC SLF	VAFB Airfield	Kwajalein Island	WFF Airfield	NA
Taurus	LC-20 and/or LC-46	SLC-576E	NA	Pad 0	LP-1
Taurus II	NA	NA	NA	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 is currently under design.
b
LP-3 is currently under design.
c
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.

NASA Routine Payload Checklist

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 (NiH_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.

Note:
A positive response was indicated for Question E.1 because the lithium -ion battery capacity is ~12.3 kW-hr.

A positive response was indicated for Question E.4 because when the refueling tool disconnects from the client S/C there will be residual hydrazine (~16cc) that escapes in space in low earth (680-700 kilometers) orbit. In addition, at end of mission any remaining hydrazine will be vented prior to a controlled reentry. Per the Routine Payload EA, positive responses on the routine payload checklist require further analysis or clarification. As this release of hydrazine will occur in space and will not affect the earth or its atmosphere, it does not become an environmental issue under NEPA. No additional analysis will be required for the routine payload classification

GSFC Flight Project Environmental Checklist

1. Project/Program Restore-L (Low Earth Orbit)	Date: August 2017
2. Schedule	
PDR/CDR: October 2017 / June 2018	Launch Date: November 2020

3. Current Status

Pre-Phase A, post Mission Concept Review (MCR) held on April 7-8, 2016

4. Project Description

a. Purpose:

Technology demonstration of autonomous capture, perform tele-operated robotic servicing tasks, refuel a Government-owned satellite, and demonstrate relocation of client satellite.

b. Spacecraft:

Spacecraft Bus procurement awarded December 2016.

c. Instruments:

N/A

d. Launch Vehicle:

Atlas V, Falcon 9

e. Launch Site:

Vandenburg Air Force Base

f. NASAs Involvement/Responsibility: (include other NASA Centers)

GSFC: Team leadership, Project Management, Systems Engineering, Mission Assurance and Ground System.
KSC: Payload Propellant Transfer Subsystem, Hydrazine testing covered under existing environmental permits for existing Center facilities
JSC: Analysis and support for reviews. WFF: Range sensor (LiDAR and LRF) characterization test

g. Participants/Locations:

NASA-GSFC, NASA-KSC, NASA-JSC, Naval Research Laboratory, U.S. Geological Survey

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

Controlled re-entry

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

Autonomous capture, refueling of satellite, release/return of satellite into orbit

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	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 Cultural Resources	☐	☒	☐
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&D. Hydrazine, Monomethylhydrazine, Nitrogen Tetroxide
E. Laser range finder / 3D Lidar
I. Launch
K. Ka-band, S-band

8. What Safety Hazards are associated with the mission?

Hydrazine, Monomethylhydrazine, Nitrogen Tetroxide
Client Satellite Refueling and Release

9. Summary of Subsystem Components	
Propulsion (Include fuel type, amount, tank size, materials, dimensions	MMH: 1410kg, 1275L Titanium tank. NTO: 1410kg, 1275L Titanium tank N2H4: 318kg, split between 2x 28" spheres. 6Al-4V titanium with reversible AF-E-332 rubber diaphragm
Communications	S-band: up to 128kbps uplink via NEN and TDRSS and 144kbps downlink via TDRSS and 1Mbps downlink via NEN. Ka-band: up to 75Mbps downlink only via TDRSS.
Structural Materials	Metallics: Titanium, Aluminum, CRES Non-Metallics: High-modulus graphite-fiber composite, Intermediate modulus graphite-fiber composite
Power	1x four-panel Solar Array providing a maximum of 6500W to the Spacecraft 1x 23-cell 144 A-hr Li-Ion battery
Science Instruments	N/A
Hazardous components (radioactive materials, lasers, chemicals, etc.)	See propulsion for fuels. Lasers - Laser Range Finder, 3D Lidar
Other (include dimensions and weight of s/c)	6478kg - Vehicle mass 6m x 3.8m x 3m - Vehicle dimensions

GSFC Flight Project Environmental Checklist

Project Manager Printed Name:	Signature Field		
Robert C. Smith	[signature]		
Project Name: Restore-L (Low Earth Orbit)	Date: 9/8/17	Phone Number: 301-286-9065	Org Code: 483

Comments: