governmentattic.org
"Rummaging in the government's attic"

Description of document:	SETI Institute Unsolicited Proposal to NASA (National Aeronautics and Space Administration) Ames Research Center (ARC) For a New Cooperative Agreement titled: "Planetary Science and Exploration Studies," 2014
Requested date:	10-November-2018
Release date:	13-December-2018
Posted date:	31-December-2018
Source of document:	FOIA Request NASA Headquarters 300 E Street, SW Room 5Q16 Washington, DC 20546 Fax: (202) 358-4332 Email: hq-foia@nasa.gov

The governmentattic.org web site ("the site") is noncommercial and free to the public. The site and materials made available on the site, such as this file, are for reference only. The governmentattic.org web site and its principals have made every effort to make this information as complete and as accurate as possible, however, there may be mistakes and omissions, both typographical and in content. The governmentattic.org web site and its principals shall have neither liability nor responsibility to any person or entity with respect to any loss or damage caused, or alleged to have been caused, directly or indirectly, by the information provided on the governmentattic.org web site or in this file. The public records published on the site were obtained from government agencies using proper legal channels. Each document is identified as to the source. Any concerns about the contents of the site should be directed to the agency originating the document in question. GovernmentAttic.org is not responsible for the contents of documents published on the website.

-- Web site design Copyright 2007 governmentattic.org --

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

December 13, 2018

Office of Communications

FOIA: 19-NSSC-F-00090

Thank you for your Freedom of Information Act (FOIA) request dated November 10, 2018, and received November 13, 2018, at the NASA Headquarters FOIA Office. Your request will be processed by the NASA Headquarters FOIA Office on behalf of the NASA Shared Services Center (NSSC). Your request has been assigned as FOIA Case Number 19-NSSC-F-00090 and is for:

> I request a copy of the Statement of Work for contract NNX14AT27A from NASA to the SETI Institute, awarded 9/12/2014.
>
> I also request a copy of the successful proposal for this contract. I agree to omit proprietary financial information.

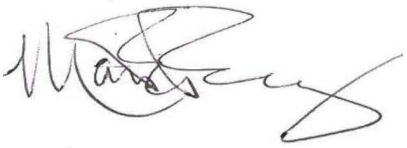
The NASA Headquarters program office(s) conducted a search for Agency records. We have identified one document consisting of 22 pages as responsive to your request. This document is releasable in full.

Please be advised that NNX14AT27A corresponds to a grant rather than a contract. There is no statement of work under a grant. However, the document we are releasing contains a description of the proposed research as well as a work plan.

Fees for processing this request are less than $50.00 and are not being charged in accordance with 14 CFR §1206.504(f).

If you have further questions, please feel free to contact me at hq-foia@nasa.gov or (202) 358-2339.

Sincerely,



Martha Terry
NASA FOIA Officer
Headquarters, Office of Communications

Carl Sagan Center for the Study of Life In The Universe
189 Bernardo Ave., Suite 100
Mountain View, CA 94043–5203
(650) 961–6633

Unsolicited Proposal

To NASA Ames Research Center

For a New Cooperative Agreement titled:

“Planetary Science and Exploration Studies”

Dr. Pascal Lee, Principal Investigator

Amount Requested Year 1: $1,055,414

Date Submitted: June 23, 2014

Carl Sagan Center for the Study of Life In The Universe
189 Bernardo Ave., Suite 100
Mountain View, CA 94043–5203
(650) 961–6633

The SETI Institute is a nonprofit 501(c)3 California Corporation.

Principal Investigator:
Pascal Lee, SETI Institute
408-687-7103

SETI Institute Grants Office:
Barbara Vance, Grants Administrator
650-960-4531

Debbie Kolyer, Grants Manager/AOR
650-960-4521

NASA Ames personnel:
Christopher McKay, proposed Technical Officer
650-604-6864

This proposal, titled "Planetary Science and Exploration Studies" has not been submitted to any other Government Agency or NASA installation, nor is it a continuation or renewal of a previous Agreement. The original date of submission is June 23, 2014. The desired starting date is July 1, 2014. We request a duration of 4 years for this award.

Debbie Kolyer

Debbie Kolyer, Grants Manager/AOR

Table of Contents

Abstract

A 4-year multidisciplinary research program supporting NASA's Strategic Plan and Science Plan goals and objectives is proposed.

The guiding theme for the proposed Science investigations is *Water in the Solar System*; that for the proposed Exploration work is *Steps to Humans on Mars*.

The proposed Science investigations will address central questions in planetary science and astrobiology by focusing on studies of the origin and evolution of water on planetary bodies, in particular via Earth-based and spacecraft investigations of physical, chemical, geologic, and hydrologic features, settings, properties, and processes on the Earth, the Moon, Mars, Asteroids and other small bodies, including the moons of Mars, Phobos and Deimos.

The proposed Exploration work will provide critical support to planning and implementing the future human exploration of Mars by helping achieve incremental steps towards this goal, in particular via the development, testing, and validation of new exploration concepts, technologies, systems, mission architectures, operations, and strategies for future robotic and human missions to the Moon, Near-Earth Asteroids, Phobos and Deimos, and Mars.

The proposed research will be carried out through a combination of theoretical and concept studies, spacecraft mission data analysis, field investigations in terrestrial analog environments, and collaborative workshops.

The proposed effort will build on two decades of related investigations led by the proposing PI, including field studies at the NASA Haughton-Mars Project on Devon Island, High Arctic. Coordination of the proposed research activities with NASA's Solar System Exploration Research Virtual Institute (SSERVI) will be sought whenever appropriate.

Background

The *NASA Strategic Plan 2014* document outlines NASA's current Strategic goals and objectives. Those goals and objectives to which the proposed research will be relevant are listed in Table 1.

Table 1. NASA Strategic Plan 2014 goals and objectives to which the proposed research will be relevant.

NASA Strategic Goal	NASA Objective	
1. Expand the frontiers of knowledge, capability, and opportunity in space, by empowering the NASA community to:	1.1	Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.
	1.5	Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.
	2.4	Advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers, and faculty in NASA's missions and unique assets.
3. Serve the American public and accomplish our Mission by effectively managing our people, technical capabilities, and infrastructure, by working together to:	3.1	Attract and advance a highly skilled, competent, and diverse workforce, cultivate an innovative work environment, and provide the facilities, tools, and services needed to conduct NASA's missions.
	3.2	Ensure the availability and continued advancement of strategic, technical, and programmatic capabilities to sustain NASA's mission.
	3.4	Ensure effective management of NASA programs and operations to complete the mission safely and successfully.

The *NASA Science Plan 2014* document outlines NASA's current Science goals and objectives, in particular NASA SMD's Planetary Science Goals. The latter were developed in response to both the objectives of the NASA Strategic Plan 2014 (Objective #1.5 in Table 1) and the priorities identified in the NRC's planetary science decadal survey document titled "*Vision and Voyages for Planetary Science in the Decade 2013-2022"* (NRC, 2011). Those SMD Planetary Science Goals to which the proposed research will be relevant are listed in Table 2.

Table 2. NASA Strategic Plan 2014 Objective #1.5, NASA Science Plan 2014 Planetary Science goals, and NRC Decadal Survey Priorities to which the proposed research will be relevant.

NASA Strategic Objective	NASA SMD Planetary Science Goals	Decadal Survey Priority (Associated SMD Science Goals in parentheses)
Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.	1. Explore and observe the objects in the solar system to understand how they formed and evolve. 2. Advance the understanding of how the chemical and physical processes in our solar system operate, interact, and evolve. 3. Explore and find locations where life could have existed or could exist today. 4. Improve our understanding of the origin and evolution of life on Earth to guide our search for life elsewhere. 5. Identify and characterize objects in the solar system that pose threats to Earth, or offer resources for human exploration.	a. Building New Worlds – advance the understanding of solar system beginnings (1, 2) b. Planetary Habitats – search for the requirements for life (3, 4) c. Workings of Solar Systems – reveal planetary processes through time (1, 2, 5)

Proposed Research

The proposed research is divided into two classes of activities: A) Fundamental and Applied Planetary Science and Exploration Research not conducted in the field; B) Planetary Analogs Field Research.

A. Fundamental & Applied Planetary Science & Exploration Research.

The proposing PI will cooperate with NASA in achieving its Strategic Plan 2014 and Science Plan 2014 goals and objectives listed in Tables 1 and 2 by providing support in the following areas:

- Investigations of the origin, evolution, distribution, accessibility, and usability of H_2O and water of hydration on the Moon, Mars, Asteroids, and the moons of Mars.
- Investigations of the geologic features, processes, and evolution of the Moon, Mars, Asteroids, and the Moons of Mars, with particular emphasis on the physics of their regolith.
- Conception and development of novel planetary science and exploration missions to advance our scientific understanding of the Moon, Mars, NEAs, and the moons of Mars.
- Convening and organization of NASA-co-sponsored planetary science and exploration conferences and workshops in connection with the science and exploration of the Moon, Mars, NEAs, and the moons of Mars.
- Education and Public Outreach activities related to the science and exploration of the Moon, Mars, NEAs, and the moons of Mars.

Examples of research investigations to be funded through the proposed cooperative agreement might include:

- Further synthesis studies of spacecraft and meteoritic data to constrain the abundance and distribution of water inside Phobos and Deimos.
- Development of spacecraft mission concepts to investigate Phobos and Deimos & serve as precursors for eventual human missions to Mars orbit.
- Surveys of deep drilling technologies that applicable to accessing potential deep-seated liquid aquifers on Mars (in the Martian crust).

The proposed research would be supported in full or in part by NASA, and where approved by NASA, would involve partnerships with other non-NASA organizations, including non-profits (*e.g.,* the Mars Institute, a NASA partner based at the NASA Research Park (NRP) at NASA Ames Research Center (ARC)), commercial and industry partners (*e.g.,* Moon Express Inc., a NASA partner also based at the NRP), and academia.

The proposed research will build on the proposing PI's two decades of successful planetary science and exploration research experience and cooperative partnerships with NASA and non-NASA organizations.

B. Planetary Analogs Field Research

NASA is pursuing an ambitious program of exploration and discovery with robotic and human missions to the Moon and Mars, and options for potential intermediate missions to NEOs and Phobos and Deimos as well. In this context, *terrestrial planetary analog environments* play a key role in enabling comparative planetary science studies, technology maturation, surface operations planning, and human experience building.

Planetary analogs may be defined as natural or artificial (lab) terrestrial environments, features, or processes, similar or relevant in specific ways to possible counterparts on other planets (Lee and McKay 2006).

Over the past two decades, the proposing PI has led the "NASA Haughton-Mars Project" (HMP), an international multidisciplinary field research project centered on the scientific study of the Haughton impact structure and surrounding terrain, Devon Island, High Arctic, viewed as a terrestrial analog for the Moon and Mars. The rocky polar desert setting, geologic features and biological attributes of the site offer unique insights into the possible evolution of Mars - in particular the history of water and of past climates on Mars -, the effects of impacts on Earth, the Moon, and on other planetary bodies, and the possibility of life in extreme environments.

The HMP comprises a Science program focused on advancing scientific knowledge of the site itself - and, by comparison, of other planetary bodies -, and an Exploration program that *uses* the site to develop the technologies, strategies, and human experience needed to plan future Moon, Mars, NEA, Phobos and Deimos exploration missions by robots and humans.

Since 2000, the HMP has been successfully managed for NASA by the SETI Institute under Cooperative Agreements NCC2-1185, NCC2-1416, and NNX08AO59A (P. Lee PI at SETI Institute, C. P. McKay Technical Monitor at NASA ARC).

The research proposed below includes additional investigations at the Haughton impact structure site and investigations at other planetary analog sites.

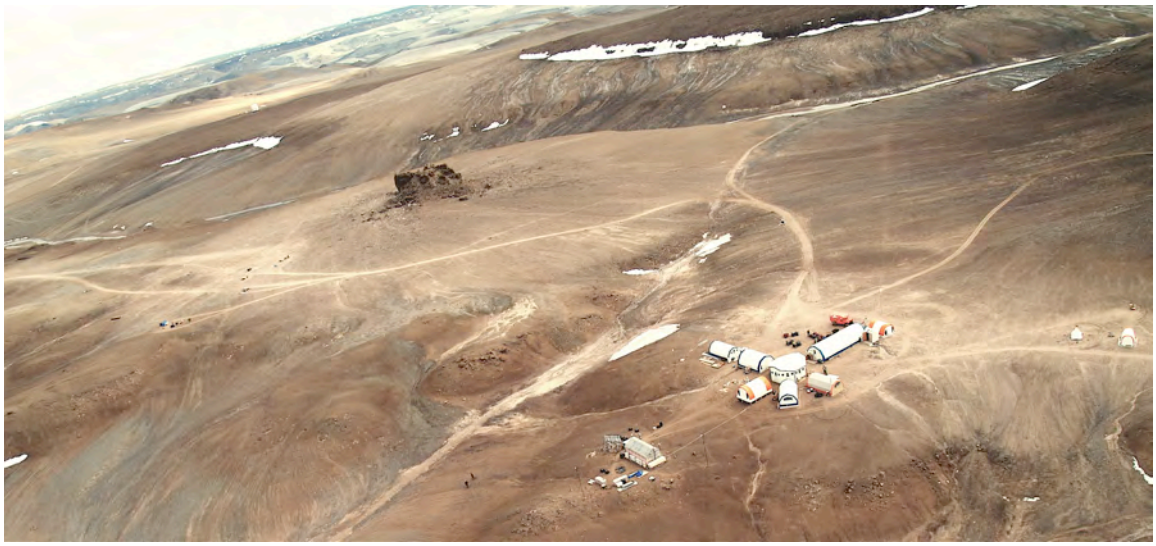


Fig. 1: The Haughton-Mars Project Research Station (HMP RS) on Devon Island, High Arctic (Photo HMP-2006/P. Lee).

B.1 Science Program

B.1.1 Objectives

Planetary Geology and Astrobiology are key themes in NASA's Science Mission. We propose a program of scientific investigations that will focus on the following outstanding issues in Planetary Geology and Astrobiology:

a) Mars Environment and Life.
Questions: - How have environmental conditions on Mars evolved over time?
- To what extent has liquid water been available at/near the martian surface over time?
We propose to examine the geologic record of Mars as revealed in orbital and surface spacecraft data, and to interpret this record in light of data collected in terrestrial analog environments.

b) H_2O in Arid Environments.
Questions: - How does H_2O occur and persist in association with lava tubes and impact structures in terrestrial arid environments?
- What are the implications for the Moon, Mars and other planetary bodies?
We propose to investigate the hydrologic processes involved in the occurrence and persistence of H_2O in all its forms in lava tubes and impact structures in terrestrial arid environments, in particular the specific physical, chemical, and geologic conditions allowing liquid H_2O-rich habitats to exist in these settings.

c) Impact Cratering and Deep Sampling
Questions:
- Can hypervelocity impacts expose unshocked deep subsurface materials?

- What are implications for needing to conduct deep-drilling on the Moon and Mars in order to access well-preserved deep samples?
- How are denudation rates on Mars constrained by the recent discovery of distal impact ejecta remnants at Haughton Crater?

We propose to survey the occurrence of deep subsurface materials having escaped substantial shock metamorphism at large terrestrial impact structures and to examine implications for the need to undertake deep drilling on other planetary bodies.

B.1.2 Approach and Tasks

Field studies in Planetary Geology and Astrobiology in *terrestrial planetary analog environments* are a powerful approach to addressing the objectives of the proposed research. The above questions are reformulated as specific hypotheses we propose to test through field-based analog studies:

Hypothesis 1: Cold Mars:
The record of aqueous processes on Mars does not imply any substantial episode of climatic warmth and wetness and is consistent with a predominantly cold climate prevailing throughout Mars's history, with arid cold climate regions on Earth providing relevant (although not necessarily identical) analogs.

Hypothesis 2: H_2O Enhancement in Lava Tubes and at Impact Structures:
In arid regions on Earth, basaltic lava tubes and impact structures are local environments exhibiting systematic enhancement in H_2O mobilization, accumulation, and persistence.

Hypothesis 3: Impacts Can Sample Deep at Low Shock:
Hypervelocity impacts may excavate solid planetary materials from the deeper subsurface (transient crater depths) that escape substantial shock metamorphism.

To test Hypothesis 1, we propose to systematically search for, and investigate the nature, origin, and evolution of a variety of geologic features attributable to H_2O processes in arid cold-climate regions on Earth that may offer possible parallels with specific morphologic and contextual counterparts observed on Mars. Focus will be placed on analogs for: 1) liquid H_2O flow features such as small valley networks, outflow channels, gully systems, and deltaic deposits; 2) H_2O ponding features such as paleoshorelines, paleolacustrine deposits, and paleomarine deposits; 3) H_2O ice flow features such as glaciers, rock glaciers, debris aprons, and glacial trough valleys; 4) H_2O freeze-thaw features such as patterned ground, ice-cored mounds, and alas valleys.

To test Hypothesis 2, we will investigate lava tubes and impact structures set in arid environments and examine any evidence of associated enhancements in H_2O abundance past or present in contrast to surrounding features and terrain. Quantitative environmental data (P, T, RH) will be systematically logged in select locations both inside and outside lava tubes and impact structures, and H_2O-bearing samples will be collected for compositional analysis (mineral and isotopic) and dating (oxygen isotopes).

To test Hypothesis 3, we will survey polymict impact breccia deposits associated with several well-preserved impact structures and search for any occurrence of low-to unshocked samples among the deepest excavated lithologies exposed.

B.2. Exploration Program

B.2.1 Objectives

The main objectives of our proposed Exploration Program are to assist NASA in achieving the goals of its Science and Exploration Missions by:
1) providing support to NASA in the definition, implementation (science, logistical support and flight support) and analysis of concept studies, scientific investigations, systems development, operations tests, and analog field campaigns;
2) providing support to NASA in the study, evaluation, and selection of terrestrial planetary analog sites and of landing and surface operations sites on the Moon, Mars, NEOs, Phobos & Deimos;
3) providing support to NASA in the definition, implementation and analysis of Science & Exploration missions, and Surface Science & Exploration Operations, on the Moon, Mars, NEOs, Phobos & Deimos.
4) providing support to NASA, whenever appropriate, in meeting the Agency's International collaboration and partnership goals, in particular as part of NASA's role in the Global Exploration Strategy.
5) providing support to NASA in meeting the agency's Education and Public Outreach goals.
6) providing advice to NASA whenever appropriate to help the Agency achieve it goals.

Terrestrial planetary analog environments play a critical role in helping plan and prepare for future planetary exploration by robotic systems and/or humans. Analog sites may offer relevant science content and/or operational challenges that will be key in driving the definition of requirements and in developing the new technologies, strategies, and human experience needed to "safely" take the next steps in planetary exploration.

Note: The following five factors need to be considered in assessing the *value* of a planetary analog: 1) Aspect; 2) Applications; 3) Functions; 4) Fidelity; and 5) Cost-effectiveness (Lee and McKay 2007).

Aspects. The most common broad planetary analog aspects considered are: climate, geology, biology, terrain, operations, and "other". Within each aspect, a variety of sub-aspects may be considered.

Applications. Two categories of planetary analog applications are readily distinguished: science and exploration. Science applications encompass comparative planetology and astrobiology, including science instrument development. Exploration applications include integrated technology development and human exploration preparation.

Functions. Planetary analogs can serve four functions. They may help: a) learn, b) test; c) train; and/or d) engage. In the latter case, they may help engage the public, students, and international partners.

Fidelity. A given analog may offer different levels of fidelity depending on the aspects, applications, and functions considered. The fidelity of a planetary analog is ideally assessed using a fidelity scale. In practice, a scale distinguishing simply *low*, *medium*, and *high* fidelity analogs may be sufficient. Low fidelity means that important factors in a comparative study are lacking, making the analogy potentially difficult to interpret. High fidelity means that all significant factors in a comparison are adequately simulated or approximated sufficiently well.

Cost-effectiveness. The cost-effectiveness of a planetary analog weighs the range of aspects, applications, and functions it covers, the fidelity achieved in each area, the uniqueness of the analog, and the cost of accessing and using the analog. A costly analog may still be cost-effective if it is unique and considered necessary.

Ultimately, the *value* of a planetary analog is determined by assessing how it addresses all five factors described above.

B.2.2 Approach & Tasks

The PI of the proposed research will continue to lead and/or actively participate in NASA-supported concept studies, scientific investigations, systems development, operations tests, and analog field campaigns critical to achieving NASA's Science and Exploration Missions goals. He will provide intellectual input in meeting these goals and will deploy to the field whenever necessary to help NASA study, evaluate, select, and use analog sites in support of its programs. He will also continue to support NASA in implementing its Global Exploration Strategy, participate in NASA Education and Public Outreach activities, and provide advice to NASA, as appropriate, to help the Agency meet its goals.

The PI will in particular lead and/or actively participate in the implementation of analog field campaigns in remote and isolated environments such as the Arctic or Antarctica. In the Arctic, he will continue to direct the Haughton-Mars Project

(HMP) on Devon Island, High Arctic, be responsible for the management the Haughton-Mars Project Research Station (HMP RS) and its assets (including existing deployed NASA assets), and support NASA activities at the site as required to meet NASA's Science and Exploration Missions goals. Safety will remain a top priority in the conduct or support of all analog field deployments.

The SETI Institute will subcontract to the Mars Institute the provision of logistical support for the analog field deployments required in the proposed effort. The Mars Institute (MI) is a California-registered non-profit research and logistics organization based at the NASA Research Park at Moffett Field. MI is the established manager and logistics provider for the Haughton-Mars Project, and has unique expertise and experience for supporting NASA and/or SETI Institute missions at other remote and isolated analog sites.

The PI will focus his participation in exploration field research in areas that will advance our understanding of how to enable and optimize the future exploration of rocky planetary surfaces by robotic systems and humans, in particular the conduct of advanced planetary exploration EVA (extravehicular activity), the support of surface operations (in particular science operations), the design and use of planetary exploration instruments, tools, and systems (including surface exploration mobility systems), and investigations of human factors as they pertain to planetary exploration.

The PI will carry out these tasks by interacting closely with Dr. Christopher P. McKay, Technical Officer for the proposed Cooperative Agreement, and with other researchers and personnel throughout NASA.

Impact of Proposed Work to Knowledge in the Field and How it Builds on Previous Accomplishments

The proposed research addresses all five key objectives for NASA's Science Plan (Table 2) and will advance our knowledge in many areas of Earth and Planetary Sciences and Astrobiology, in particular:

- Earth and Planetary Geology
- Earth and Planetary Climate Evolution
- Polar Science
- Ecology
- Microbiology

It is anticipated that the proposed research will result in advances not only in our academic understanding of planets and astrobiology, but also in the definition and implementation of new Moon and Planetary science missions for NASA.

The proposed field research will build on over 12 seasons of field science investigations at the Haughton Crater site on Devon Island and on the many other analog field research programs the PI has participated in (see List of Publications in PI's CV).

The proposed research is also responsive to core needs of NASA's Strategic Plan exploration goals and objectives, and will be critical to advancing our knowledge of how to plan and execute future exploration missions to the Moon, Mars, NEAs, Phobos and Deimos with robotic systems and humans, in particular through:

- Analog Site Selection and Field Activities
- Moon/Planetary Science and Exploration Missions Site Selection
- Technology Development for Moon/Planetary Science and Exploration
- Strategies for Moon/Planetary Science and Exploration
- Moon/Planetary Surface Science and Exploration Operations
- Human Experience Building for Moon/Planetary Science and Exploration.

It is anticipated that the proposed research will provide critical support and guidance to NASA's exploration mission. The primary purpose and established benefit of analog fieldwork lies in risk reduction. Field validated technologies and strategies, and field-trained personnel – crew and ground personnel alike – are essential to the success of robotic missions and human spaceflight. For instance, the participation of NASA flight surgeons in HMP field campaigns has been key to advancing not only new telemedicine technologies and the development of critical crew health support strategies for Moon and Mars, but also the training of crew support personnel in planetary analog surface operations and expeditionary medicine.

Maximizing Impact and Leveraging

An important attribute of the proposed research is the maintenance of a tight connection between NASA's SMD and HEOMD goals. For instance, Exploration activities to be conducted at analog sites will be driven, whenever possible, by actual and planetary-relevant field science agendas and operations. This has been the premise of the NASA Haughton-Mars Project since its inception. The proposed research will build on 12 years of experience and successes at HMP.

The proposed work will continue to access and use, whenever appropriate, the HMP Research Station's infrastructure and assets, including its airstrip, base camp facilities, field vehicles, science instruments, field equipment, tools, and also the considerable experience of the HMP's field personnel. The leveraging of existing infrastructure and resources dedicated to supporting planetary analog field activities will optimize risk reduction and cost-effectiveness for NASA.

The proposed research also has strong potential for engaging external (non-NASA and non-SETI Institute) parties as deemed of value to NASA. Analog fieldwork is a fertile ground for establishing win-win collaborations with International space agencies. At HMP for instance, the Canadian Space Agency (CSA) has been involved in supporting a portion of the Science and Exploration studies conducted at the site. The HMP RS was selected by CSA to serve for six years as a node in the CSA's Canadian Analog Research Network (CARN). At a minimum, this means that there may be opportunities, where appropriate, for leveraging field resources to reduce costs for all parties.

The proposed research will also be conducive to establishing collaborations between government and private sectors. For instance, HMP may serve as an experimental model for how a remote and isolated outpost dedicated to field research can be operated by the private sector (Mars Institute and SETI Institute) in support of research activities and other exploration operations sponsored by government agencies (NASA and CSA).

The proposed research will also provide ample opportunities for offering Science and Exploration Community Services, such as the convening and organization of science and exploration conferences and workshops, and for conducting Education and Public Outreach activities, including opportunities for direct participation of students and teachers in field campaigns, where appropriate.

Relevance of Proposed Research to NASA Programs

The proposed research is directly relevant to several of NASA's enterprises and programs and is cross-cutting by design.

The proposed research addresses several specific research themes central to areas of interest in NASA's Science Mission Directorate (SMD). The proposed research will in particular fit squarely within the scopes of NASA's new Emerging Worlds, Habitable Worlds, PSTAR (Planetary Science and Technology through Analog Research), and Solar System Workings programs. Support for the proposed research may come in part from grant funding from the above programs.

The proposed research will also be responsive to the Robotic Exploration goals of NASA SMD, and also to the Human Exploration goals of NASA HEOMD, in particular NASA's Asteroid Grand Challenge (AGC) and NASA's Asteroid Retrieval Mission (ARM). Existing collaborations between the PI and research teams with various NASA Human Architecture Teams (HATs), and the PI's involvement in Blue Sky brainstorming meetings on a as-needed basis, are anticipated to continue and be further developed through the proposed cooperative research.

The proposed Education and Public Outreach activities will support the goals of NASA's STEM education goals and objectives.

Coordination with NASA's SSERVI

Whenever possible, the proposed research will be carried in coordination with the NASA Solar System Exploration Research Virtual Institute (SSERVI). As indicated in the NASA Science Plan 2014 document, "*NASA SMD and HEOMD established the SSERVI to conduct basic and applied research fundamental to understanding the Moon, Mars and its moons, near-Earth asteroids, and the near-space environments of these target bodies, while advancing human exploration of the solar system*". The proposed research fits squarely within the scope of the SSERVI's research interests and activities.

Examples of proposed research activities that would benefit from coordination with the SSERVI include field research activities to be conducted at planetary analog field sites, including HMP, or the proposed organization of a *Third International Conference on the Exploration of Phobos and Deimos*.

Work plan

A three-year work plan is proposed, including provisions for three NASA Haughton-Mars Project summer field campaigns on Devon Island and/or at other terrestrial analog sites.

A summary breakdown of the proposed work plan schedule with field season-driven HMP campaigns is provided below.

YEAR 1

2014

Jul-Aug:	HMP-2014 Field Campaign, Devon Island, Arctic
Sep-Dec:	HMP-2014 Data Analysis and Results Publication

2015

Jan-Jun:	HMP-2015 Field Campaign Planning Published Papers in Coop Agreement Annual Report

YEAR 2

2015

Jul-Aug:	HMP-2015 Field Campaign, Devon Island, Arctic
Sep-Dec:	HMP-2015 Data Analysis and Results Publication

2016

Jan-Jun:	HMP-2016 Field Campaign Planning Published papers in Coop Agreement Annual Report

YEAR 3

2016

Jul-Aug:	HMP-2016 Field Campaign, Devon Island, Arctic
Sep-Dec:	HMP-2016 Data Analysis and Results Publication

2017

Jan-Jun:	HMP 2017 Field Campaign Planning. Published papers in Coop Agreement Annual Report

YEAR 4

2017

Jul-Aug:	HMP-2017 Field Campaign, Devon Island, Arctic
Sep-Dec:	HMP-2017 Data Analysis and Results Publication

2018

Jan-Jun:	HMP 2018 Field Campaign Planning. Published papers in Coop Agreement Final Report

Personnel

Dr Pascal Lee (408-687-7103; plee@set.org of the SETI Institute's Carl Sagan Center will serve as Principal Investigator (PI) for the research proposed in this Cooperative Agreement. He will be responsible for meeting all research and research support objectives set forth in this proposal. He will in particular continue to serve as PI and Director for the NASA Haughton-Mars Project.

Dr Chris McKay (650-604-6864; chris.mckay@nasa.gov) at NASA Ames Research Center (ARC) will serve as Technical Officer for this Cooperative Agreement.

Exploration program activities will be coordinated with other NASA centers, NASA HQ, and the NASA SSERVI.

The proposed research will also involve a number of collaborations outside NASA, including external Education and Public Outreach (E/PO) partners.

Facilities, Equipment and Logistics

The SETI Institute is the home institution of the proposing PI. The Institute will provide overall management support for the proposed research program.

The NASA Haughton-Mars Project Research Station (HMP RS) represents a significant infrastructure and set of pre-deployed assets at the field research site on Devon Island, High Arctic, currently under management and operational responsibility of the Mars Institute in collaboration with the SETI Institute.

The Mars Institute will be subcontracted by the SETI Institute to arrange, procure or provide the required field project management, field logistics, field safety measures, field equipment and supplies, programmatic travel, and field communications, computing and networking needs of the HMP in support of NASA-sponsored activities on Devon Island and other accessible areas of the High Arctic. Logistics support for the NASA HMP may be purchased in part from the Polar Continental Shelf Project (PCSP) of Natural Resources Canada.

The Mars Institute, as collaborating partner on the NASA HMP, will make its “MOON-1” (a.k.a. *HMP Okarian*) and “MARS-1” Humvee rovers and other assets deployed at the HMP RS available to the SETI Institute in support of the proposed field research program on Devon Island.

Budget Justification

The proposed total budget includes provisions for research to be performed at the SETI Institute, NASA Ames Research Center, and the Mars Institute as subcontracted by the SETI Institute.

The proposed budget is divided into two components:

1) The SETI Institute Core Budget, which includes the costs incurred in the performance of all tasks under Category A (Fundamental & Applied Planetary Science and Exploration Research) + the PI's labor costs in the performance of tasks under Category B (Planetary Analogs Field Research).

2) Subcontract to Mars Institute, which covers the performance of all tasks under Category B (Planetary Analog field Research), except the PI's labor costs.

1. Core Budget at SETI Institute

The Core Budget at the SETI Institute covers tasks to be performed under Proposed Research Category A, as well as the PI's labor when planning and implementing field deployments to planetary analogs.

Labor at the SETI Institute includes:

- 80% of P. Lee's time as PI of the proposed Cooperative Agreement
- 100% of time for a graduate student to help the PI with research and logistics tasks at the SETI Institute.

Materials, Supplies and Services to be provided to the SETI Institute in support of the proposed research include:

- Field safety equipment and supplies for the PI and/or Student n support of analog field deployments.
- Office equipment and supplies for the PI and/or Student.
- Systems Administration support for the PI and/or Student, as well as work related long-distance roaming phone and internet access services for the PI and/or Student.
- Academic and/or technical literature directly related to the PI's proposed research.
- Copying and Printing costs, for instance publications and conference posters.

Travel comprises both Programmatic Travel and Professional Travel.
Programmatic travel includes travel for the PI or Student to participate in field campaign planning meetings (NASA JSC in Houston, MI in Vancouver), two annual NASA HQ briefing, the HMP Summer Field Campaign in the Arctic (2 trips to enable participation in the mid-season SSERVI meeting at NASA ARC), and

the HMP Winter Meeting in the Arctic (to meet reporting obligations to local government agencies overseeing access and use of HMP field site).
Professional travel includes travel for the PI or Student to present and/or discuss Science and/or Exploration research results at NASA-sponsored technical meetings. Substantial professional travel is required due to the multidisciplinary nature of the proposed analog field research and the large collaborative teams typically involved in NASA analog field activities.

Indirect costs are computed consistent with the SETI Institute's approval from the Office of Naval Research on 8/21/13 for a negotiated FY 2013 Indirect Cost rate. The approved indirect cost rate is 25.9%. Items of equipment with a unit purchase price of $5,000 or more are excluded from indirect cost application. Subcontract amounts above $25,000 per subcontract are excluded from IDC.

2. Subcontract to Mars Institute

The Mars Institute is a California-registered private non-profit research & logistics organization based at NASA's Ames Research Center's NASA Research Park, Bldg 19, Suite 2047, Moffett Field, CA 94035-0006, USA.

MI is currently the established organization providing project management and logistics support to the Haughton-Mars Project (HMP). In particular, the MI manages and operates the Haughton-Mars Project Research Station (HMP RS) on Devon Island, High Arctic. The MI has unique expertise in supporting the HMP and other complex analog field campaigns in remote and isolated environments. While the MI's role is to provide project management and logistics support to the HMP, ultimate responsibility for the direction and implementation of HMP research and field campaigns rests with PI P. Lee at the SETI Institute. (Note: Mars Institute is not to be confused with the Mars Society, a former participating organization in HMP activities).

The proposed subcontract to the Mars Institute covers tasks to be performed and anticipated expenses associated with field deployments, except the PI's labor when planning or implementing the field deployments. The field budget was estimated on the basis of the PI's 17 consecutive years of experience in developing and directing the NASA Haughton-Mars Project (HMP) (1997-Present) and participation in over 30 polar field campaigns, the SETI Institute's 14 years of experience in managing the HMP (2000-Present), and the Mars Institute's 10 years of co-management of the HMP with the SETI Institute (2005-Present).

The *field* budget is designed to accommodate NASA's continued need to access and use planetary analogs over the next few years in support of its Science and Exploration Missions. This need is evidenced by the specific inclusion of the HMP in recent MMAMA (Moon & Mars Analog Missions Activities) Announcements of Opportunity over the past 5 years. The MMAMA

AO explicitly identified the HMP as an established site for NASA to conduct both Science and Exploration research activities and invites researchers to propose to do work at HMP. It is anticipated that the HMP will continue to be identified in upcoming PSTAR AOs.

The MI subcontract budget is based on an estimation of need of use by NASA of the HMP site over the next three years: approximately 900 NASA person-days in the field plus the deployment of substantial amounts of hardware in support of NASA SMD and HEOMD activities. The present MI subcontract budget includes provisions for:

Basic Services (Support to be provided to all field participants regardless of the specifics of their field program). Basic Services are budgeted on the basis of:

- A Fixed Access Fee, which covers i) the cost of transporting each participant between Resolute Bay and Devon Island, ii) the cost each year of transporting all common-use equipment and supplies from their source to HMP RS (general deployment cost), and iii) the cost of using the existing HMP RS material infrastructure (amortization and maintenance of existing HMP RS assets). The Fixed Access Fee is assessed once per person participating at HMP regardless of the duration of their stay on Devon Island.
- A Field Per Diem, which covers i) the daily cost of each participant's use of common consumables (food, fuel for base camp power and heating, etc.), and ii) the daily share of each participant's contribution to the employment cost of HMP field support personnel employed by the Mars Institute.

Advanced Services (Additional support to be provided to Complex Activities based on those activities' specific needs). NASA Science and Exploration analog field campaigns are typically Complex Activities in this regard. Their planning and implementation requires:

- Labor, i.e. Additional MI personnel labor support specifically needed to ensure adequate planning and implementation of a Complex Activity during an HMP field campaign.
- Equipment, Supplies & Services, i.e. Additional material or service support specifically needed to ensure adequate planning or implementation of a Complex Activity, including fuel for ATVs (All-Terrain Vehicles) needed in traverse-intensive activities, dedicated tent space at camp or deep in the field, ATV rental, a *share (50%)* of the daily cost of operating the MI's Mars-1 and Moon-1 Humvee Rovers during the analog field campaign, and high-bandwidth satellite communication time.
- Logistics and Travel, i.e. Additional programmatic transportation and travel costs specifically needed to ensure adequate planning or implementation of a Complex Activity, in particular travel costs for MI personnel to attend field campaign planning and coordination meetings at NASA ARC or JSC, field deployment costs of key MI personnel needed to support a Complex Activity, and field deployment costs for specialized Cargo needed in to implement the Complex Activity. Cargo airlift from Moffett Field, CA to Resolute Bay may be

procured through the Air National Guard (ANG), an arrangement between NASA and the ANG which results in considerable cost reduction for NASA deployments to Devon Island.

-