Lunar Exploration Analysis Group
Resource Prospector Mission Special Action Team

At the request of NASA HEOMD, the Lunar Exploration Analysis Group (LEAG) established a Special Action Team (SAT) to review the Resource Prospector Mission (RPM). The SAT convened at the Ames Research Center on March 4, 2014.

The Terms of Reference for the SAT review are listed in Appendix 1. The SAT membership is listed in Appendix 2, and the meeting agenda is in Appendix 3.

The major elements of the mission were presented, including the Level 1 and 2 requirements, instruments, site selection, and mission operations. As a lander and rover have yet to be identified for the mission, these aspects were not discussed.

The RPM mission is a Class D, Category 3 mission. Launch is planned in FY19. A Mission Concept Review was conducted in October 2013. Level 1 requirements include landing at a sunlit site in the polar regions of the Moon that has the potential for volatiles and to acquire measurements of surface and subsurface material at multiple locations, including both sunlit and shadowed areas. Level 2 requirements provide more detailed information regarding the specific measurements to be made and, in many cases, information as to the details of the measurement or the acquisition of samples. The RPM requirements are attached in Appendix 4.

The SAT believes that there are areas of concern that need to be addressed, so that the mission has a greater chance of success in terms of collecting data that can be clearly interpreted in a geological context, thereby contributing to our basic understanding of lunar volatiles. Specifically, we find the following:

FINDINGS:

The RPM mission has the potential to make significant contribution to our understanding of the nature of the lunar volatiles in the shallow regolith of polar areas in both sunlit and shadowed areas.

The ability to collect and analyze both surface and subsurface samples is critical to understanding the natural processes of volatile storage and transport in the regolith, as well as to developing processes to extract the volatiles for in situ resource utilization (ISRU).

Samples from permanently shadowed areas are critical to understanding the extent to which differences in the thermal environment of the lunar surface influence volatile sequestration.

The lack of an identified lander and rover makes a complete assessment of the mission impossible and significantly increases the technical risk of the mission, although the slip of the launch to FY/CY19 alleviates some of schedule risk in that it gives the team more time to find partners to provide the lander and rover elements.

This mission is an opportunity to test hypotheses of volatile deposition and storage mechanisms. An initial model(s) is required on which to base mission planning, measurement strategies and requirements. This is typically illustrated in the construction of a science tracebility matrix.

The geologic model of the thermal and volatile environment of the lunar poles needs to be defined, including an evaluation of the ambiguities in different data sets, to plan the mission operations and sampling strategies.

The current version of the mission requirements needs to be clarified and described in more explicit and consistent terms. The current version is vague and inconsistent in terms of details (e.g., the statement is made that the objective of the RPM mission is to validate the LCROSS measurements and make measurements while traversing in the dark).

A rationale for each requirement needs to be established based on a current understanding of the environment and acquiring specific types of data. Many of the requirements appear to be ad hoc, in the sense that there is no rationale for the stated requirements. Details regarding whether measurements are absolute or relative; whether uncertainties are 1 or 2 σ, etc. should be defined.

The stated requirements appear to be derived from the capabilities of a previously designed system, rather than derived from the questions to be addresses and types of data necessary to address those questions. For example, the hydrogen reduction of the regolith to produce water is a technology demonstration better suited to mid- and equatorial latitude sites, not the polar highlands are where the RPM polar mission will land.

A prioritization of measurement objectives (analysis and sampling) is required to guide mission operations and ensure success. Such a prioritization could also help guide possible descopes that might be needed if cost or schedule issues arise.

The subsurface sampling strategy and hardware should be defined as soon as possible. The current design carries an auger, push tube, and drill to acquire samples. It is not clear why three different sample acquisition mechanisms are required, given the cost, risk, and complexity of design and operation on the surface. A clear traceability between the objectives and the sampling strategy needs to be defined. Additionally, possible inadvertent changes to the sample during its acquisition should be considered and mitigation strategies devised.

The requirements indicate that a sample would be acquired from an area in shadow. This wording suggests that an area currently shadowed by a rock but not permanently shadowed would be sufficient to meet that requirement, but such a result would not answer one of our fundamental questions about volatile sequestration in permanently shadowed "cold traps." The value of and opportunities to obtain both such measurements should be specifically justified in the mission requirements.

Operations in shadowed areas require further definition. Given the limited time within a shadowed area (~6 hours), a concept of operations for exploration, sampling, and analysis should be developed to understand what is reasonably possible.

Site selection is critical to mission success. Currently, there are no specific requirements for the site or a defined process to select the site. While the mission operations may dictate certain aspects of the site, the scientific objectives also dictate requirements and these two aspects should be clearly defined and how they will be balanced and traded.

Mineralogy and general makeup of the regolith samples are critical to understanding the volatile content and the processes of its deposition. It is not clear how the mineralogy of the samples will be determined. A near-infrared volatiles spectrometer system (NIRVSS) beneath the rover will only observe the immediate surface and any material raised by the auger. The actual samples to be analyzed should be mineralogically examined by the spectrometer.

To properly simulate the experiments and validate their results, highland samples should be used to test the proposed experimental approach.

The con-ops scenario for mission operations has not been considered in sufficient detail and the version described appears inappropriate. This is a complicated mission with a short lifetime that will operate 24/7 for only 6 days. Experienced scientists should be an integral part of the operations team at all times in order to achieve mission success; decisions about sampling and analysis cannot be left to a non-scientist who makes a decision solely based on raw data sent from the spacecraft. Team scientists need to be included in operational readiness tests so that they are familiar with the operations approach and timeline.

There appears to be little interaction and input from the lunar science community as the mission is being formulated. While there was some interaction at an earlier time, presently all input appears to be in-house. An argument was made that this was because funding and time are limited. A large number of individuals from the lunar science and resource geology communities would be willing to contribute their expertise to help define aspects of the mission and the LEAG offers its assistance in this effort.

The LEAG offers to provide whatever assistance it can to help resolve the issues identified here, to broaden scientific participation in the mission, and to review the complete mission plan in the future once all of the flight elements are identified.

Submitted on behalf of the Lunar Exploration Analysis Group

Jeffrey Plescia
Chair
April 8, 2014

APPENDIX 1
RESOURCE PROSPECT MISSION
LEAG SPECIAL ACTION TEAM
TERMS OF REFERENCE

The Lunar Exploration Analysis Group (LEAG), at the request of the NASA Human Exploration and Operations Mission Directorate (HEOMD), will establish a Special Action Team (SAT) with the objective of assessing the NASA Resource Prospector Mission (RPM) and establishing whether the mission has appropriate objectives and is designed such that the risk of achieving those objectives is minimized with the context of Class D mission.

The SAT will consist of 7 members drawn from academia, industry and government. The membership will be established by the Chair of LEAG in consultation with HEOMD.

The SAT will meet, in person, at the Ames Research Center before March 1, 2014 to discuss the RPM mission and the SAT will deliver its report to HEOMD before March 30, 2014. The report may be in the form of text or ppt presentation (or both) such that sufficient information is provided to document the SAT's recommendation. A draft of the report will be forwarded to HEOMD and the RPM mission to ensure that the report is accurate and to resolve any outstanding issues.

The SAT will assess the goals (scientific, exploration, technology, programmatic), the questions to be answered, the measurement objectives, the proposed instruments, the mission design and the mission characteristics of the RPM Mission. The object of the analysis will be to determine whether these aspects are realistic and if the proposed implementation has an appropriate probability of success from measurement and objectives point of view. The engineering aspects of the mission are not within the purview of the SAT except to the extent that they impact the ability to achieve the objectives.

The report will be sent to Victoria Friedensen and John Connolly. The final report will also be available on the LEAG web site.

APPENDIX 2
Lunar Exploration Analysis Group
Resource Prospector Mission Special Action Team

Jeff Plescia
The Johns Hopkins University
Applied Physics Laboratory
Laurel, MD

Leslie Gertsch
Geological Sciences and Engineering
Missouri University of Science and Technology
Rolla, MO

Ben Greenhagen
Jet Propulsion Laboratory
Pasadena, CA

John Gruener
Johnson Space Center
Houston, TX

Vicki Hamilton
Southwest Research Instititue
Boulder, CO

Clive Neal
University of Notre Dame
Norte Dame, IN

Paul Spudis
Lunar and Planetary Institute
Houston, TX

Larry Taylor
Department of Earth and Planetary Sciences
University of Kentucky
Knoxville, TN

APPENDIX 3
Resource Prospector Mission
LEAG Strategic Action Team Review Agenda
March 4 2014

8:30 Welcome, Introductions
AES' background and goals

8:45 LEAG SAT Charter

09:00 Mission Overview – Soup to Nuts

09:30 Goals and Measurement Objectives
L1/L2s and trace to SKGs

10:00 Site Selection

10:20 Break

10:30 Payload

12:00 Lunch

1:00 Rover Overview
Requirements; Rover Status

1:45 Mission Concept and Operations
CONOPS
Traverse Planning

2:20 Break

2:30 Mission Requirements
Success Criteria / MOEs
L-1/2/3 reqs,
Analysis of Alternatives
Mission descope approach

3:00 Interpretation of Results - Implications of results
Success vis-a-vis increased understanding

3:30 SAT Executive Session

4:45 Adjourn