Preface

In 2007, the National Research Council published a report called *The Scientific Context for Exploration of the Moon*, which provided NASA, at its request, scientific guidance for an enhanced exploration program that would provide global access to the lunar surface through an integrated robotic and human architecture.

This was an important and fundamental growth in our ability to study the Moon. Prior missions, while extraordinary for their time, were limited to the nearside, largely to the equatorial region, had little mobility, and were short in duration. We have never been to the far side of the Moon, the western limb of the Moon, or either one of the polar regions. Most of the Moon remains unexplored. Global access with the capacity to travel substantial distances for greater periods of time would greatly enhance our opportunities to explore this fascinating world.

It is sometimes forgotten that the entire field of planetary sciences was born with geologic studies of the lunar surface and the samples that were returned to Earth. The Moon remains the foundation for studies involving planetary surfaces throughout the Solar System and even those beginning to emerge in planetary systems around other stars. The NRC (2007) report reminded the nation of those important links and outlined the major hypotheses around which lunar science still turns. The report then identified a series of eight key scientific concepts that capture the scope of lunar science and produced a prioritized list of thirty-five specific scientific goals designed to address them. It remains an extraordinary document, providing the blueprint needed to dramatically expand our ability to understand fundamentally important planetary processes that shaped the Earth-Moon system and many other parts of the Solar System.

The LPI-JSC Center for Lunar Science and Exploration was created, in part, to help integrate NASA's scientific and exploration objectives. With that in mind, we developed a multi-year landing site study designed to ask a simple question for each of the scientific goals in the NRC (2007) report: Where on the lunar surface can you address them?

We were also tasked to support the development of lunar science community that both captures the surviving Apollo experience and trains the next generation of lunar science researchers. To accomplish both tasks, we created the Lunar Exploration Summer Intern Program, which allowed teams of graduate students and a few advanced undergraduate students to work with LPI and JSC science staff and other collaborators to identify landing sites that address the National Research Council's science priorities. The students' principal responsibilities were to study those lunar science priorities, define their mission requirements, and integrate them with a study of the lunar surface to identify a list of reasonable landing sites. This was a unique team activity that fostered extensive discussions among students and senior science team members. The program also provided an opportunity for the interns to visit facilities at the NASA Johnson Space Center to observe lunar science and exploration activities (i.e., the development of the Lunar Electric Rover and Space Exploration Vehicle) that are feeding into the lunar exploration program.

Eight teams, over a five year period, have produced a set of landing sites that are suitable for robotic and human exploration missions. Each team was assigned one of the NRC (2007) science concepts and asked to identify sites where each of the concept's scientific goals could be addressed. In some cases this exercise produced an array of discrete locations on the lunar surface while, in others, it identified large regions where the issues could be addressed. Maps with those locations were compiled for each scientific goal.

It is important to point out that this is a completely novel and objective way to identify landing sites. In the end, when we overlay the maps for each of the goals, a series of scientifically-rich landing sites emerge. Some of the most fascinating sites that you will read about in the following pages have never appeared in previous studies of landing sites, because the latter were burdened with other constraints or selection biases.

The teams studied Science Concepts 1 through 7. They did not pursue Concept 8, because the science in that concept will be investigated with the Lunar Atmosphere and Dust Environment Explorer (LADEE), which has already been selected for flight. Throughout the landing site study, we remained responsive to the evolving needs of the exploration program. In the midst of the study, several study groups, including the LEAG (Lunar Exploration Analysis Group) Science Scenarios for Human Exploration Strategic Action Team, were asked to evaluate science opportunities within the South Pole-Aitken basin. At that time, scenarios involving exploration within 500 km and 1000 km mobility distances of the South Pole were being considered, as were sortie missions throughout the basin. To assist with that stage in the development of the exploration architecture, one of our student teams conducted a separate study that examined where each of the NRC (2007) science concepts and goals could be addressed within South Pole-Aitken basin. As readers will see in the following pages, that generated a particularly rich set of landing site options within the South Pole-Aitken basin.

Throughout these studies, the Lunar Exploration Summer Intern Program was governed by an important observation:

- Ever since the world marveled at the first step, we have been diligently contemplating the second.

It was also designed to:

- Integrate science with lunar exploration, while creating real opportunities for tomorrow's leaders.

And throughout each summer, the students were reminded to:

- Never stop exploring.

As readers turn through the pages that follow, they may also want to take inspiration from those lines.

The program was made possible by support from Dr. Wendell Mendell, Chief, Office for Lunar and Planetary Exploration, Constellation Systems Program Office, Johnson Space Center; the NASA Lunar Science Institute, Ames Research Center; and the Lunar and Planetary Institute. The students and I thank the people within those organizations for making the landing site study a reality.

At the end of each summer, the students briefed the LPI and JSC communities, including members of the former Constellation Systems Program Office, the Lunar Destination portion of the current Human Spaceflight Architecture Team (HAT), and the Astronaut Office. Multiple mission concepts have already been explored within NASA using the input the students provided. The following report assembles all of the students' work and makes it available to the broader lunar community, supplementing portions of it that have appeared in abstract form and in two papers (listed below). The work is released with a single caveat: the results represent a series of summer studies and are not intended to provide final detailed descriptions of landing sites. Nonetheless, the landing site study provides a comprehensive and global assessment of the NRC (2007) science goals for the Moon. It is an excellent foundation for more detailed studies once specific missions are being planned.

This landing site study is part of a larger effort to provide a productive interface between the lunar science and exploration communities that is designed to maximize science return and reduce mission risk. Tasks involve the development of lunar analogue study sites, the simulations of lunar missions in those study sites, and trade studies that investigate different hardware and operational options. We have, for example, assisted the Desert Research and Technology Studies program with simulations of 3-day, 14-day, and 28-day lunar missions using a combination of robotic and crew assets. The goal of those and other activities is to develop the architecture, tools, and operational protocols that will create the most efficient and productive lunar surface operations when our nation returns crew to the Moon.

We look forward to those missions. As the science in the following pages unfolds, it should be clear that the Moon is the best and most accessible place in the Solar System to explore the fundamental principles of our origins.

David A. Kring
Houston

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