Extreme Environment Technologies for In-situ Lunar Exploration

Tibor S. Balint1, James A. Cutts2, Elizabeth A. Kolawa3, Craig E. Peterson4

1Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, M/S 301-170U, Pasadena, CA 91109-8099
2JPL/Caltech, 4800 Oak Grove Drive, M/S 301-385F, Pasadena, CA 91109-8099
3JPL/Caltech, 4800 Oak Grove Drive, M/S 180-603J, Pasadena, CA 91109-8099
4JPL/Caltech, 4800 Oak Grove Drive, M/S 301-175E, Pasadena, CA 91109-8099
Tel: 818-354-1105, email: tibor.balint@jpl.nasa.gov

Abstract. Future exploration of the Moon – through robotic science and manned exploration missions – is proposed by virtually all national and international space agencies. At NASA, proposed science missions are included in the 2006 Solar System Exploration Roadmap in response to recommendations by the National Research Council’s Decadal Survey (NRC DS), while exploration missions were addressed in the Vision for Space Exploration. A number of these planned missions have elements that must survive and operate in extreme environments (EE). Environments on the Moon are defined as “extreme,” if spacecraft components, throughout various mission phases, are directly exposed to extremes in temperature, thermal cycling, dust, radiation, and for sample return missions to extremes in Earth re-entry heat flux and deceleration. Consequently, some of the lunar in-situ missions could be in need of technologies for extreme environments. While some of the technologies for EE mitigation are currently available, development of numerous new technologies are also required to enable a number of these proposed missions. To address these needs – and others for solar system exploration – NASA’s Planetary Science Division (PSD) within the Science Mission Directorate (SMD), supported a technology planning effort at JPL, with a specific goal to identify the technologies needed for future missions. More specifically, it attempted to determine those technologies where a NASA investment can have the greatest impact on future missions. In this paper we outline a subset of the findings by the EE Technologies Study Team related to robotic lunar in-situ exploration, including discussions on the state of practice of EE technologies; mission impacts; and emerging technology capabilities to enable mission architectures. Under systems architectures we describe protection systems; component hardening; and hybrid systems. For technologies we summarize low temperature power storage and generation; thermal management to mitigate thermal cycling; low temperature operations; sample acquisition and handling mechanisms; mobility; and thermal protection systems (TPS) for Earth return aeroshells. It is expected that the work summarized here and reported in the EE technologies assessment would play an important role in documenting the needs for technology investments, and would support the formulation of a coherent program to address extreme environment technologies. In addition, this paper could provide a valuable overview of relevant technologies to benefit the international community’s plans to explore the Moon.

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REFERENCES


TIBOR BALINT’S BIO

Tibor Balint is a Senior Engineer at the Jet Propulsion Laboratory, California Institute of Technology, in Pasadena, CA. His work within the Planetary and Lunar Missions Concepts Group involves programmatic support on technologies and mission concepts to NASA’s Planetary Science Division. Tibor obtained several masters degrees from the Technical University of Budapest, Hungary; the University of Exeter, UK; and the International Space University, France; and a PhD in engineering from the University of Warwick, UK. He also worked as a nuclear design engineer for 9 years at Ontario Hydro, Canada.