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Author: Mrs. Christina Toldbo
Technical University of Denmark - National Space Institut (DTU Space), Denmark,
christina.toldbo@gmail.com

Mr. Adam Kiss
Technical University of Denmark - National Space Institut (DTU Space), Denmark, adamantan@gmail.com
Mr. Noel Törjék
Technical University of Denmark - National Space Institut (DTU Space), Denmark, ntorjek@gmail.com
Mr. César Alejandro Torrealba Vázquez
Technical University of Denmark - National Space Institut (DTU Space), Denmark,
cesar.torrealba.vazquez@gmail.com
Mr. Dániel Bényei
Technical University of Denmark - National Space Institut (DTU Space), Denmark, benyeid@gmail.com
Mr. Magnus Oksbøl Therkelsen
Technical University of Denmark (DTU), Denmark, magnus@thrklsn.dk

IN-SITU NAVIGATION SYSTEM FOR PRECISION LUNAR LANDINGS

Abstract

In the near future, missions to the Lunar South Pole will commence. These will initially be prospecting missions but with the development of the Lunar Orbital Platform Gateway (LOP-G) and NASA's Artemis program, manned and unmanned missions to the Lunar South Pole are planned to occur several times each year [1]. Plans to establish a permanent human outpost on the Lunar South Pole will require the capability to soft-land successive missions in near proximity to each other. However, the Lunar South Pole is a notoriously challenging environment due to poor illumination and Earth line of sight conditions, combined with hazards in the form of boulders, craters and slopes. Although landing technologies have been developed and refined, the precision requirements and increased landing frequency warrants new approaches in navigation technology [1],[2].

We present a concept for an in-situ navigation system installed on the lunar surface to support frequent, pin-point lunar landings at the same landing site. The system consists of a series of radio beacons deployed on the lunar surface around a designated landing area. The position and velocity of the approaching lunar lander is determined using multilateration and time of flight measurements.

We assume the Shackleton Crater Rim "SR1" landing site on the Lunar South Pole as the targeted landing site and present simulated navigation results obtained from lunar landers approaching directly from Earth or from the Lunar Orbital Platform Gateway (LOP-G) currently under construction. We present considerations for optimal placement and geometry of the radio beacons based on the landing site topography and an analysis of dilution of precision (DOP).

The beacons are deployed using a novel method based on surface penetrator technology combined with embedded thermoelectric generators (TEGs). The deployment method is inexpensive and efficient as it allows all the beacons to be deployed at once. In addition, the beacons penetrate to a depth of a few meters where the temperature gradient is large enough to enable self-sufficient power generation for the

beacons using the embedded TEGs and thereby ensuring long term survivability of the system.

References

[1] *Artemis Plan* 2020, National Aeronautics and Space Administration (NASA), NASA's Lunar Exploration Program Overview.

[2] *ESA's Technology Strategy* 2019, European Space Agency (ESA), ESA's Technology Strategy.