PRELIMINARY DESIGN OF THE GRAINCAMS PAYLOAD: A SUITE OF TWO LIGHT FIELD CAMERAS FOR THE STUDY OF DUST PARTICLES ON THE LUNAR SURFACE. Dukhang Lee[1], Bongkon Moon[1], Minsup Jeong[1], Jehyuck Shin[1], Jihun Kim[1], Dae-Hee Lee[1], Seonghwan Choi[1], Minbae Kim[1], Woojin Kim[1], Chae Kyung Sim[1], Mingyeong Lee[1,3], Seul-Min Baek[1], Sungsoo S. Kim[2], and Young-Jun Choi[1,3], [1]Korea Astronomy and Space Science Institute, 776 Daedeok-daero, Yuseong-gu, Daejeon 34055, Republic of Korea (7grace7@kasi.re.kr), [2]Department of Astronomy and Space Science, Kyung Hee University, 1732 Deogyeong-daero, Giheunggu, Yongin-si, Gyeonggi-do 17104, Republic of Korea, [3]University of Science and Technology, 217 Gajeong-ro, Yuseong-gu, Daejeon 34113, Republic of Korea.

Introduction: GrainCams is a suite of two light field cameras, called SurfCam and LevCam, for the study of the regolith structure and dust particles on the surface of the Moon. The science goal of SurfCam is to study the characteristics of the 3-D microstructure of the upper lunar regolith, known as the 'fairy castle structure,' and that of LevCam is to detect the electrostatically lofted dust particles near the lunar surface [1].

GrainCams is designed to be used on a lunar rover so that SurfCam can observe undisturbed areas of the lunar surface that could be disturbed by the descent engine exhaust plumes of a lander, and LevCam can orient its field of view (FOV) against the sun to increase visibility and detection probability of lofted dust particles that reflect solar radiation against a deep space background (Fig. 1). SurfCam is stowed during the stand-by mode while the rover is moving to prevent dust deposition on the lens, and deployed during the observation mode.

The GrainCams development team at the Korea Astronomy and Space Science Institute (KASI) has passed the Preliminary Design Review (PDR) at the end of 2022, suggesting it to be onboard a Commercial Lunar Payload Services (CLPS) lunar lander [2].

Optical System Design: The SurfCam optical design utilizes a micro lens array of ~400 x 300 placed in front of the detector to produce 3-D microscopic images. The optical system has a magnification of x3 with an aperture size of ~30 mm and a spatial resolution of approximately 20 μm in the 400 to 700 nm wavelength range.

The LevCam optical system uses a micro lens array as well, but it has a smaller number of lenslets (~48 x 45) as the main scientific objective of LevCam is to detect (not to obtain resolved images of) levitating or lofted dust particles. LevCam has a larger aperture size of about 70 mm with a FOV of ~7° to gather more light. Its working distance is 1 m.

Mechanical Design and Analysis: The opto-mechanical design of each camera is able to maintain the required optical performance within the operating temperature range (-20 to 60°C). The cameras have a total mass of less than 9.6 kg and are designed to be thermally adiabatic from the rover. A dust mitigation module is being developed as an emergency plan in case the cover glass of the SurfCam optical system accidentally touches the regolith and becomes dirty [3]. This module, which can shake off a significant portion of deposited dust grains by vibrating, is attached to the front end of the optical barrel.

We performed structural analyses of the cameras to verify their mechanical designs. The results of the modal analysis in free-free and fixed conditions and linear static analysis assuming ~60g showed the cameras have enough margin of safety.

We also performed thermal analyses under worst case scenarios. Using the initial results of these analyses, we optimized the thermal design, including the radiator design, and determined the necessary heater power in the worst cold case. Both the stand-by and observation modes were considered in the SurfCam thermal analysis.

Electronics Design: The operation of the SurfCam and LevCam cameras is controlled by the GrainCams Electronics Box (GEB), which is physically installed on the LevCam electronics box. The GEB is designed to be electrically connected to the rover via RS-422 (data & CMD/TM) and power channels (main & heater). The detectors used are CMOS sensors: IMX253 for SurfCams and e2v 3D BORA for LevCam.

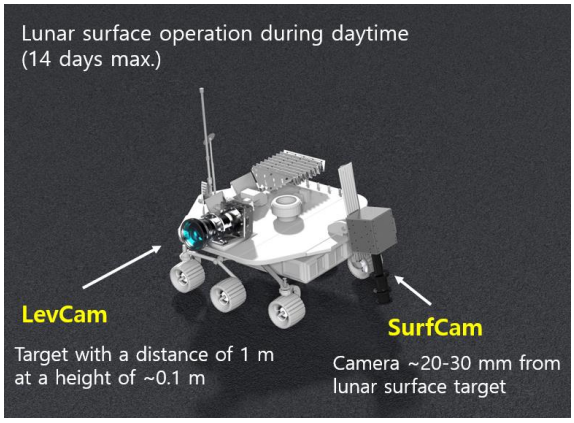

Figure 1. An illustration of GrainCams onboard an arbitrary rover, with SurfCam in the observation (deployed) mode.

The SurfCam and LevCam electronics were designed based on the experiences and heritage of the COronal Diagnostic EXperiment (CODEX) payload and the PolCube CubeSat Polarimeter, respectively. These electronics have successfully undergone environmental tests including radiation, thermal vacuum, and vibration tests.

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