UCL	**Project: ESA LUNAR LANDER CAMERA** **MULLARD SPACE SCIENCE LABORATORY** **UNIVERSITY COLLEGE LONDON** **Author:** Dr. Andrew Griffiths

TITLE: L-CAM Executive Summary

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CHANGE RECORD

Issue	Date	Sections changed	Comments
1	30 Oct 2013	All	First Issue
2	13 Nov 2013	Sec 1	Update to thermal model

CONTENTS

1 Executive Summary

Beginning in June 2012, an MSSL-led team have performed a study of the requirements and design of a Lunar Surface Camera Package for Exploration L-CAM for the ESA Lunar Lander. However, the Lunar Lander program was terminated by the ESA Ministerial Council in November 2012. As a result, with four of the six TNs requested in the SoW completed, ESA instructed MSSL to concentrate work on the L-CAM thermal model. The following final report is therefore composed of TNs 1-4 and the Thermal Report.

TN1 analysed the top-level requirements provided in the SOW and found the majority of them to be applicable and well written. One requirement (RQ17) was modified, one new science requirement (RQ37) was added and five (RQ5, 23, 24, 34 and 36) were converted to sub-level requirements. Additionally a total of 88 new lower level requirements were generated. A requirements traceability matrix was included (as requested at the ESTEC requirements review meeting of 18 September 2012).

TN2 provided a description of the relevant state-of-the-art of existing camera technologies. Several examples of sensor designs, stereo acquisition technologies, panoramic imaging techniques and multispectral/hyperspectral systems were considered. The pros and cons of each option were discussed and examples provided of missions where the technologies under discussion had been flown. A short description was also provided of the study team's previous Moonrise context imager design, a contribution to the NASA Moonrise South Pole-Aitken lunar sample return mission.

The identified technologies were then examined to determine their compatibility with the L-CAM requirements specification and a compliance matrix generated. This analysis indicated the need for both wide and narrow-angle imaging and that a filter wheel-based fixed-baseline stereo system best met the L-CAM requirements while minimising system complexity and mechanism count. The analysis also demonstrated that the EPC system met the majority of the requirements, possessing most of the technical features required for L-CAM.

Finally, the following technical issues with adopting the current ExoMars Panoramic Camera (EPC) design (due to lander context and environment) were considered:

- Thermal Environment
- Radiation Environment
- Lunar Dust
- Micrometeoroid Impact

- Low Sun-Angle in HS Mode

Where these issues were judged to prevent the current EPC design from meeting all of the L-CAM requirements, potential solutions and areas for further study were identified.

TN3 established a package design description of the Lunar Lander surface camera system. Given the conclusions of TN2, it is adapted from the EPC Design Report.

TN4 established a preliminary experiment interface control document (E-ICD) for the Lunar Lander surface camera system as required in Task 2 of the SOW. It also follows the format of the EPC E-ICD.

A thermal model of the L-CAM Optical Bench was built and analysed using ESATAN TMS. The baseline steady state hot and cold cases (for the latter case with the instrument both operating and not operating) were modelled and analysed, with the result that the EPC design would experience unacceptably high internal temperatures. Based on this result further modelling was undertaken to analyse potential thermal design changes to mitigate this issue.

The conclusions of this modelling effort are:

- For the baseline analysis, the heat flows were balanced and deemed realistic.
- The criterion for the analysis is that the operational temperatures for the electronic components (i.e. PIU, DC-DC Converter, WACs and the HRC) are kept within the -50°C to +30°C operating range.
- The baseline (EPC design) hot case yields unsatisfactory high temperatures.
- Using polished gold or MLI for the OB exterior surfaces increases that effect.
- Using a high emissivity, black external surface coating reduces the temperatures in the hot case. The temperatures for the PCBs are still high but better coupling to the optical bench could reduce this. In the cold case however, the temperatures are below the minimum operating temperature.
- The use of 2 Watts of additional heating was explored with the black coating in the cold operating case. This was only applied between the PIU, the WACs and the DC-DC converter. It showed that the temperatures for these units could be brought into the operational temperature range. The HRC was left unheated but the same principle could be applied to the components of this camera.
- For the cold non-operating case it was determined that 2W of survival heating (distributed between the WACs, HRC FPGA and PIU) was sufficient to keep the instrument above the minimum operating temperature. A total of 5W of

warm-up heater power is required to get the instrument above the minimum operating temperature in the steady state.

- The HRC motor temperature is always high, so its thermal coupling must be investigated in any future analyses.
- Other known technologies for varying the emissivity of the external surfaces could be use but would result in increases in mass and complexity of L-CAM
- A future development could be electrochromic devices with variable electrically-controlled absorption and emissivity.

The thermal modelling suggests that there is a simple, low mass technical solution to the thermal problems inherent in using the EPC design on the Lunar surface.