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Progress in Development of a Dust-Resilient Active Radiator for Lunar Applications

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The design of active radiators for the lunar surface is influenced strongly by extreme temperature variations, risks associated with highly abrasive lunar regolith and thermal cases including those with high IR backload from the surface of the Moon as well as the long lunar night.

For hot cases during the lunar day, surface temperatures are higher than the radiator operating temperatures. Zenith pointing is often preferable, but not always possible. If not suitably protected, the high lunar surface IR backload could result in a 'run-away' effect in radiator sizing. In configurations where it is not possible to mount the radiator to be zenith pointing, the IR back-load from the lunar surface needs to be minimised by constructive means. Zenith pointing radiators can be more impacted by direct solar irradiance, though this factor is more relevant in lunar equatorial regions and becomes less problematic towards the Lunar Poles.

The cold case on the lunar surface is driven by the duration of the lunar night. There are regions close to the Poles with almost permanent sunlight and also with permanent shadow. Yet, on average the lunar night is 14 Earth days in duration for most latitudes. These long duration thermal cycles necessitate an active control to 'close' the radiator and minimise heat rejection during the cold phase.

The development of an active radiator of the thermal shutter type is described, being led by ESR Technology under ESA Expro+ funding, with the support of Almatech SA, Spacemech Limited and Space Science Solutions Limited. 2 initial concepts were developed with working prototypes built, including an alternative solution based on a flexure-based louvre device, in addition to a thermal shutter device. A thermal analytical model was developed in Python, to study the relative benefits of the thermal shutter and louvre devices according to the lunar latitude and orientation of the radiator as it is required to be as universal as possible to support applications on landers, rovers, ISRU and other science instrumentation packages. This analysis was a key input to the overall trade-off analysis that resulted in the selection of the thermal shutter device, which was favoured for higher overall field of view, potential for lower mass and high reliability due to overall mechanism simplicity.

The current design baseline will be presented, highlighting key thermal design choices and thermal capabilities predicted for this device as well as the mounting approach taken. A brief overview of the mechanism design will be provided to demonstrate the dust-resilient approach for this device, as it is intended for EL3 lander and related surface applications.

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