

SATIRIM

Executive Summary Report

Report

[OIP-ESR]

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Distribution list

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# Executive Summary

In this contract OIP and its subcontractor VITO, have investigated the application of uncooled microbolometer detectors in thermal imagers for space missions. In particular, it was investigated if this technology is suitable for earth observation, with special attention to the measurement of evapotranspiration of the earth’s vegetation. Evapotranspiration is the loss of water by plants, by both evaporation and transpiration.

Knowledge of the evapotranspiration is economically important, for example to monitor the irrigation needs of agricultural fields.

With thermal imager microbolometers differences in thermal radiation can be measured. So they can be used for imaging in the long wave infrared spectrum, covering the wavelength range from 8 to 14 micrometer.

The final goal would be to deploy a cubesat constellation, each cubesat using an uncooled microbolometer as thermal imager to provide (near-)daily coverage.

In the first phase of the project, VITO established the scientific requirements of such a mission.

OIP investigated if and how these scientific requirements could be achieved. It was evident quite early that a relatively large optical system would be needed.

A major conclusion of the study is that microbolometer detectors that are suitable for use in space missions are commercially available. They can withstand the space environment and maintain their performance.

To investigate this in further detail, a commercially available microbolometer detector was integrated in a breadboard of a thermal imager.

The complete breadboard setup consisted of an objective lens, microbolometer sensor, readout electronics, framegrabber and computer. By this way, a thermal image of a certain scene can be easily captured and stored on the computer.

The radiation reaching the sensor was artificially adapted to the levels which would be seen in a typical space flight.

The objective of a first series of tests was to determine the minimum resolvable temperature difference, for a range of targets of different sizes. The performance of the sensor was as expected, or slightly better that expected.

In a second series of tests a large number of images of a uniform scene were made. This was done for a range of temperatures of the scene and for a range of temperatures of the camera itself.

Using all these images as a set of calibration images, it was then checked how accurate the temperature of a scene could be measured by the system.

The conclusion is that there is an uncertainty of the temperature measurement. This can go up to 10°C, which is about 6 times more than expected.

Increasing the radiation reaching the sensor could improve this. This can be done in two ways: increasing the size of the optical system and increasing the width of the spectral bands being transmitted to the sensor.

A third evaluation was done on the sensor, regarding the speed with which it reacts to changes in the scene. Since the microbolometer sensor performs its measurements by reaching a thermal equilibrium with the scene, via the radiation emitted by the scene, it can be understood that this is takes some time.

The relaxation of time of the sensor is a measure for this. After consulting with the manufacturer, it became clear that reaching a full equilibrium can take up to 30 milliseconds. This seems fast, but for the intended application, the speed of the satellite will cause some blur in the image. This was experimentally verified during this project.

As an overall summary we can conclude that the microbolometer technology can be applied in thermal imagers for a space mission Solutions will have to be found for the two identified limitations: the relaxation time and the temperature measurement accuracy.