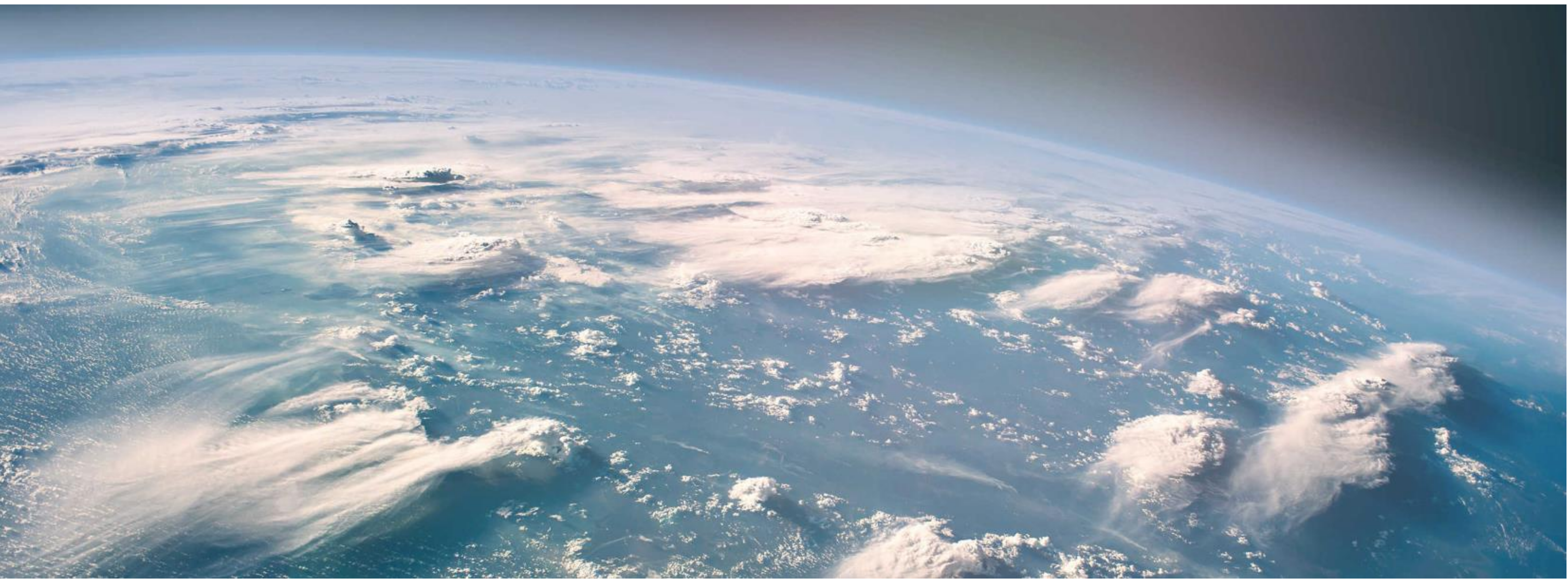
SURPRISE

SUPER-**R**ESOLVED COM**PR**ESSIVE **I**N**S**TRUMENT IN THE VISIBLE AND MEDIUM INFRARED FOR **E**ARTH OBSERVATION APPLICATIONS



Summary of Detailed Evaluation Report [D4.4]

CNR – IFAC

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Based on the specifications and final optical design, D4.4 provides an evaluation of the expected performances of the SURPRISE demonstrator. The demonstrator is conceived as a whiskbroom spectral imager working in the VIS-NIR and MWIR spectral ranges, able to acquire super-resolved images of a generic target by using an implementation of CS architecture. The scene is scanned along two axes by means of a suitable target scanning system.

The expected performance of the demonstrator has been evaluated considering the following main aspects:

- Total diffraction efficiency of the optical system, with reference to the optical section from the collection optics to the collimation optics, which includes the SLM as a core element of the demonstrator; the study also included the analysis of the effects of the micromirror tilt angle tolerance on the diffraction efficiency.

- Radiance expected at input of the VIS-NIR and MWIR channels and evaluation of the photoelectrons generated at the VIS-NIR channel and the analogue output voltage at the MWIR detector;

- Image reconstruction tests starting from two dataset of simulated images that were generated by taking into account the demonstrator's main optical parameters.

The evaluation of the total diffraction efficiency of the optical system's section comprised between the collection and collimation optics was carried out by means of numeric simulations. It took into account the main opto-mechanical parameters of the final design of the SURPRISE demonstrator. This evaluation included both the diffractive effects introduced by the finite size of the collection optics and those introduced by the intrinsic characteristics of the array of micromirrors constituting the micropixel. This efficiency is wavelength dependent and is an essential step for the evaluation of the expected performances of the different spectral channels, with particular reference to the MWIR channels. Also the effects of the micromirror tilt angle tolerance on the diffraction efficiency was analysed.

The evaluation of signal intensity at the input of the VIS-NIR and MWIR channels provided indications for the selection of the most suitable detectors. The radiance expected at the input of the VIS-NIR channels is relatively high and does not pose major constraints on the selection of the spectrometer and detector. On the other hand, the evaluation of the expected radiance for the MWIR channels provided useful inputs for the selection of the single element MWIR detectors and the range of target's temperatures that could be detected and the relevant integration times expected for the acquisition.

CS image reconstruction tests were carried out starting from simulated dataset that took into account the main characteristics of the SURPRISE demonstrator and its optical design parameters. These datasets were used as input for testing the performance of the reconstruction algorithms. In general, the results of the reconstruction tests confirmed that deep learning methods significantly outperform the traditionally used Total Variation (TV) algorithm. In the case of no compression, the deep learning approach yields an essentially perfect image, whereas the TV method has a quality plateau. Deep learning methods require a training image set and a training stage, although the latter should be not necessarily specific to the sensor under analysis; indeed, the results reported in this deliverable were obtained *without* retraining the deep network, which had been trained on natural (as opposed to Earth observation) images. For the MWIR bands, we used the TV model instead of deep learning approach since these bands have a very different informative content and sparsity with respect to the typical VNIR images used for training.

Additional tests were performed on a second dataset of simulated images, generated starting from hyperspectral images acquired in the laboratory with a VIS-NIR hyperspectral scanner on a natural target. For this dataset, the results underlined that TV provides results in line with the previous experiments.

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