Payload and application selection for a mini satellite mission at very low orbit

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Abstract. In the last decades, there has been a large increasing of small-satellite applications in many space programs, thanks, in particular, to their reduced cost and response time compared to larger satellite projects. The satellite altitude is another factor that impacts on the mission performance and design, since it allows smaller and less powerful payloads to provide performance comparable to larger sensors at higher altitude, but at expense of high propellant consumption.

This study concerns the selection of possible applications and related optical payloads for a mini satellite (IAA classification) of a total mass below 500 kg, operating at a Very Low Earth Orbit (VLEO - altitude below 250 km), thanks to an Air-Breathing Electric Propulsion (RAM-EP) system to win the atmospheric drag [1]. This satellite mission, hereafter referred as CLOSE, has the following features: altitude of 190 km, payload mass of about 100 kg, revisit time of about 10 days, power of 1750 w.

Respect to the CLOSE features, there are two aspects that affect the performance of an optical payload: (i) the VLEO altitude and (ii) the small size of the platform (mini-satellite). Both field of view and spatial resolution depend on the former, while size and weight of the sensor depend on the latter [2]. Since the typical altitudes of the Earth observation missions are between 600 km and 800 km, we expect that observed area of the CLOSE mission will reduce proportionally to h^2/h^2_{CLOSE} (between 9 and 16). The spatial resolution is proportional to the detector size and to the altitude h, and to the inverse of the instrument focal length (f). Therefore, either, on equal f the resolution improves by a factor proportional to h/h_{CLOSE} (between 3 and 4), or the same resolution value can be obtained reducing f (by a factor between 3 and 4). The latter option allows reducing the size of the instrument, which is a relevant issue for designing a mini satellite mission. Finally, since the received signal power is inversely proportional to the square of the distance and directly proportional to the square of the lens diameter, by decreasing the satellite altitude the radiometric quality of the images will improve.

A review has been carried out concerning the state of the art of both applications implemented through satellite optical data, and optical payloads of operative satellite missions. This has been needed in order to select the more promising applications with respect to the CLOSE features, and to evaluate the performance of CLOSE products in comparison to other missions. According this analysis, we selected as potential payloads multispectral/hyperspectral sensors, and as reference applications the following: i) vegetation mapping, ii) urban mapping, iii) contaminated sites

identification (illegal dumps), iv) hazard related to coastal erosion, v) cartography. Specifically, payload selection was carried out by verifying the compatibility of multispectral/hyperspectral sensors with both CLOSE features, and application requirements. For each selected application we perform a comparative analysis with respect to multispectral/hyperspectral sensors onboard of operative satellite missions. An example is reported in Figure 1 concerning the vegetation mapping, where the performance of CLOSE mission in terms of spatial resolution and revisit time is sketched by blue and red squares.

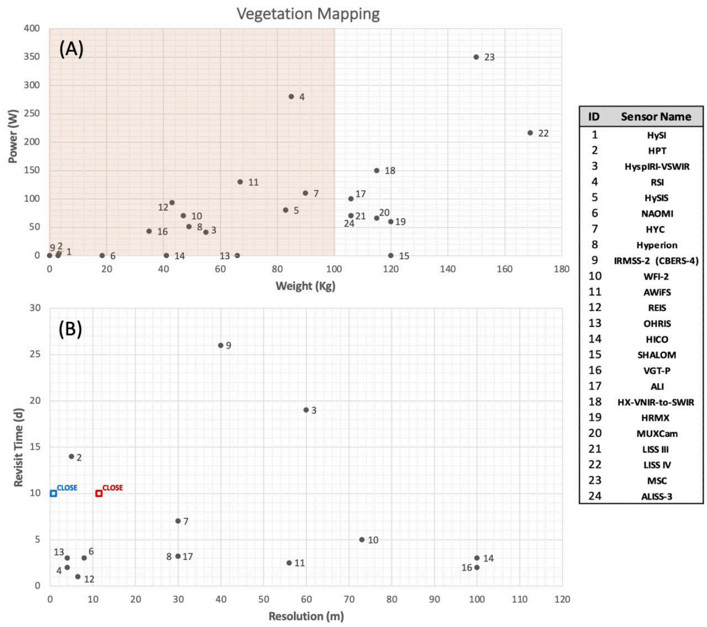

Fig. 1. (A) Scatter-plot of weight and power values of the satellite sensors supporting vegetation mapping applications. The red area encloses values fulfilling CLOSE mission requirements. (B) Scatter-plot of spatial resolution and revisit time of sensors lying within the red area in plot A. Number labels correspond to sensors according to the table on the right side.

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References

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