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Author: Ms. Tarifa AlKaabi
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates

Mr. Yousuf Faroukh
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates
Mr. Abdulrahman Sulaiman
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates
Dr. Antonios Manousakis
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates
Prof. Hamid Al Naimiy
Sharjah Academy for Astronomy, Space Sciences, and Technology (SAASST), United Arab Emirates
Ms. Amel Alhammadi
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates

OPTIMIZING CUBESAT CONSTELLATIONS FOR LEO EARTH OBSERVATION: MAXIMIZING COVERAGE AND REVISIT CAPABILITIES

Abstract

The trade-off between spatial and temporal resolution remains pivotal in Low Earth Orbit (LEO) Earth observation (EO). Larger platforms can deliver high-fidelity data at resolutions approaching sub 1m, but often revisit a given target only once a week. Smaller satellites—often in CubeSat form factors (6U to 20U) equipped with X-band downlink—can be deployed as constellations to achieve revisit rates up to twice daily, though at coarser resolutions (typically 5m).

Using STK simulations, we analyze various multi-satellite constellations to find the optimal number of CubeSats that maximize coverage and revisit frequency for a given target area. The focus is on maintaining a spatial resolution of 5 m while varying the number of satellites in the constellation, to identify the point at which adding more satellites no longer significantly improves the revisit rate or coverage.

The choice of orbital regime also plays a key role. Sun-synchronous orbits (SSO) offer consistent lighting for change-detection applications such as vegetation and deforestation/desertification. Polar orbits approach full global coverage, especially at higher latitudes, while mid-inclination orbits enable more frequent revisits over specific regions. Each orbit type interacts differently with sensor design and mission goals. For instance, advanced hyperspectral payloads, commonly found on larger satellites, excel at detailed environmental studies. Meanwhile, CubeSat constellations can be outfitted with narrower band sensors for rapid, broad-scale monitoring of floods, wildfires, or agricultural stress.

In summary, no single approach emerges as universally optimal. Missions requiring very high spatial detail and radiometric precision favor fewer, larger satellites, albeit with lower revisit frequencies. Rapid-response applications—disaster management, real-time agriculture, and weather-driven phenomena—benefit from CubeSat constellations that deliver frequent overpasses at modest (few meters) resolution.