BINAR
REVOLUTIONISING ACCESS TO SPACE

Curtin University

Remote Sensing: A CubeSat Study

What is the Study?

The purpose of this study is to inform small research groups on the potential Earth observation (EO) and remote sensing missions that are feasible and beneficial that can be conducted on small 1-2U CubeSats. The first steps are to identify the gaps in the current Earth observation missions run by the likes of NASA and ESA for example. By understanding the limitations of conventional satellites, we can match EO and remote sensing missions to the capabilities of CubeSat technology. Four potential EO missions are outlined describing the benefits of utilising CubeSats alongside traditional satellites.

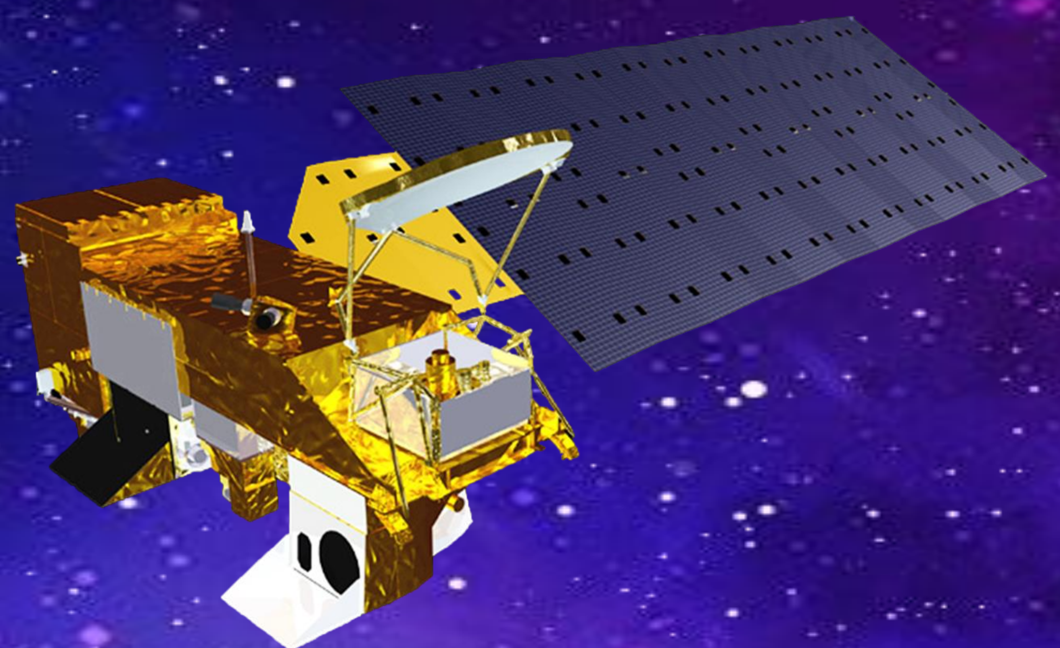
Earth Observation

Earth Observation (EO) or Remote Sensing is the process of obtaining information about the Earth's surface using satellite or aircraft-based sensors . It involves collecting data about the Earth's features, such as land, oceans, atmosphere, and vegetation, and analysing it to gain insights and make decisions. The spatial coverage that satellites provide means global observations can be taken consistently without the need for active monitoring or in-situ testing. EO satellites provide vital information about climate trends, disaster warning, security purposes and so much more. The development of CubeSats in this field will increase the accessibility to space for small research groups including high-school students, undergrad and postgrad students and researchers.

CubeSat Integration

CubeSats equipped with Earth observing remote sensors deployed in addition to traditional EO satellites can revolutionise access to space. Being small, relatively cheap and modular in nature means they can fill a variety of roles and can be utilised as a short life orbital with a high revisit rate. One of the downfalls of traditional non-geostationary satellites is that their revisit rate is relatively low as they are usually designed to cover the largest ground path. CubeSats can be designed to fill these gaps in satellite coverage with their relatively low cost and fast revisit rates. Space should be accessible to as many people as possible and the hope is that the missions suggested can aid in that goal.

Earth Observation Satellites



MODIS Satellite[1]

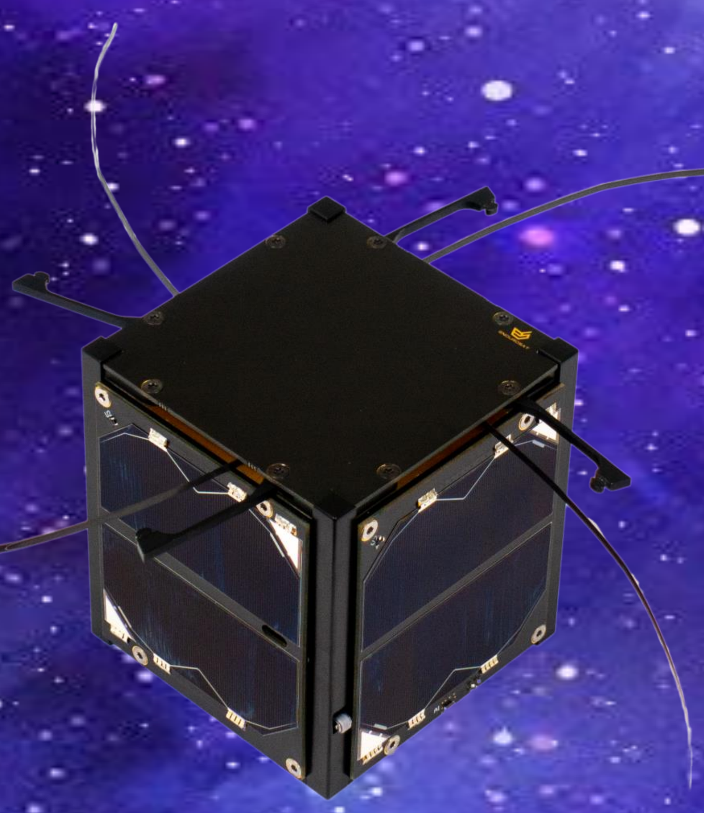
Unfeasible for small research groups

Expensive:
- **Manufacturing costs**
- **Launch costs**

Outsourcing:
- **Majority of engineering and innovation cannot be achieved within a small research group**

Restricted temporal scale

CubeSats



Binar 1 CubeSat[2]

Feasible for small research groups

Inexpensive
- **Student-developed < $10,000**
- **Tag-along launch system**

In-house development
- **Engineering**
- **Project opportunities**
- **Publicity**

Multitude of orbital capabilities

Earth Observation Missions Ideal for CubeSats

Bushfire Detection

Bushfires are becoming a more common occurrence with the current climate crisis with more frequent extreme temperatures and prolonged periods of drought. The current application of satellites in regards to bushfire emergencies is primarily utilised as a catalogue of on-going fires rather than an alert to new fires. MODIS Terra[3] (NASA's current surface temperature satellite) takes 2-4 hours from when the satellite passes the target location to process and upload the data and covers each point on the earth at a maximum of 2 days providing a spatial resolution of 250m. This delay significantly limits the effectiveness of satellite data and bushfire response time and hence provides a window of opportunity for smaller CubeSat systems to be deployed in targeted regions.

Wildlife Monitoring

Satellites are performing a substantial role in monitoring wildlife movement and supporting conservation efforts. They enable scientists to track animal movements through GPS and radio transmitters, providing valuable data on migration patterns and habitat use. Satellites also aid in identifying threats to species such as poaching, habitat encroachment and disease.

The radio receivers and transmitters on board the satellites are small and are usually added as secondary payloads. SmallSats have been used in the past including the ICARUS[4] system developed by the European Space Agency (ESA). This system utilises sensitive GPS tracking allowing for smaller tags on animals as small as birds. Some development however would be required before the tracking of marine life is possible due to the limited amount of time surfaced above the water for transmission and retrieval.

Land Deformation

Satellites can measure land deformation using a technique called satellite-based interferometric synthetic aperture radar (InSAR). InSAR involves using radar signals transmitted from a satellite to the Earth's surface and measuring the reflections of those signals that return. By comparing the phase and amplitude of the reflected radar signals over time, changes in the Earth's surface can be detected i.e land deformation.

CubeSats equipped with InSAR[5] can be deployed orbiting over target areas with high risk of deformation. Areas include volcanoes, tectonic plate boundaries and mountainous rockfall regions. Ordinarily having a satellite system focussed on one land area is unreasonable for the cost however having multiple cheaper CubeSats deployed over targeted regions allows for the coverage to be broadened with rapid revisit times.

Hurricane Detection

Traditional satellites detect hurricanes by capturing images of Earth's atmosphere using visible light, infrared, and other wavelengths. These images provide visual information about the storm's location, size, and structure. Satellites also measure cloud temperatures, atmospheric moisture, and microwave radiation emitted by hurricanes. Additionally, they use scatterometers to determine ocean surface roughness and geostationary satellites to provide real-time monitoring. By combining these data sources, meteorologists gain insights into hurricane intensity, movement, and potential impacts, enabling accurate forecasting and timely warnings.
These sensors have been scaled down to CubeSat requirements most recently by NASA[6] who have deployed systems to study tropical cyclones. .

References

[1,3]NASA, (2023), Fire Information for Resource Management System, https://firms.modaps.eosdis.nasa.gov/

[2]Binar, (2021), Binar-1, https://www.binarspace.com/mission/1/

[4]CORDIS; (2016), ICARUS for aerospace application, https://cordis.europa.eu/project/id/713514

[5]Wye, L. et al., (2016), A Constellation of CubeSat InSAR Sensors for Rapid-Revisit Surface Deformation Studies, American Geophysical Union, https://ui.adsabs.harvard.edu/abs/2016AGUFM.A33P..07W

[6]NASA, (2023), NASA, Rocket Lab Launch First Pair of Storm Observing CubeSats, https://www.nasa.gov/press-release/nasa-rocket-lab-launch-first-pair-of-storm-observing-cubesats

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