# High-Altitude Balloon-Launched CubeSat Platform for Small Satellite Undergraduate Space Technology Education in Saudi Arabia

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## ABSTRACT

In this work, we discuss the effort of King Fahd University of Petroleum KFUPM undergraduate students to design a Balloon CubeSat and fly it to an altitude of about 30km. This approach allows enhancing the payload through several launching attempts at a relatively low cost. The KFUPM balloon CubeSat is the first stage in a multi-year program to enable undergraduate students to design and test a CubeSat platform and eventually launch to Earth orbit.

## INTRODUCTION

The King Fahd University of Petroleum & Minerals (KFUPM), Saudi Arabia established a new Interdisciplinary Research Center for Aviation and Space Exploration (IRC – ASE) in 2022. Since then the IRC– ASE is working closely with the Saudi Space Commission (SSC) and industrial partners to establish an educational and a research small satellite program at the KFUPM. Through IRC-ASE internal fund and CapStone02 senior project, students were able to put together their first non-flying CubeSat design and a ground station.

The 1U KFUPM Balloon CubeSat payload includes a Raspberry PI as its onboard computer (OBC), four small camera, digital temperature and humidity sensors, GPS, and an Antenna. It is expected that adopting the Balloon CubeSat model will increase the educational impact by providing a low-cost platform for small satellites testing and undergraduate research.

## TECHNICAL APPROACH

This work includes performing two experiments using CubeSat payload:

### *Cloud seeding near Earth's surface*

Cloud seeding is a human-made way to induce moisture in the air so as to cause rainfall. In this process, either dry ice or silver iodide is dispersed in the air using an aircraft which leads to a rain formation. Alternatively, materials like table salt are increasingly being used. Researchers are also using cloud seeding as one way of increasing winter snowfall. At least 56 countries including the Kingdom of Saudi Arabia have used some sort of cloud seeding, according to the World Meteorological Organization.

The experiment aim to test cloud seeding within a small controlled environment using a CubeSat and a weather balloon. A cloud seeding experiment has been designed by the King Fahd University of Petroleum & Minerals (KFUPM), the Saudi Space Commission, and Nanoracks to answer this question. The experiment was operated under microgravity conditions at the International Space Station (ISS) and operated by two Saudi Astronauts onboard. In this work, a similar technique is used, however the experiment is operated near the Earth's surface using a weather balloon.

### *Soil moisture monitoring*

The objective of this project is to develop a decision-making tool to reduce carbon emissions of Saudi

Arabia by planting trees across the country especially in remote areas utilizing a space solution

**Parts list**

The following parts have been used in the design of the CubeSat and the ground station

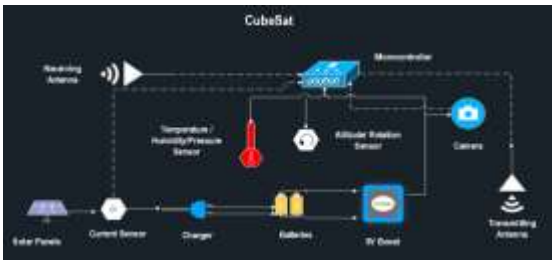


**Figure 1.** Schematic diagram for the KFUPM soil moisture CubeSat

***CubeSat***

- Wave share Environmental Sensor Sensing Environmental Temperature Humidity and barometric Pressure for Raspberry Pi STM32 I2C and SPI Interfaces
- Bipolar Ion Generator Air Purifier for Home A/C - 24VAC - Millions of Positive and Negative Ionization Output
- Ultrasonic Atomization Maker 20mm 113KHz Mist Atomizer DIY Humidifier with PCB 3.7-12V
- Micro Linear Electric Actuator Linear Actuator, 6.74 lbs/30N - High Speed 1.2"/sec DC 12V Waterproof with Brackets for Remote Controls, Robotics, Cosplay, Intelligent Range Hood, Home Automation.
- Uninterruptible Power Supply UPS HAT for Raspberry Pi Series Boards (Raspberry Pi 4

***Ground Station***

- S Series Nema 34 Stepper Motor Bipolar 1.8deg 12.0 Nm(1699.34oz.in) 6.0A 86x86x151.5mm 4 Wires
- Nema 42 CNC Stepper Motor Bipolar 30Nm (4248oz.in) 8A 110x201mm 4 Wires
- Digital Stepper Driver 0.5-8.2A 180-240VAC for Nema 34,42 Stepper Motor
- Digital Stepper Driver 1.8~5.6A 20-50VDC for Nema 23, 24, 34 Stepper Motor
- 400W 48V 8.3A 115/230V Switching Power Supply Stepper Motor CNC Router Kits
- Model B/3B+/3B) Charge and Power Output at the Same Time, Multi Battery Protection Circuits.
- JESSINIE for Raspberry Pi Bluetooth SIM868 Development Board GSM GPRS GPS Positioning Module Board Based on Raspberry PI 40pin GPIO Interface.
- Arducam Multi Camera Adapter Module V2.2 for Raspberry Pi 4B, Compatible with Rasperry Pi Camera Module 3/V2/V1, and 12MP IMX477 Cameras.
- 5 Megapixels 1080p Sensor OV5647 Mini Camera Module with 6 Inch 15 Pin Ribbon Cable Compatible with Raspberry Pi Model A B B+, Pi 2.
- Marstudy Raspberry Pi 4 Model B Complete Starter Kit -64GB Edition/Raspberry Pi 4B (4GB RAM) /Raspberry Pi OS Pre-Installed.

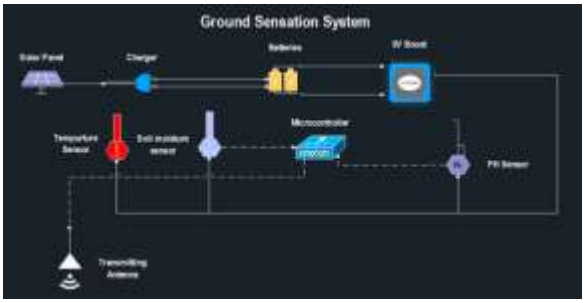


**Figure 2.** Schematic diagram of the ground station.

- Ratio 7.5:1 to 100:1 Worm Gear Reducer NMRV075 with 19/ 22/ 24/ 28 mm Input size and 28 Output size for NEMA42/52 Motor
- Sirio WY380-10N 380-440MHz Base Station 10 Element Yagi Ant
- NooElec NESDR Smart XTR SDR - Premium RTL-SDR w/Extended Tuning Range, Aluminum Enclosure, 0.5PPM TCXO, SMA Input. RTL2832U & E4000-Based Software Defined Radio.

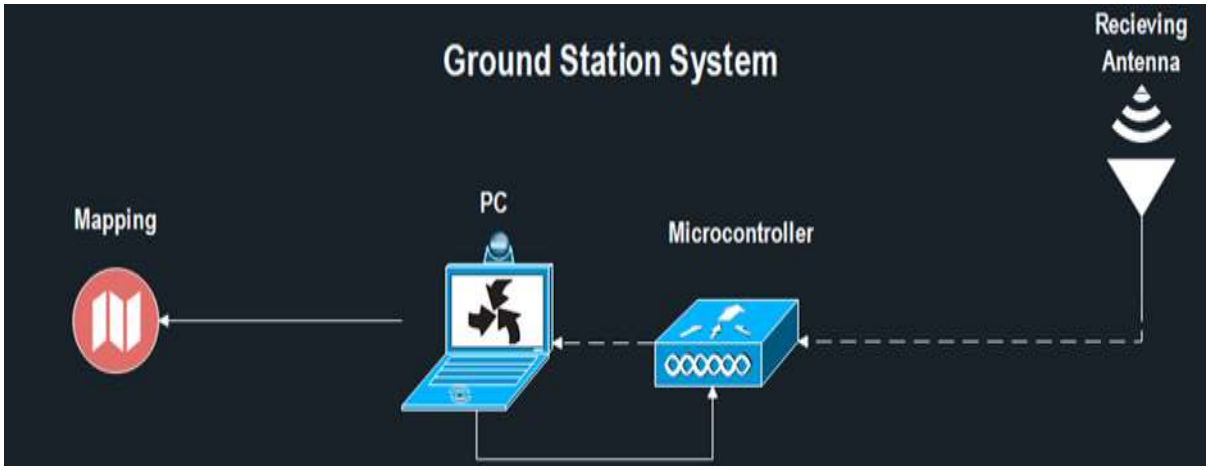


**Figure 3.** Schematic diagram of the ground station system with mapping tools

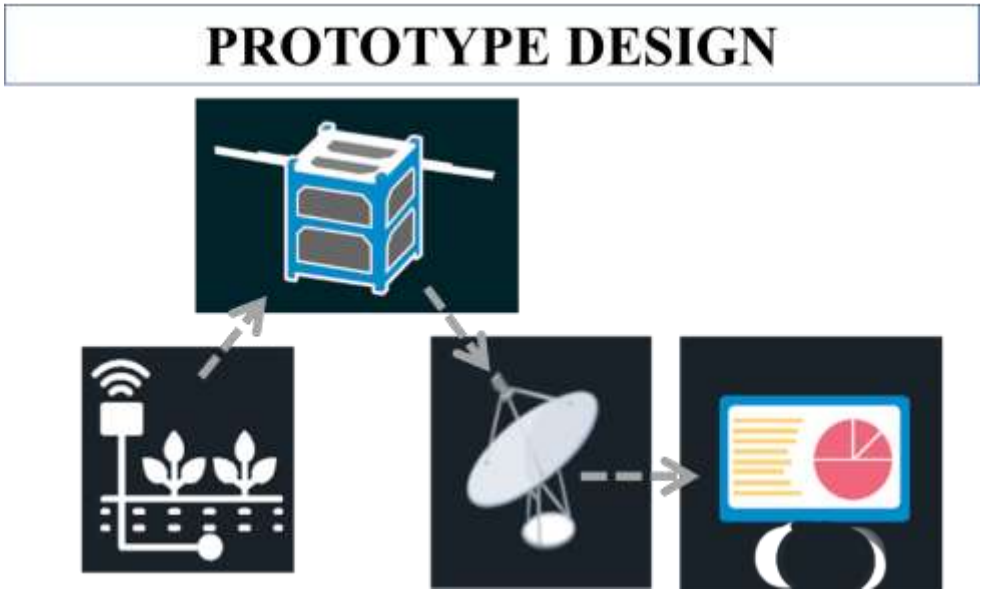


**Figure 4.** Schematic diagram of the soil moisture prototype design

Using the telemetry from the CubeSat a calculation of the power was done and it met the specification with a power consumption of 2.412 W. A calculation of the power from the solar and the power consumption ensure that the battery life will exceed 10 hours. The time for transmission and processing of sensors data met the goal in less than 6s. The achieved data rate is more than 3 times of the specified target.

## Conclusions

The KFUPM balloon CubeSat is an innovative solution to increase students' educational opportunities to have a hand on experience to designing and building a CubeSat and modify their design then reattempt to launch it. The research will also improve students' knowledge in research applications for high altitude balloon research programs. The payload will mimic a CubeSat standard structure design, thereby it will be an initial step for launching students' spacecraft to Earth's orbit.

The CubeSat proved that it is a valid solution for monitoring the soil in remote areas by sending numerical and visual data to Ground Station.

The cost for installing Ground Sensation Station is relatively low compared to other solutions.

For future recommendations, using gateways between different GSS would save both cost and energy.

***Acknowledgments***

Authors would like to thank the KFUPM Captston program for funding the senior students' soil moisture project and the Saudi Space Commission (SSC) for funding the cloud seeding experiment, and NanoRacks for helping to build the cloud seeding hardware.

***References***

1. Wesley S., The Spacecraft Challenge: A Student Satellite Program Accelerator, Small Satellite Conference, Utah, United States 2019

2. Friedhelm O., Martin K., Klaus M., Tom N., Heinz R., Martin R., Ralf K., Small Satellite Payload for Airglow Measurements in the Upper Atmosphere by Spatial Heterodyne Interferometry, Small Satellite Conference, Utah, United States 2019