iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VII **Month of publication:** July 2021

DOI: https://doi.org/10.22214/ijraset.2021.37043

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VII July 2021- Available at www.ijraset.com

1U CubeSat: For monitoring Weather and Air Quality Index from Low Earth Orbit

Jayrajsinh Parihar[1], Rishabh Patel[2], Aniket Parmar[3], Rishi Patel[4], Varun Jaiswal[5], Meet Patel[6]
[1, 2, 3, 4, 5, 6]*Department of Aeronautical Engineering, SVIT, Vasad, Gujarat, India*

Abstract: A weather satellite is a sort of satellite utilized essentially to screen the Earth's weather and environment. This research intends to plan a model of the 1U CubeSat, a Weather satellite to screen the state of a small geographic region and determine the weather conditions and air quality records. Different sensors like temperature, barometric, dampness, dust, and lux intensity sensors just as rain detectors are utilized to gauge actual amounts and separate circumstances for this reason. This framework utilizes nRF trans-receivers for the transmission of information from the CubeSat to the ground station. The report incorporates the list of components, fabricating procedures, and a plan of arrangement of Components. SolidWorks has been utilized to plan the model.

Keywords: Cubesat, Satellite, Nano-Satellites, Weather Monitoring, Air Quality Index, AQI

I. INTRODUCTION

CubeSats are a class of Research Spacecraft called Nano satellites. CubeSats are built to standard measurements (Units or "U") of 10 cm x 10 cm x 11 cm. They can be 1U, 2U, 3U, or 6U in size, and regularly weigh under 1.33 kg (3 lbs) per U. CubeSat is a kind of miniature satellite for space research. It is normally utilized as Commercial Rack Components (COTS) for electronics and their development. CubeSats are regularly dispatched into space by deployers on the International Space Station or dispatched as an auxiliary payload on a dispatch vehicle. To date, a huge number of Nano satellites are dispatched into space and the majority of them have been effectively sent to orbit. The Weather satellite is a kind of satellite that is essentially used to monitor the Weather and environment of the Earth. Satellites can be polar orbiting, covering the whole Earth non-concurrently, or geostationary, hovering over a similar spot on the equator. Meteorological satellites see more than cloud and cloud frameworks: city lights, fires, impacts of contamination, auroras, sand and dust storms, snow cover, ice mapping, boundaries of Ocean Currents, energy streams, and so on. Different kinds of ecological data are gathered utilizing Weather satellites.

A. *Problem Statement*

Draft and design a CubeSat of 1U capable of monitoring weather and Air Quality Index from low Earth orbit.

II. LIST OF COMPONENTS

FUNDAMENTAL COMPONENTS	SUB COMPONENTS
STRUCTURE AND MECHANISM (S&M)	Main structure Internal structure Antenna release Deployment switches Remove before flight pin
THERMAL CONTROL	Battery heater (active) Heat/EMI shield (passive) Mylar® (passive) Apiezon® grease (passive) Teflon® covered glass / polyamide for the z+ face cover (passive)

ELECTRIC POWER SYSTEM (EPS)	Solar panels Battery cell PCB module
COMMUNICATION SYSTEM	PCB module Antenna
ALTITUDE DETERMINATION AND CONTROL (ADCS)	Coarse sun sensors Gyroscope Control Magnetometer Magnetic torquers Reaction wheel
SCIENTIFIC PAYLOAD (PL1)	FPGA module Antenna
SECONDARY PAYLOAD (PL2)	PCB module Detector collector
COMMAND DATA AND HANDLING (C&DH)	Main PCB module Monitoring sensors Interfaces

III. METHODOLOGY

A. System Architecture

In the framework, some physical quantities like internal and external temperature, pressure, altitude, moistness, light intensity, proportion of dust just as the occurrence of precipitation are estimated or identified by their sensors and the information got, will be broken down by the microcontroller to decide the upsides of these actual amounts which may not be provided straight by the sensor. The information from the sensors will then, at that point be communicated to the ground station by nRF trans receivers. At the ground station, information got by the microcontroller through the receiver is then displayed on a serial monitor and saved to a text file for future reference.

B. Instrumentation

Different equipment parts have been utilized in this framework. They include the sensors, the controller, the trans receivers, and different segments.

1) *CubeSat Structure (External-Major):* The structure of CubeSat, for the most part is made of Aluminium Alloys 6061 – an appropriate material must be chosen and tested for all dispatch and thermal loads/specifications. The size of 1U Cubesat is 10cm x 10cm x 11cm.
2) *Antennae (External-Major):* Outline of the working frequencies, information rate, and Antennae gains for Weather observing satellites:

C. Operating Frequency Band

Application-explicit Frequency (range) - X-band (8–12 GHz) ·
Correspondence with a ground station (range) - S-band (2–4 GHz)

D. Communication Performances

- Required transmitting Gain - 26 dB and 37 Db
- Required information rate - Up to 400 kbps

1) *Solar Panels (External-Major):* The normal arrangement of Solar panels utilized in Cubesat is as per the following Mass (precise mass relies upon setup) - 1U: 50g Panel Thickness - Top/Bottom: 1.8 mm; Side Panel: 2.5 mm Operating
   a) Temperature - 40 to +125°C
   b) Force conveyed - 1U: 2.3 W
   c) Supply Voltage - 3V (5V and 8V on demand)
   d) Cell-Material – GaAs
   e) Cell effectiveness – 30%
   f) The material utilized – Fiberglass

2) *Batteries (Internal-Major):* Barrel-shaped 18650 (18 mm diameter and 65 mm stature) COTS cells are broadly utilized for CubeSats, because of their appropriate size and for the most part great capacity to bear the space environment. The Li-ion battery family covers various sciences, for this situation, their anode is commonly graphite or other carbon-based materials.
3) *ADCS Components:* The Attitude Determination and Control System (ADCS) is a critical subsystem of a spacecraft. It gives pointing preciseness and steadiness of the payloads and antennas as basic pieces of the S/C operation and the mission achievement.
4) *Payload Controller:* The payload regulator is a subsystem devoted to the interface between the payloads and CubeSat bus. It has various interfaces for payload association and can buffer information from payloads. It likewise controls the S-band transmitter or trans-receiver to send the buffered information to Ground Station.
5) *C&DH Subsystem:* The target of the Command and Data Handling subsystem is to give the CubeSat operation sequence to different subsystems. As a result of the size limitations of the CubeSat, the C&DH subsystem should be productive, small, lightweight, and simple to incorporate with the entirety of different subsystems in CubeSat. We picked a microcontroller that has built-in memories and timers; this makes the microcontroller the most basic segment in the C&DH subsystem. To help with choosing the right microcontroller (processor) and to meet the prerequisites of the OBC (On-board Computer), a bunch of minimum specifications was created and is listed beneath:
   a) EEPROM (Electrically Erasable Programmable Read-Only Memory) – min. 8 kB
   b) Flash - least 512 bytes
   c) SRAM (Static Read Only Memory) - least 512 bytes *f*

E. Desirable Feature
1) High processing speed – more than 4 MHz
2) Built-in Analog/Digital Converters
3) Programmable UART (Universal Asynchronous Receiver-Transmitter)

F. Master/Slave SPI Serial Interface
1) Controllable I/O pins
2) Programmable timers, especially the watch-dog timer
3) Minimum 16 bit architecture
4) Avoid Ball-grid-array (BGA) microcontrollers (Difficult to solder)

Low Power utilization – under 10 mA and voltage under 5 volts

Size – should fit on a 5 cm x 5 cm Printed Circuit Board

C compiler - must be accessible for the processor (microcontroller) Operable in the temperature range 0 – 40° C; be that as it may, the more extensive territory is best.

G. Sensors Utilized
1) *Temperature Sensor:* LM35 is utilized to gauge the exact centigrade temperature. The yield of this sensor changes portrays the linearity. It can recognize temperature with a reach - 55˚ to +150˚C. It was worked utilizing 5V. LM35 is interfaced directly with the microcontroller and the analog information it gives in voltage and afterward it is changed over to Celsius temperature.
2) *Barometric Sensor:* The BMP180 comprises of a piezo-resistive sensor, an analog to advanced converter, and a control unit with E2PROM and a sequential I2C interface. It offers the uncompensated value of pressure and temperature. The microcontroller sends an initial sequence to begin a pressure or temperature estimation. In the wake of changing over time, the

outcome value (pressure or temperature) can be read by the I2C interface. It gives temperature in Celsius just as the total pressure in hPa that varies with height. By utilizing a predetermined benchmark pressure, the relative pressure as well as altitude was determined.

3) *Humidity Sensor:* The humidity detecting component of the DHT11 is moisture holding substrate with the electrodes applied to the surface. At the point when water-vapor is absorbed by the substrate, it releases the ions, which expands the conductivity between the electrodes. The change in resistance between the two terminals is corresponding to the relative humidity. The resistance between the electrodes is contrarily corresponding to the relative moisture. DHT11 is interfaced directly with the microcontroller by diminishing input current utilizing a 1K resistor. It gives temperature as well as relative humidity.
4) *Optical Dust Sensor:* GP2Y1010AU0F contains an infrared transmitting diode and a phototransistor which are diagonally arranged into this gadget, to permit it to distinguish the mirrored light of dust in the air. The yield of the sensor is a simple voltage corresponding to the deliberate dust density. GP2Y1010AU0F is interfaced with the microcontroller directly according to its datasheet, utilizing a 150-ohm resistor as well as 220 microfarad capacitor for the pulse drive of the LED.
5) *Light Dependent Resistor (LDR):* This resistor deals with the concept of photoconductivity. It is only when the light falls on its surface, then, at that point, the material conductivity lessens, and the electrons in the valence band of the gadget are excited to the conduction band. These photons in the incident light should have energy more prominent than the band gap of the semiconductor material. This takes the electrons to jump from the valence band to conduction. These gadgets rely upon the light, when light falls on the LDR then the resistance diminishes, and increments in dark place. At the point when an LDR is kept in dark place, its resistance is high and, when the LDR is kept in the light its resistance will diminish. On the off chance that a consistent V is applied to the LDR, increase in the intensity of the light increases the current. The figure beneath shows the curve between resistances versus illumination curve for a specific light dependent resistor. The LDR is directly interfaced with the microcontroller utilizing a voltage divider circuit with a 10K resistor.
6) *Rain Detector:* A rain detector contains an electronic circuit utilized as a switch and a transistor, the yield from the normally open circuit is fed to the base of an NPN transistor. The circuit has a 5V input and is intended to be shut when water falls on its surface. At the point when the circuit shuts, the current in the base of the transistor causes the current from the collector to the emitter. The voltage at the emitter side of the transistor in the Rain Detector is checked utilizing the microcontroller. On the off chance that the voltage is discovered to be high, it implies there is rainfall.
7) *Final Model Of Cubesat Prepared On Solidworks*

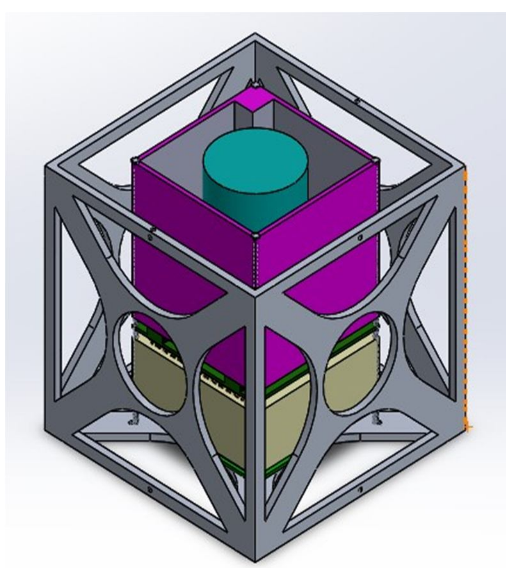


Fig. 1 Final Model of 1U CUBESAT

H. Cubesat Components List & Price

From research finished to construct and dispatch a CubeSat will cost around $45000-$55000 relying upon the segments utilized and the size of CubeSat. We calculated the estimated sum, as the specific amount would rely upon the current component costs.

I. Application Strategy

Weather monitoring has definitely improved in the past few decades, yet there are times when looking outside the window gives a preferable supposition and estimate over your cell phone Weather application. It positively is a field of science where even 80-85% precision is as yet insufficient.

Weather monitoring models have improved somewhat recently as researchers have had more satellite information than any other time to advance their models, which implies that on the off chance that we had more Weather satellites now, the Weather expectations would be significantly better however dispatching these immense Weather satellites takes both time and many millions.

It is the case that Earth Observation satellites are, in general, gigantic and are truth be told the absolute greatest and heaviest satellites in orbit. The size is an immediate consequence of the number of sensors they carry on-board and their normal orbital lifetime.

So, we had intended to plan and launch the CubeSat for checking Weather just as air quality index. The primary benefit of CubeSat, our enormous satellites is that it has tiny measurements when contrasted with bigger satellites. Additionally, CubeSats are extremely light in weight than heavier satellites.

The starting expense is extremely less for these satellites just as it is not difficult to manoeuvre. It additionally consumes less energy for manoeuvring after launching.

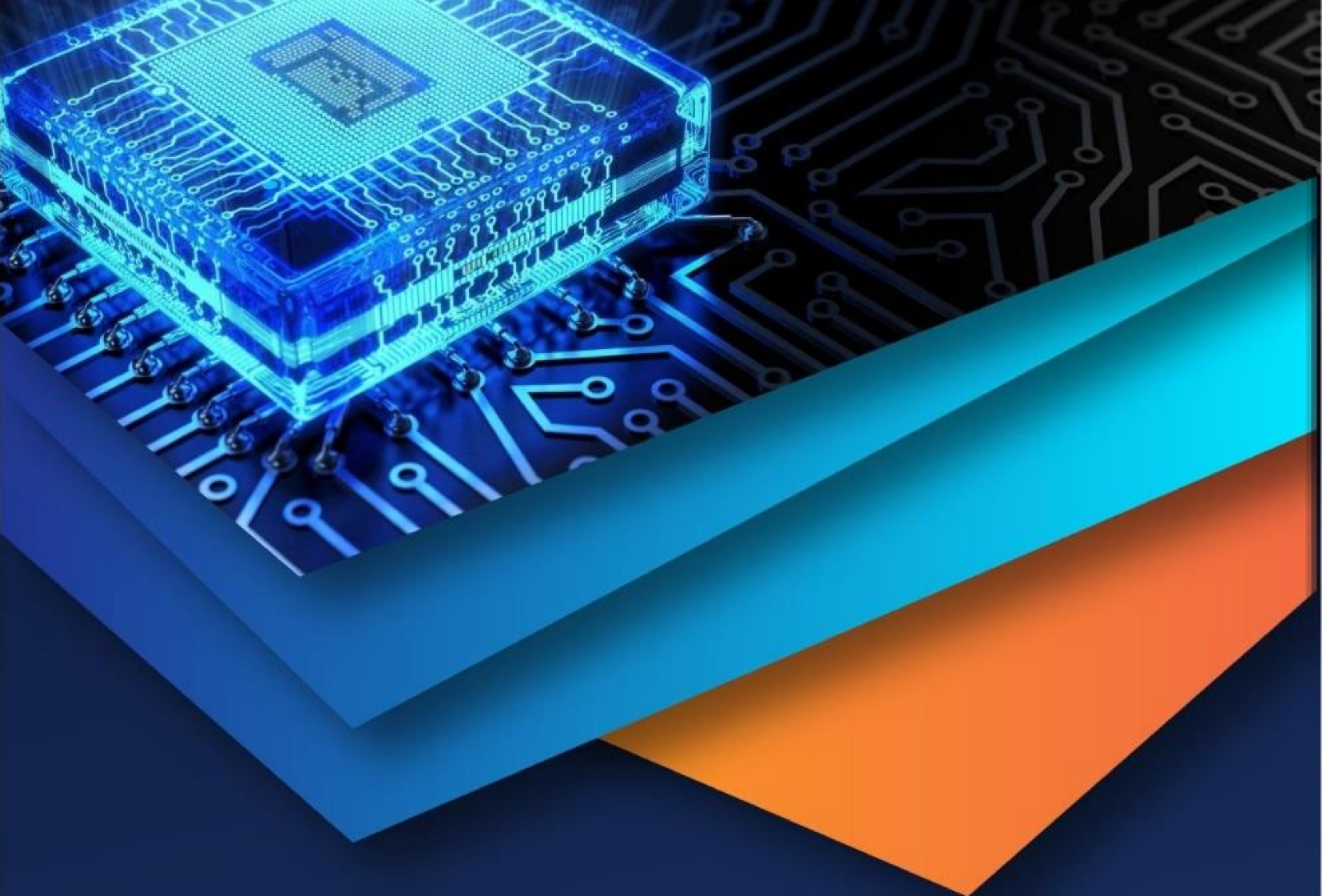
IV. CONCLUSION

This research shows a CubeSat model with all the fundamental equipment. This current task's point was to plan a CubeSat model to quantify actual amounts to determine Weather conditions and air quality records at the satellite location and communicate telemetry information. Utilizing the most cutting-edge innovation it estimates the air index and Weather monitoring progressively.

The design has gone more than a few revisions to agree from the verification matrix point of view, a lot of work has been done in the design and inspection of data sheets, some work has been done in the field of analysis with hypothetical computations and demonstrating and simulation. Hence, this report presents the idea of execution of the mission design of a CubeSat of 1U equipped for checking Weather and air quality index from low earth orbit.

REFERENCES

[1] Abhishek Silwal, A. G. (n.d.). A model of CubeSat.
[2] Nasa.gov. (n.d.). Retrieved from Nasa.gov: https://www.nasa.gov/sites/default/files/atoms/files/nasa_csli_cubesat_101_508.pdf
[3] Reising, D. S. (n.d.). Big Weather Data from a Tiny CubeSat | Science Mission Directorate. Retrieved from https://science.nasa.gov/technology/technology-highlights/big-weather-data-from-tiny-cubesat
[4] https://www.nasa.gov/feature/goddard/2017/cubesat-to-test-miniaturized-weather-satellite
[5] National Environmental Satellite Center, "SIRS and the Improved Marine Weather Forecast," Mariners Weather Log, vol. 14, pp. 12 - 15, January 1970.
[6] Arash Mehrparvar, "CubeSat Design Specification," The CubeSat Program, CalPoly SLO, 2014.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY