

# **Development of 3D Printed Cube Satellite for Measuring Climatic Conditions to Determine Rocket Trajectory**

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in  
Aeronautical Engineering

By

Konchada Uday Kumar (Reg. No. 38260020)

Yaparala Mallesh babu (Reg. No. 38260040)



**DEPARTMENT OF AERONAUTICAL ENGINEERING**

**SCHOOL OF MECHANICAL ENGINEERING**

**SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY**

**(DEEMED TO BE UNIVERSITY)**

Accredited with grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119

May 2022



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Accredited with "A" grade by NAAC  
Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119  
[www.sathyabama.ac.in](http://www.sathyabama.ac.in)



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**DEPARTMENT OF AERONAUTICAL ENGINEERING**

**BONAFIDE CERTIFICATE**

This is to certify that this Project Report is the bonafide work of **Konchada Uday Kumar (Reg. No. 38260020)** and **Yaparala Mallesh babu (Reg. No. 38260040)** who carried out the project entitled **Development of 3d Printed Cube Satellite for Measuring Climatic Conditions to Determine Rocket Trajectory** under our supervision from September 2021 to April 2022.

**Internal Guide**  
**Mr. GUNA SHEKAR., M.E., (Ph.D.),**

**Head of the Department**  
**Dr. P. BOOMADEVI, ME., PhD.,**

---

**Submitted for Viva voce Examination held on 05-05-2022**

**Internal Examiner**

**External Examiner**

## DECLARATION

We Konchada Uday Kumar (Reg. No. 38260020) and Yaparala Mallesh babu (Reg. No. 38260040) hereby declare that the Project Report entitled **Development of 3d Printed Cube Satellite for Measuring Climatic Conditions to Determine Rocket Trajectory** done by us under the guidance of Mr. Guna Shekar, M.E, (Ph.D.), is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Aeronautical Engineering.



DATE: 05-05-2022

SIGNATURE OF THE CANDIDATE

PLACE: CHENNAI

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## **ABSTRACT**

The development of the CubeSat, has turned out to be a device that encourages engineering collaboration, trains college students with actual-world satellite reveal in, and provides era advancement within the aerospace enterprise. The Poly-Picosatellite Orbital Deployer (P-POD), in conjunction with the CubeSat widespread, performs a key function in providing get right of entry to space for CubeSats. Developing satellites at the CubeSat stage highlight the increasing possibilities for get entry to area while yielding quicker development times. The upcoming launches display the growing hobby of universities, companies, and authorities' groups to increase CubeSats to perform treasured medical experiments and missions. The educational benefits of CubeSat development are emphasized through imparting an excellent training ground for future scientists and engineers. In 2016, the Center for Space Exploration and Technology Research of UTEP planned to increase a 1U small satellite (commonly termed CubeSat). Such a CubeSat changed into proposed to the United Launch Alliance initiative that would award free rides to area of 1U CubeSats. The UTEP group obtained the first region to be released to GTO in an Atlas V rocket. The concept is innovative and difficult in numerous senses: as of May 2018, no University-advanced CubeSat has traveled to GTO and face the hard radiation surroundings of Van Allen Radiation Belt, and trying to 3-d print in space is hard due to the decreased gravity, vacuum and severe temperatures environment. The modern-day achievement charge of CubeSat missions, especially for first-time builders, can also discourage non-income companies to start new projects. CubeSat development teams may not be able to dedicate the assets which are important to keep Quality Assurance as it's far accomplished for the dependable conventional satellite initiatives. This paper discusses the structured lifestyles-cycle of a CubeSat assignment, using as a reference the authors' current enjoy of growing and working a 2U CubeSat, referred to as qbee50-LTU-OC, as a part of the QB50 task. This paper also affords a critique of a number of the modern-day poor practices and methodologies whilst sporting out CubeSat tasks.

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## LIST OF SYMBOLS AND ABBREVIATIONS

|            |                                                                                   |
|------------|-----------------------------------------------------------------------------------|
| $\Delta V$ | delta-V (change in velocity)                                                      |
| AAReST     | Autonomous Assembly of a Reconfigurable Space Telescope                           |
| ADR        | active debris removal                                                             |
| ADRe       | active rehabilitation                                                             |
| ADS        | Astrophysics Data System (NASA)                                                   |
| AES        | Advanced Exploration Systems                                                      |
| AFOSR      | Air Force Office of Scientific Research                                           |
| AFRL/RV    | Air Force Research Laboratory's Space Vehicles Directorate                        |
| ASTERIA    | Arcsecond Space Telescope Enabling Research in Astrophysics                       |
| Astro2010  | <i>New Worlds, New Horizons in Astronomy and Astrophysics</i> decadal survey      |
| BARREL     | Balloon Array for Radiation-belt Relativistic Electron Losses                     |
| BRITE      | Bright Target Explorer                                                            |
| C&DH       | command and data handling                                                         |
| CADRE      | Community for Advancing Discovery Research in Education                           |
| Cal Poly   | California Polytechnic State University                                           |
| CANYVAL-X  | CubeSat Astronomy by NASA and Yonsei using Virtual Telescope Alignment Experiment |
| CeREs      | Compact Radiation Belt Explorer Missions                                          |
| CINEMA     | CubeSat for Ions, Neutrals, Electrons, and Magnetic Fields                        |
| CIRAS      | CubeSat Infrared Atmospheric Sounder                                              |
| CIRiS      | Compact Infrared Radiometer in Space                                              |
| COSMIC     | Constellation Observing System for Meteorology, Ionosphere, and Climate           |
| CSSWE      | Colorado Student Space Weather Experiment                                         |
| CSUNSat    | California State University Northridge Satellite                                  |

|          |                                                          |
|----------|----------------------------------------------------------|
| CubeRRT  | CubeSat Radiometer RFI Technology Validation mission     |
| CuSP     | CubeSat to Study Solar Particles                         |
| CXBN     | Cosmic X-Ray Background Nanosatellite                    |
| CYGNSS   | Cyclone Global Navigation Satellite System               |
| DRIVE    | diversify, realize, integrate, venture, and educate      |
| DSL      | Discovering the Sky at Longest wavelengths               |
| DSN      | Deep Space Network                                       |
| DYNAMIC  | Dynamical Neutral Atmosphere-Ionosphere Coupling Mission |
| EcAMSat  | E. coli AntiMicrobial Satellite                          |
| EDL      | entry-descent-landing                                    |
| EDSN     | Edison Demonstration of Smallsat Networks                |
| EELV     | Evolved Expendable Launch Vehicle                        |
| IRIS     | Interface Region Imaging Spectrograph                    |
| ISARA    | Integrated Solar Array and Reflect array Antenna         |
| iSAT     | Iodine Satellite                                         |
| ISM      | Industrial Scientific and Medical                        |
| $I_{sp}$ | specific impulse                                         |
| ISS      | International Space Station                              |
| ISX      | Ionospheric Scintillation explorer mission               |
| ITU      | International Telecommunication Union                    |
| IV&V     | Independent Verification and Validation                  |
| IXO      | International X-ray Observatory                          |
| JAXA     | Japan Aerospace Exploration Agency                       |
| JPL      | Jet Propulsion Laboratory                                |
| JPSS     | Joint Polar Satellite System                             |
| JSpOC    | Joint Space Operations Center (U.S. Air Force)           |
| JWST     | James Webb Space Telescope                               |
| LAICE    | Lower Atmosphere/Ionosphere Coupling Experiment mission  |

|           |                                                                            |
|-----------|----------------------------------------------------------------------------|
| LEO       | low Earth orbit                                                            |
| LISA      | Laser Interferometer Space Antenna                                         |
| LMPC      | Linear Mode Photon-counting CubeSat                                        |
| LMRST     | Low Mass Radio Science Transponder                                         |
| LunaH-Map | Lunar Polar Hydrogen Mapper                                                |
| MagCat    | Magnetospheric Constellation and Tomography                                |
| MagCon    | Magnetospheric Constellation Mission                                       |
| MarCO     | Mars Cube One                                                              |
| MCubed    | Michigan Multipurpose Minisat                                              |
| MEDICI    | Magnetosphere Energetics, Dynamics, and Ionospheric Coupling Investigation |
| MEROPE    | Montana Earth Orbiting Pico Explorer                                       |
| MHD       | magnetohydrodynamic                                                        |
| MinXSS    | Miniature X-ray Solar Spectrometer                                         |
| MiRaTA    | Microwave Radiometer Technology Acceleration mission                       |
| MITEE     | Miniature Tether Electrodynamics Experiment                                |
| MLI       | Multi-Layer Insulation                                                     |
| MMO       | Mars Micro Orbiter                                                         |
| MMS       | Magnetospheric Multiscale Mission                                          |
| MRO       | Mars Reconnaissance Orbiter                                                |
| NASA      | National Aeronautics and Space Administration                              |
| NEA       | near Earth asteroid                                                        |
| NOAA      | National Oceanic and Atmospheric Administration                            |
| NuSTAR    | Nuclear Spectroscopic Telescope Array Mission                              |
| O/OREOS   | Organism/Organic Exposure to Orbital Stresses                              |
| OCSD      | Optical Communication and Sensor Demonstration                             |
| OPAL      | Orbiting Picosatellite Automated Launcher                                  |
| RFID      | Radio-frequency Identification                                             |

|         |                                                                              |
|---------|------------------------------------------------------------------------------|
| ROSES   | Research Opportunities in Space and Earth Sciences                           |
| SAO     | Smithsonian Astrophysical Observatory                                        |
| SIMPLEx | Small, Innovative Missions for Planetary Exploration                         |
| SLS     | Space Launch System                                                          |
| SMC     | Space Missile Command                                                        |
| SMD     | Science Mission Directorate (NASA)                                           |
| SO/PHI  | Polarimetric and Helioseismic Imager                                         |
| SORCE   | Solar Radiation and Climate Experiment                                       |
| SORTIE  | Scintillation Observations and Response of the Ionosphere to Electrodynamics |
| SRAM    | static random-access memory                                                  |
| STEM    | science, technology, engineering, and mathematics                            |
| STMD    | Space Technology Mission Directorate (NASA)                                  |
| STP     | Space Test Program (DOD)                                                     |
| STRaND  | Surrey Training, Research, and Nanosatellite Demonstrator                    |
| TIR     | thermal infrared                                                             |
| TIRFF   | Thermal Infrared Free Flyer                                                  |
| TJ3Sat  | Thomas Jefferson CubeSat                                                     |
| U       | unit, with 1U being about 10 cm × 10 cm × 10 cm                              |
| UHF     | ultrahigh frequency                                                          |
| ULA     | United Launch Alliance                                                       |
| UNP     | University Nanosatellite Program                                             |
| USGS    | U.S. Geological Survey                                                       |
| USML    | U.S. Munitions List                                                          |
| UV      | ultraviolet                                                                  |
| VCLS    | Venture Class Launch Services                                                |
| VHF     | very high frequency                                                          |
| VLBI    | Very Long Baseline Interferometry                                            |

|        |                                      |
|--------|--------------------------------------|
| WFIRST | Wide-Field InfraRed Survey Telescope |
| WISE   | Wide-field Infrared Survey Explorer  |
| WMAP   | Wilkinson Microwave Anisotropy Probe |
| WoS    | Web of Science                       |

# CHAPTER 1

## INTRODUCTION

### 1.1 What is a nanosatellite?

In strict terms, a nanosatellite (nanosat, nano-satellite) is any satellite tv for pc with mass from 1 kg to ten kg. In this database, "nanosatellite" covers all CubeSats, PocketQubes, Tube Sats, Sun Cubes, Thin Sats and non-fashionable picosatellites, except otherwise said.

All are a part of the equal CubeSat revolution and modern electronics technology leap. Limiting to 1-10 kg would be complicated and troublesome. 1U CubeSat can be zero eight kg, however also 1.3 kg. 6U can be less or more than 10 kg. Most hundreds aren't public.

Upper limit in this database is 10 kg for non-preferred types of nanosats and 27U CubeSat (30-40 kg). Lower limit is 1p Pocketqubes and custom picosatellites over one hundred g and SunCubes that can be much less than one hundred g.

Chipsats are not included. Breakthrough Starshot calls them nanocrafts, however in addition they can be attosatellites (attosats). They will be a massive bounce within the future: "gram-scale wafer, carrying cameras, photon thrusters, energy deliver, navigation and conversation equipment."

### Satellite mass classification

- Large satellites: >1000 kg
- Medium satellites: 500 to 1000 kg
- Small satellites: < 500 kg
- Minisatellites: 100 to 500 kg

- Microsatellites: 10 to 100 kg
- Nanosatellites: 1 to 10 kg
- Picosatellites: 100 g – 1 kg
- Femtosatellites: 10 g – 100 g
- Attosatellites: 1 g – 10 g
- Zeptosatellites: 0.1 g – 1 g
- CubeSat sizes:
- From 0.25U to 27U
- From ~0.2 kg to ~40 kg

Small satellite (smallsat) is any satellite below 500 kg. This term should be used rarely, there can be large differences between sizes and capabilities.

## 1.2 What is a CubeSat?

CubeSats (cubesatellite, cube satellite) are a type of nanosatellites defined by the cubesat design specifications (CDS), unofficially called the CubeSat standard.

Dimensions:

- 1U CubeSat is 10 cm × 10 cm × 11.35 cm.
- 2U CubeSat is 10 cm × 10 cm × 22.70 cm.
- 6U CubeSat is 20 cm × 10 cm × 34.05 cm.

- 12U CubeSat is 20 cm × 20 cm × 34.05 cm.
- Smallest existing CubeSat design is 0.25U and largest is 27U.
- Smallest launched CubeSat is 0.25U and largest is 12U as of 2019 January.  
Very soon 16U from US or 20U from China.

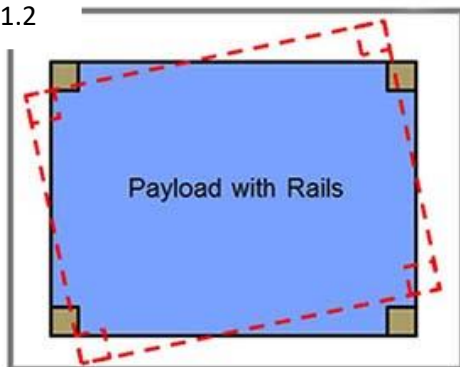
**There are 2 different classes of deployers/dispensers:**

1. First type is the classic 4 rails in the corners. It's recommended to be aware of the specifications of modern deployers, because dispensers from ISIS and Nano racks allow larger deployables, wider solar panels and thinner rails compared to original P-POD. For example

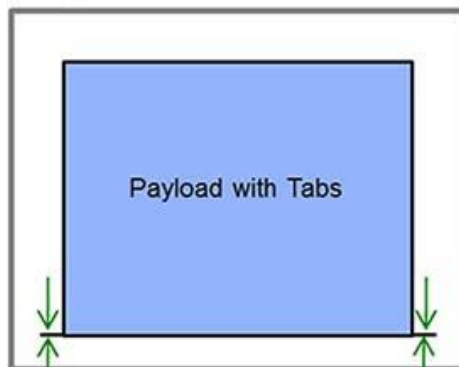
- extruded height can be 9 mm instead of 6.5 mm and
- can be up to 2 kg per 1U which should not cause problems with launch providers.

2. Second type is tabs on planetary corp systems(PRS) dispensers. The 13 CubeSats that will fly on SLS in 2018 will use them.

FIG 1.2



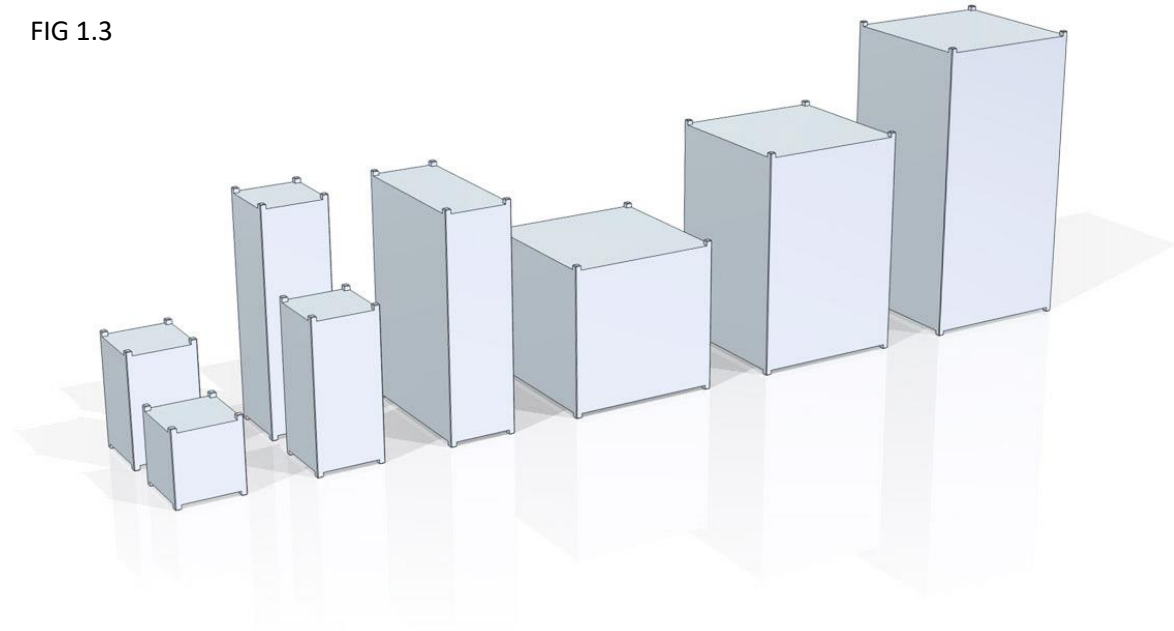
Payload may vibrate in canister because of small gap (~0.5 mm) between rails and CSD walls.



Tabs guarantee an invariant load path, allowing useful predictions of dynamic response.

## 1.3 CubeSat sizes

FIG 1.3



### Getting started with building CubeSats

#### Things to watch out for:

- On-board flight software program and undertaking control software program (MCS) are important and regularly forgotten or not noted while placing together an Excel sheet of subsystem prices from on-line stores. Some degree of customization for mission requirements is possibly too depending on the mix of subsystems and payload. MCS is already required from the mixing and testing levels. Companies like Kubos and Bright Ascension provide each flight-verified and well integrated solutions.
- Second set of hardware for parallel software improvement and operations rehearsals after release is notably advocated.
- Most modern-day deployers permit for larger extrusions, better mass and smaller rails than the mechanical necessities from the CubeSat Design Specification (CSD). Deployments from P-POD are becoming uncommon.
- Launch Providers desk consists of some CubeSat release charges. These are just like the final prices. Free or less expensive launches are feasible in some cases, but be cautious with flight historical past and viable delays. CubeSat launch costs

depend on units and no longer on the precise spacecraft mass. It isn't always encouraged to estimate the dollar in keeping with kg charge of rockets as that does not consist of deployers and lots of different relevant charges.

## **1.4 Fun CubeSat quotes**

It all started out as a university training application satellite. It turned into form of funny. I didn't assume that people might criticize it as an awful lot as they did, but we got numerous feedback, you recognize, "That's the dumbest idea I've ever heard. Nobody's going to use this toy." We said, "Who the heck cares. We'll cross beforehand and use it. We're the usage of it for schooling."

A chat with Bob Twiggs through Stephen Clark, 2014,

Another thing that become form of funny is we had no hobby from NASA or any of the navy corporations. It just wasn't something they were interested in, so it become all funded without any investment from the one's aerospace corporations. I'm kind of glad that NASA didn't help us, or we might in all likelihood never were given it performed.

It turned into evolved for the training of college students. If you make it small, they cannot placed much in it, so they get it accomplished faster, and hopefully you can get it launched for a lot much less cash. I don't suppose Jordi Puig-Suari at Cal Poly or myself had any concept that we would see days like this . A chat with Bob Twiggs with the aid of Stephen Clark, 2014,

Early release companies have been Russian. We did visit a number of the American launch companies, Lockheed Martin comes to thoughts, and that they stated, "If you give us a half of-million greenbacks, we will have a look at it, after which if it makes economic sense for us to launch it, we will do it." We stored asking them to take some of the lead (ballast) off and fly some of this stuff as secondaries, however they simply failed to go along with it. I changed into certainly disillusioned that the aerospace enterprise could not see the benefit aside from earnings from it. They couldn't see the instructional advantage from it, and the potential of the educational benefit turning into business applications. Now, you see the economic programs coming at the side of Skybox Imaging, with Planet Labs. Oh my goodness, they appear to be they have got a first-rate financial potential. A chat with Bob Twiggs by using Stephen Clark

### **1.4.1 PocketQubes**

CubeSats are becoming too large for many applications like education. Smaller and even cheaper spacecraft will be a better option. pocketQubes are 5 cm cubes compared to 10 cm CubeSats.

- 1p is 5 cm × 5 cm × 5 cm.
- 3p is 5 cm × 5 cm × 17.8 cm.

The concept was announced in 2009 at the 2nd European CubeSat Symposium. As of early 2020, 10 PocketQubes have been launched in total. First 4 from UniSat satellites and the latest rest with Alba orbital on their own developed deployers for rideshare launches.

There are also 2 types of PocketQubes: MRFOD and CubeSat dispenser compatible.

### **1.4.2 MRFOD PocketQubes**

MRFOD has a backplate that slides into deployer rails. Only MRFOD type of PocketQubes have been launched to space using the Morehead-Roma FemtoSat Orbital Deployer (MRFOD) onboard UniSat-5 satellite.

FIG 1.4.2



### 1.4.3 CubeSat type PocketQubes

8 would fit and be deployed from a 1U CubeSat dispenser. This was the original idea, but none have been launched. It requires close cooperation between manufactures or a single organization must launch all at the same time.

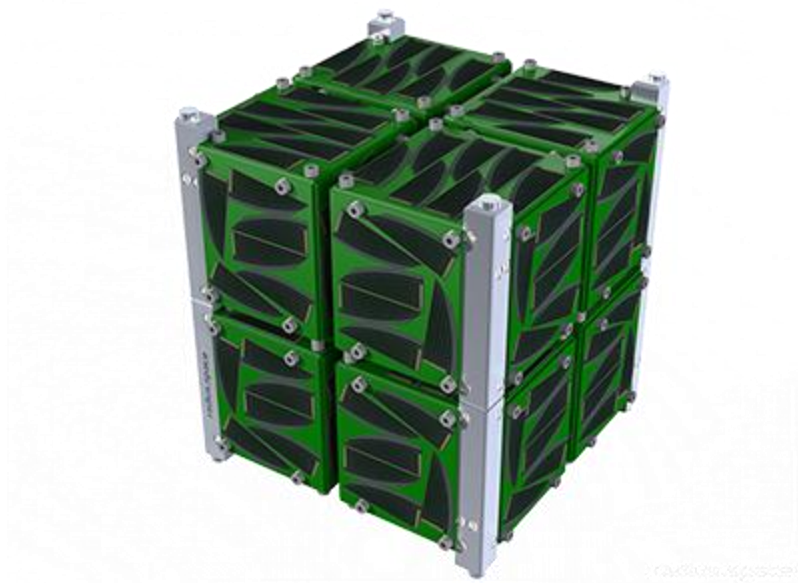


FIG 1.4.3

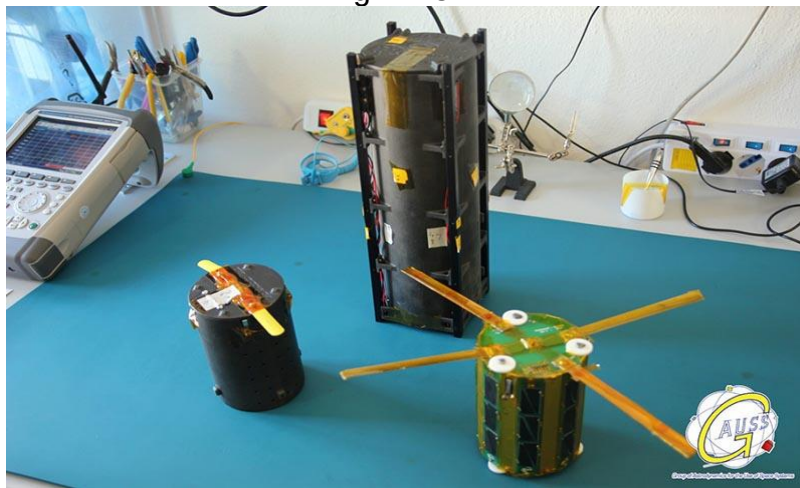
### 1.4.5 TubeSat

TubeSats are eight.9 cm in diameter, 12.7 cm in period and weigh 0.75 kg. First 2 have been released in 2016 on TuPOD 3U CubeSat from GAUSS. Using a CubeSat to set up 2 TubeSats makes release prices similar to 1U-2U CubeSat, but possibilities

are very uncommon. Their simplest advantage seems to be less difficult and much less expensive deployer for rockets.

TubeSat kits have been created through Interorbital Systems and value simplest \$8000 together with free flight, which makes it low-cost for lots teams. They have sold one hundred+, but first orbital launch has been behind schedule with the aid of more than 7 years. Launching 24 TubeSats gives a sales of \$192,000, low considering all the expenses. Unless Interorbital begins with launches quickly, there probably will not be a future for TubeSats.

Fig 1.4.5

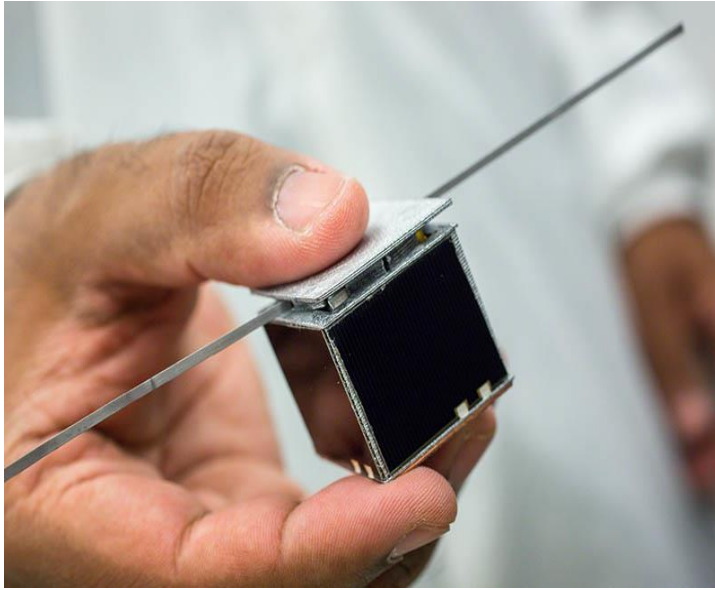


### 1.4.6 SunCubes

SunCubes are 3 cm cubes. 1F is three cm  $\times$  three cm  $\times$  three cm and 3F is 3 cm  $\times$  3 cm  $\times$  9 cm. Goal is to make satellites even greater affordable. None had been launched, however they were introduced in 2016. 1U CubeSat might match up to 27 unmarried 1F SunCubes. Assuming \$80,000 to release 1U CubeSat then one SunCube release might be best \$3000!

Challenge might be filling 1U CubeSat with 27 SunCubes, until all of them are from the same corporation and a part of a constellation. Deploying 27 SunCubes at the identical time could also create problems with collisions and tracking, which means one-by using-one deployment is probably wanted. First SunCubes might be possibly be released from satellites (CubeSats) with other primary missions. As of 2021, none have been launched and probably in no way will.

FIG 1.4.6



## CHAPTER 2

### LITERATURE SURVEY

#### **2.1 CubeSat Mission: From Design to Operation Cristóbal Nieto-Peroy**

The present-day fulfillment price of CubeSat missions, specifically for first-time builders, may discourage non-income companies to begin new tasks. CubeSat improvement groups won't be capable of commit the assets which are vital to preserve Quality Assurance as it is achieved for the reliable conventional satellite projects. This paper discusses the established existence-cycle of a CubeSat mission, the use of as a reference the authors latest enjoy of developing and working a 2U CubeSat, known as qbee50-LTU-OC, as part of the QB50 challenge. This paper also provides a critique of some of the current bad practices and methodologies even as wearing out CubeSat tasks. Keywords: CubeSat; miniaturized satellite tv for pc; nanosatellite; small satellite improvement

1. Introduction There were nearly one thousand CubeSats released to the orbit for the reason that inception of the concept in 2000 [1]. An up-to-date data of CubeSat missions may be observed in Reference [2]. A precis of CubeSat missions up to 2016 can also be observed in Reference [3]. However, the existence expectancy of a CubeSat mission could be very confined. Two fundamental motives make contributions to such a short lifetime: First, CubeSats are generally released into Low Earth Orbits (LEOs), resulting in their fast orbit decay and reentry. For instance, from an unique circular orbit with an altitude of four hundred km, CubeSats typically decay to a reentry trajectory within a duration of 1 to two years [4]. Secondly, the early failure rate of (university-led) CubeSats is around forty-eight% [5]. One motive for such a low reliability may be the surprisingly terrible-quality standards that builders follow for the duration of the manufacturing, assembly, integration and validation phases. Despite developing interest from enterprise in CubeSats as right means of generation demonstration, such platforms are nevertheless mostly considered as an educational device. Therefore, it is understandable that they'll now not quite simply reach a level of best suitable for the gap conditions, if every improvement is executed without thinking about the experience of similar preceding missions

## **2.2 DESIGN AND TESTING OF AN ADDITIVELY MANUFACTURED CUBESAT STRUCTURAL BUS**

**THESIS Karson A. Roberts, Second Lieutenant**

Recent innovations in additive manufacturing and design competencies have opened the door for more opportunities to combine a couple of features right into a structural layout. Specifically, 3D printing through superior laser powder bed fusion of metal powder lets in for the development and integration of advanced structures that were formerly unachievable. The demonstration of those techniques on a small satellite consequences in a structural bus consisting of numerous outside and internal features, growing its capability and talents past sincerely supplying structural aid. 3D printing a multi-practical CubeSat bus with those incorporated capabilities along with internal lattices and wiring tabs demonstrates a new way of wondering going ahead: modularizing the structural design and incorporating diverse talents which could meet a completely unique or everyday satellite project. This research addresses the design and trying out of an additively manufactured CubeSat structural bus. 3D printing skills have been harnessed to incorporate lattices into the walls of the shape, increasing its herbal frequency and reducing mass. The three-D printed unloaded CubeSat shape became vibration examined to NASA GEVS qualification stages, and confirmed no harm and proved survivability under those loading conditions In a surroundings that strives for new reducing aspect technology and innovations, satellite tv for pc applications around the world are confronted with terrific expectancies. These programs enjoy a constant strain to produce excessive performing satellites with maximum talents, all even as attempting to meet a price range. Additive Manufacturing (AM) is a developing technology with aerospace applications that can assist obtain this objective. Also called 3D printing, this production approach builds components by using adding successive layers of substances, as opposed to the conventional subtractive manufacturing method that eliminates cloth. This layer-smart fabrication method lets in for the advent of complex geometries at the same time as reducing fabric, reducing fee, and lowering weight [9]. AM lets in for virtual modularity and parametric designs that conventional machining strategies can't accomplish. It can print plastics, metals, composites, and an expansion of other substances which can be commonly used within the aerospace industry

## 2.3 AUTONOMOUS CUBE SATELLITE SOFTWARE DESIGN (2014)

**Author: Michael Baxter (University of Western Australia)**

Automated flying motors are a popular excellent level for self-sufficient mechanical generation studies. This document diagrams the plan and execution of multithreaded programming for a Cube satellite tv for pc limited by a raspberry pi. A form of sensors consisting of a GPS, an IMU and a digicam are utilized at the Cube satellite, and consequently the product is obligated for gathering data from and checking these sensors through their decrease-stage libraries. A specific technique is taken to programming plan so the framework may be utilized in an assortment of utilizations. The applications had a go at all through this venture had been: GPS waypoint direction and single shaded article following. GPS direction was refined with the nice route deviation of 5.66m. A conversation on enhancements to the course calculation and thusly the fuse fact be instructed rectification techniques is given. Object following figuring's were completed making use of the focus of mass and camshaft strategies, which have been overhauled using HSV thresholding, question tables and decreased shading spaces. The Cube satellite became organized to observe a pink article transferring at a lethargic waking speed for a full preliminary, 1.13 mins long. The product introduced is adaptable, currently getting used with different synchronous undertakings and units out a structure for future turn of occasions. A multithreaded programming framework became meant for and performed on an unbiased Cube satellite. The measured plan made this approach adaptable and versatile. The usage of murexes to make certain belongings across strings makes the plan strong. The product framework was confirmed to efficiently manipulate a Cube satellite in impartial flight. GPS waypoint route became finished with a manner deviation equivalent to a year ago. Camera 10

picture getting ready smoothed out, viably multiplying beyond define quotes. At closing, the item following was supported for 1.13 minutes, the entire period of the test. This framework is presently being used with a spread of synchronous ventures, which includes subject looking and diverse item following, all tied in close by a web-primarily based interface

## 2.4 Design and Analysis for a CubeSat Mission-III

This Major Qualifying Project (MQP) is part of a sixteen-scholar institution devoted to the layout and task making plans of a 6U CubeSat. Similar recent CubeSat tasks have taken area at WPI with a unique payload inside the 2016-2017 and 2017-2018 educational years. The primary aim of the MQP-2001 Cube Satellite Project is to create a conceptual design of a 6U CubeSat, wearing a mini Ion Neutral Mass Spectrometer (mINMS) made through the National Aeronautics and Space Administration (NASA) Goddard Institute for the reason of clinical experimentation and data collection in the Ionosphere. During the course of this venture there had been two orbits considered for our CubeSat, which from right here on out is referred to as NeAtO (mINMS eLEO Atmospheric Observer). The first and in the long run selected alternative can have NeAtO deployed from the International Space Station (ISS) thru a NanoRacks Double Deployer at 400 km with a fifty one.6-degree inclination. The 2nd orbit considered would have located NeAtO in a Polar Orbit, deployed from a Quadpacks Duo Pack Deployer at 400 km, on a rideshare assignment. With the first choice, following release from the ISS, NeAtO will then input a 200-440 km orbit after detumbling, keeping a perigee within severe Low Earth Orbit (eLEO) for so long as viable with the given propulsion system. The MQP-2001 CubeSat Project consists of three MQP sub-groups, every with a one-of-a-kind attention. This unique MQP, NAD-2001, referred to as Team Three, is led by using Professor Karanjgaokar with team participants Christian Anderson, Rory Cuerdon, Brian Kelsey and Nicole Petilli, with a focal point at the mechanical layout and the structural and thermal evaluation. Team One is led by means of Professor's Taillefer and Gatsonis, with team members Tristan Andreani, Edward Beerbower, Roberto Clavijo, Samuel Joy, Benjamin Snyder and Jeremiah Valero. These members are answerable for the orbital analysis and environmental results analysis together with the power, propulsion and telecommunications subsystems. Lastly, Team Two, led by means of Professor Demetriou with group members Robaire Galliath, Oliver Hasson, Andrew Montero, Chris Renfro and David Resmini, specializes in CubeSat mindset determination and control, orbital manipulate, and command and statistics dealing with subsystems. Team 2 is likewise taking lead at the layout and development of a check mattress.

## **CHAPTER 3**

### **AIM and SCOPE**

Considering the pollution within the outer environment it turns into hard to calculate the most secure and shortest trajectory for any release vehicle. To come up with a higher solution we determined to take over this task

The Aim of the undertaking is to increase a 1U 3d Printed dice satellite that can move till stratosphere and measure the dust particle density if you want to help us to calculate the successful trajectory direction for any rocket to be released into the outer space.

The cube satellite ought to be small as well as spacious enough to carry all of the onboard electronics. The electronics so that you can work in minus temperatures because the temperature at better altitudes could be very low.

Once the satellite reaches the preferred top with the assist of a latex air balloon full of helium internal. The dice satellite starts off evolved measuring the facts related to dirt sensor, GPS, Baro, Magnetometer and so forth and shops them in a SD card.

Once the balloon has pooped up the cube satellite tv for pc will make its manner lower back in to the earth's surroundings. The cube satellite could be recovered from its dropped location and then the SD card will be retrieved to plot the important graphs. Which will in go back help in calculating the safe and shortest trajectory for our rocket

## **CHAPTER 4**

### **Materials and Experimental Method**

#### **4.1 3D printing**

The creation of a three-dimensional structure from a CAD model or a digital 3D model is known as 3D printing or additive manufacturing. The term "3D printing" can refer to a range of processes in which material is deposited, joined, or solidified under machine control to create a three-dimensional structure, with the material being added together (for example, plastics, liquids, or powder grains being fusible).

In the 1980s, 3D printing methods were assumed to be only useful for the assembly of practical or decorative prototypes, and rapid prototyping was a more fitting concept. As of 2019, 3D printing's accuracy, repeatability, and material selection have improved to the point that certain 3D printing processes are now deemed feasible as an industrial-production technique. whereby the term additive manufacturing is often used synonymously with 3D printing. One of the key advantages of 3D printing is that the ability to supply very complex shapes or geometries that might be otherwise impossible to construct by hand, including hollow parts or parts with internal truss structures to scale back weight. Fused deposition modelling, or FDM, is that the commonest 3D printing in use as of 2020.3D printing, or additive manufacturing, is that the construction of a three-dimensional object from a CAD model or a digital 3D model.



Fig 4.1

## 4.2 How is it Made?

PLA is a sort of polyester crafted from fermented plant starch from corn, cassava, maize, sugarcane or sugar beet pulp. The sugar in those renewable materials are fermented and become lactic acid, when is then made into polylactic acid, or PLA. There is extra certain records on PLA production methods under.

Fig 4.2



## 4.3 What is it Used For?

The cloth residences of PLA make it suitable for the manufacture of plastic movie, bottles and biodegradable clinical gadgets, inclusive of screws, pins, plates and rods which might be designed to biodegrade inside 6 to 365 days).

PLA may be used as a shrink-wrap cloth since it constricts beneath heat. This ease of melting also makes polylactic acid appropriate for three-D printing applications.

However, many types of PLA have a low glass transition temperature, making them fallacious for making plastic cups designed to keep warm liquids

## 4.4 Is it Environmentally Friendly?

PLA production uses 65% much less strength than producing conventional plastics and generates 68% fewer greenhouse gases and consists of no pollutants. It can be additionally continued to be environmentally pleasant need to the appropriate quit-of-existence state of affairs be accompanied.

However, the rate of decay could be very slow in ambient temperatures, with a 2017 look at displaying that there has been no degradation seen in over a year of the cloth being submerged in seawater at 25°C.

However, PLA may be degraded by means of hydrolysis, thermal degradation or photodegradation:

- **Hydrolysis:** The molecular weight is reduced by cleaving the ester groups of the main chain
- **Thermal Degradation:** This process leads to the appearance of different compounds, such as linear and cyclic oligomers or lighter molecules with different lactide and Mw
- **Photodegradation:** UV radiation causes degradation, particularly where PLA is exposed to sunlight

There are currently four common end-of-life scenarios for PLA:

## 1. Recycling

This is either chemical or mechanical. Waste material can maintain contaminants, however polylactic acid may be chemically recycled the usage of thermal depolymerization or hydrolysis to create a monomer which could then be synthetic into virgin PLA. PLA also can be chemically recycled using transesterification to create methyl lactate.

## 2. Composting

Industrial composting situations permit for chemical hydrolysis accompanied by means of microbial digestion to degrade the PLA.

## 3. Incineration

End-of-life PLA can be incinerated, creating 19.5 MJ/kg (8,368 btu/lb) of energy and leaving no residue.

## **4. Landfill**

While PLA can go to landfill, this is the least environmentally friendly option, due to the slow degradation rates of the material in ambient temperatures.

## **Types**

Due to the nature of lactic acid, there are several awesome varieties of polylactide. These include poly-L-lactide (PLLA) which comes from the polymerization of L,L-lactide (additionally known as L-lactide).

In addition, while PLA may be constructed from different biomass materials, such as corn starch or sugar cane, it could also be greater with the aid of adding other materials to offer unique houses. This is mainly real with PLA filaments in which the extra materials permit 3-d published PLA to be used in unique ways.

There are many one-of-a-kind PLA blends to be had, even though adding materials to PLA can make 3D printing extra hard and even reduce the homes of PLA. Using blends also can suggest that you need to alter the temperature required to melt the material even as printing.

### **1. Wood Filaments**

PLA is mixed with woods such as bamboo, cedar, coconut wood, cork, pine, or walnut. This can, for example, be used to give PLA printed furniture a natural-looking appearance.

### **2. Metal Filaments**

Mixing PLA with metals such as brass, bronze, copper, iron and steel can make printed parts stronger and glossy.

### **3. Other Filaments**

PLA can also be mixed with other materials and substances, including carbon fiber, conductive carbon and even beer or coffee (to add a scent to printed items). PLA filaments can also be given color-changing properties.

## 4.5 Properties

PLA is soluble in solvents which includes dioxane, hot benzene, and tetrahydrofuran. The physical and mechanical residences vary according to the precise kind of polymer, ranging from an amorphous glassy polymer to a semi or exceedingly crystalline polymer with a tumblar transition of 60–sixty-five °C, a melting temperature 130-a hundred and eighty °C, and a tensile modulus of 2.7–sixteen GPa.

Heat resistant PLA can face up to temperatures of one hundred ten °C, and the melting temperature may be elevated by means of forty–50 °C and the heat deflection temperature can be expanded from around 60 °C to as much as 190 °C through bodily mixing the polymer with PDLA (poly-D-lactide).

Annealing, adding nucleating dealers or forming composites with different materials can all exchange the mechanical residences of PLA. However, the fundamental mechanical properties of PLA range between the ones of polystyrene and PET, with comparable homes to PET but a decrease most continuous use temperature.

The high floor strength of PLA makes it best for 3-d printing. PLA can also be solvent welded the use of dichloromethane, at the same time as acetone softens the surface of the fabric, making it sticky without dissolving it so it is able to be welded to some other PLA surface. Ethyl acetate can be used as a natural solvent, dissolving PLA and making it an excellent solution for doing away with PLA printing helps or cleansing 3D printing extruder heads. Propylene carbonate and pyridine can also be used as a solvent, however are less favorable than ethyl acetate and propylene carbonate, being less safe within the first example and emitting an awesome awful fish odour inside the second.

Here are the general residences of PLA:

### **4.5.1 Advantages**

PLA provides several advantages over other materials, including:

- Environmentally friendly (if disposed of correctly)
- Easy to 3D print
- Safe for use in applications such as food containers and medical devices
- Comes with a wide range of composite and color options to provide different properties and appearances
- Can be solvent welded (such as with dichloromethane)

### **4.5.2 Disadvantages**

There are, however, some disadvantages with using PLA, including:

- Low heat resistance
- Comparatively low strength
- Machine processing can be difficult

## **4.6 Production Methods**

There are numerous commercial ways to produce usable PLA with a high molecular rate. Lactic acid and the cyclic di-ester, lactide are the two major monomers used for this.

The most commonplace technique of creating PLA is ring-starting polymerization of lactide with various metallic catalysts (commonly tin octoate) both in an answer or as a suspension. The metallic-catalyzed response has a tendency to cause recemisation of the PLA, which reduces stereoregularity when as compared to the biomass starting fabric.

It is also feasible to provide PLA via the direct condensation of lactic acid monomers. This technique is executed at temperatures underneath 2 hundred °C, at which factor an entropically favoured lactide monomer is generated. This manner generates water equivalent to each esterification step. The water wishes to be removed either by using a vacuum or through azeotropic distillation to sell polycondensation and achieve a high

molecular rate. Even higher molecular charges may be carried out by using crystallising the crude polymer from the soften. This concentrates carboxylic acid and alcohol cease businesses inside the amorphous region of the stable polymer, reacting to obtain molecular weights of 128–152 kDa.

By polymerizing a racemic combination of L- and D-lactides, it's far viable to synthesize the amorphous poly-DL-lactide (PDLLA). Stereospecific catalysts can result in heterotactic PLA, that has been known to expose crystallinity. The diploma of this crystallinity is managed by way of the ratio of D to L enantiomers which are used, as well as by the kind of catalyst this is used. The five-membered cyclic compound lactic acid O-carboxy anhydride (lac-OCA) has also been utilized in educational surroundings in place of lactic acid and lactide. This compound doesn't produce water as a co-product and is more reactive than lactide. PLA has additionally been at once biosynthesized even as lactic acid has also been contacted with a zeolite, creating a one-step manner that takes vicinity at a temperature this is around 100 °C decrease.

## **4.7 Applications**

PLA has a number of not unusual uses, along with for clinical and meals purposes. It is also extensively used as a 3D printing feedstock for computer fused filament fabrication three-D printers. PLA is famous for 3-D printing as it may without problems be sanded, painted or put up processed. A user-friendly material, this plastic works with low extrusion temperatures and there is no want for a heated bed, printer chamber or reinforced nozzle. Another advantage is that PLA behaves better than many tougher plastics and also doesn't launch fumes or bad odours. Storage is easy and it could be produced in a variety of colors and as the base for a range of composites with additional houses (see above).

Because PLA can degrade into lactic acid, it is able to be used for clinical implants including anchors, screws, plates, pins, rods or as a mesh. It breaks down in among 6 months and a pair of years, depending on the precise type of material used. This method that these products can gradually transfer a load from a PLA aid shape to the body as it heals.

PLA, created with injection moulding, casting or by using being spun, is also used as a decomposable packaging fabric, film or for cups and baggage. It is used for compost baggage, food packaging, disposable tableware, and loose fill packaging. As a fiber or nonwoven material, PLA is used for upholstery, disposable garb, feminine hygiene merchandise and nappies.

#### **4.8 Future of PLA**

Made from a recyclable and renewable useful resource, PLA has a lot of positives for the future, plus with growing oil prices, a corn-based plastic has monetary benefits too. For all of these positives the low melting point of PLA compared to plastics like PET method that it has not been picked up for as many programs as of now.

The value of PLA manufacturing has also reduced over a long time, but care desires to be taken to decompose this material, which needs unique composting in facilities which can heat the material to one hundred forty °C ranges for ten days. However, whilst this requires a plant to achieve, it's miles through a long way more ultimate to sending used PLA to landfill, wherein it's far estimated it'd take as long as one hundred to at least one,000 years to break down.

While PLA is not pretty a miracle substance, the lack of fossil fuels and lower air pollution in production suggest it definitely has an area in the destiny of substances.

#### **4.9 ABS Characteristics**

ABS (acrylonitrile-butadiene-styrene) is a low-cost engineering thermoplastic this is effortlessly machined, fabricated and thermoformed. ABS plastic is taken into consideration meals grade, and can be safe to be used in meals processing and meals dealing with operations.

This thermoplastic fabric has high-quality chemical, stress and creep resistance. ABS offers a terrific stability of impact, heat, chemical and abrasion resistance, dimensional stability, tensile power, surface hardness, rigidity and electrical characteristics.

ABS plastic remains tough, inflexible and difficult even at low temperatures. It is available in hearth-retardant, heat-resistant and platable grades. Impact energy varies

with the aid of grade. See the chart under for ABS yield strength, young's modulus (ABS elasticity), tensile yield energy of ABS plastic, mechanical houses of ABS plastic, and other properties.

Most herbal ABS resins are translucent to opaque, but they can be produced in transparent grades and may be pigmented to display almost any color.

General reason grades may fit for some outdoor applications, but prolonged exposure to daylight reasons color modifications and decreases surface gloss, hardness, effect power and elastic modulus. Set the chart under for details of the cloth properties of ABS.

As a thermoplastic, ABS fabric is recyclable.

### **ABS Offers These Advantages**

- Safe for Food Processing
- Excellent impact, chemical and abrasion resistance
- Superior stiffness and strength
- Easily machined and thermoformed
- Easy to paint and glue
- Good dimensional stability
- Excellent electrical properties
- Recyclable

### **Applications for ABS Thermoplastic**

- Food processing components
- Plumbing parts
- Housings and covers
- Automotive instrument panels
- Vacuum-formed parts
- Prototypes
- Protective bumpers

**Table 4.9.1 ABS Material Properties**

| PROPERTY                      | METRIC             | UNITS                 | ENGLISH        | UNITS                 |
|-------------------------------|--------------------|-----------------------|----------------|-----------------------|
| <b>General</b>                |                    |                       |                |                       |
| Density                       | 1.01e3<br>1.21e3   | - kg/m <sup>3</sup>   | 63.1 - 75.5    | lb/ft <sup>3</sup>    |
| <b>Mechanical</b>             |                    |                       |                |                       |
| Yield Strength                | 1.85e7 - 5.1e7     | Pa                    | 2.68 - 7.4     | ksi                   |
| Tensile Strength              | 2.76e7<br>5.52e7   | - Pa                  | 4 - 8.01       | ksi                   |
| Elongation                    | 0.015 - 1          | % Strain              | 1.5 - 100      | % Strain              |
| Hardness (Vickers)            | 5.49e7 - 1.5e8     | Pa                    | 5.6 - 15.3     | HV                    |
| Fracture Toughness            | 1.19e6<br>4.29e6   | - Pa/m <sup>0.5</sup> | 1.08 - 3.9     | ksi/in <sup>0.5</sup> |
| Young's Modulus               | 1.19e9 - 2.9e9     | Pa                    | 0.16 - 0.421   | 10 <sup>6</sup> psi   |
| <b>Thermal</b>                |                    |                       |                |                       |
| Max Service Temperature       | 61.9 - 76.9        | °C                    | 143 - 170      | °F                    |
| Insulator or Conductor        | Insulator          |                       | Insulator      |                       |
| Specific Heat Capability      | 1.39e3<br>1.92e3   | - J/kg °C             | 0.331<br>0.458 | - BTU/lb.<br>°F       |
| Thermal Expansion Coefficient | 8.46e-5<br>2.34e-4 | - strain/°C           | 47 - 130       | μstrain/°F            |
| <b>Eco</b>                    |                    |                       |                |                       |
| CO2 Footprint                 | 9.1e7 - 1.02e8     | kg/kg                 | 3.27 - 3.62    | lb/lb                 |
| Recyclable                    | Yes                |                       | Yes            |                       |

## 5.0 MATERIALS USED

### 5.1 MDF

Medium -thickness fibreboard is a designed wood item made by separating hardwood or softwood residuals into wood strands, regularly during a defibrillator, consolidating it with wax and a pitch fastener, and framing it into boards by applying warmth and pressing factor. MDF is for the most part denser than compressed wood...

Fig 5.1



### 5.2 ACRYLIC

Poly (methyl methacrylate), additionally alluded to as acrylic, acrylic glass, or plexiglass, likewise as by the trademarks Crylux, Plexiglas, Acrylite, Astariglas, Lucite, Perclax, and Perspex, among a few others, is a straightforward thermoplastic regularly used in sheet structure as a light-weight or break safe choice to glass.

FIG 5.2

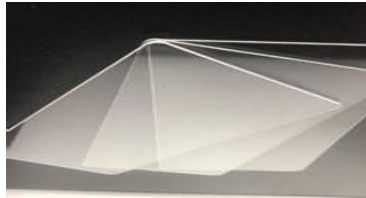


### 5.3 GLASS FIBRE

Glass fiber (or glass fiber) might be a material comprising of different amazingly fine strands of glass. Glassmakers all-around history has

explored different avenues regarding glass filaments, yet mass production of optical fiber was just made conceivable with the development of better machine tooling.

Fig 5.3



## 5.4 CARBON FIBRE

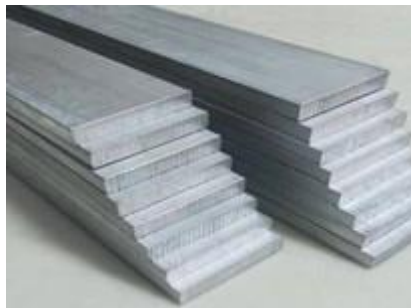
Carbon filaments or carbon strands are 5 to 10 micrometers in breadth and made generally out of carbon iotas. Carbon filaments have a few benefits including high solidness, high lastingness, low weight, high substance obstruction, heat resistance and low warm development. Carbon filaments or carbon strands are 5 to 10 micrometers in breadth and made generally out of carbon iotas. Carbon filaments have a few benefits including high solidness, high lastingness, low weight, high substance obstruction, heat resistance and low warm development.



FIG5.4

## 5.5 ALUMINIUM

Aluminum might be a component with the image Al and number 13. Aluminum includes a thickness not exactly those of other normal metals, at around 33% that of steel. It has superb insurance against oxygen and structures a defensive layer of oxide on a superficial level when presented to air...Aluminum might be a component with the image Al and number 13. Aluminum includes a thickness not exactly those of other normal metals, at around 33% that of steel. It has superb insurance against oxygen and structures a defensive layer of oxide on a superficial level when presented to air.



*Fig 5.5*

***Table 5.1 Material Properties Comparison sheet***

| <b>Material</b>     | <b>Elastic modulus<br/>10<sup>6</sup> psi</b> | <b>Shear modulus<br/>10<sup>6</sup> psi</b> | <b>Yield strength<br/>10<sup>6</sup> psi</b> | <b>Tensile strength<br/>10<sup>6</sup> psi</b> |
|---------------------|-----------------------------------------------|---------------------------------------------|----------------------------------------------|------------------------------------------------|
| <b>Aluminium</b>    | <b>70</b>                                     |                                             | <b>350</b>                                   | <b>110</b>                                     |
| <b>Carbon fibre</b> | <b>150</b>                                    |                                             | <b>611</b>                                   | <b>3190</b>                                    |
| <b>Acrylic</b>      | <b>4</b>                                      |                                             | <b>70</b>                                    | <b>225</b>                                     |
| <b>Glass Fibre</b>  | <b>17</b>                                     |                                             | <b>450</b>                                   | <b>2000</b>                                    |
| <b>MDF</b>          | <b>3.2</b>                                    |                                             | <b>137</b>                                   | <b>174</b>                                     |

|                 | Matrix                                              | Fibre                                                             |
|-----------------|-----------------------------------------------------|-------------------------------------------------------------------|
| Elastic Modulus | $E_m := 3.6 \cdot \text{GPa}$                       | $E_f := 224 \cdot \text{GPa} \quad E_{ft} := 14 \cdot \text{GPa}$ |
| Density         | $\rho_m := 1.3 \cdot \frac{\text{gm}}{\text{cm}^3}$ | $\rho_f := 1.81 \cdot \frac{\text{gm}}{\text{cm}^3}$              |
| Poissons ratio  | $\nu_m := 0.37$                                     | $\nu_f := 0.2$                                                    |
| Shear Modulus   | $G_m := G(E_m, \nu_m)$                              | $G_f := 14 \cdot \text{GPa}$                                      |

## 5.6 BMP280 Barometric Pressure and Altitude Sensor

BMP280 Barometric Pressure and Altitude Sensor I2C/SPI Module is a cheapest and tiny Atmospheric Sensor Breakout to degree barometric stress, and temperature readings all without taking over too much space. Basically, anything you want to realize about atmospheric conditions you could find out from this tiny breakout. The BMP280 Breakout has been designed for use in indoor/outdoor navigation, climate forecasting, domestic automation, or even personal health and health tracking.

### 1. BMP280 Barometric Pressure and Altitude Sensor I2C/SPI Module

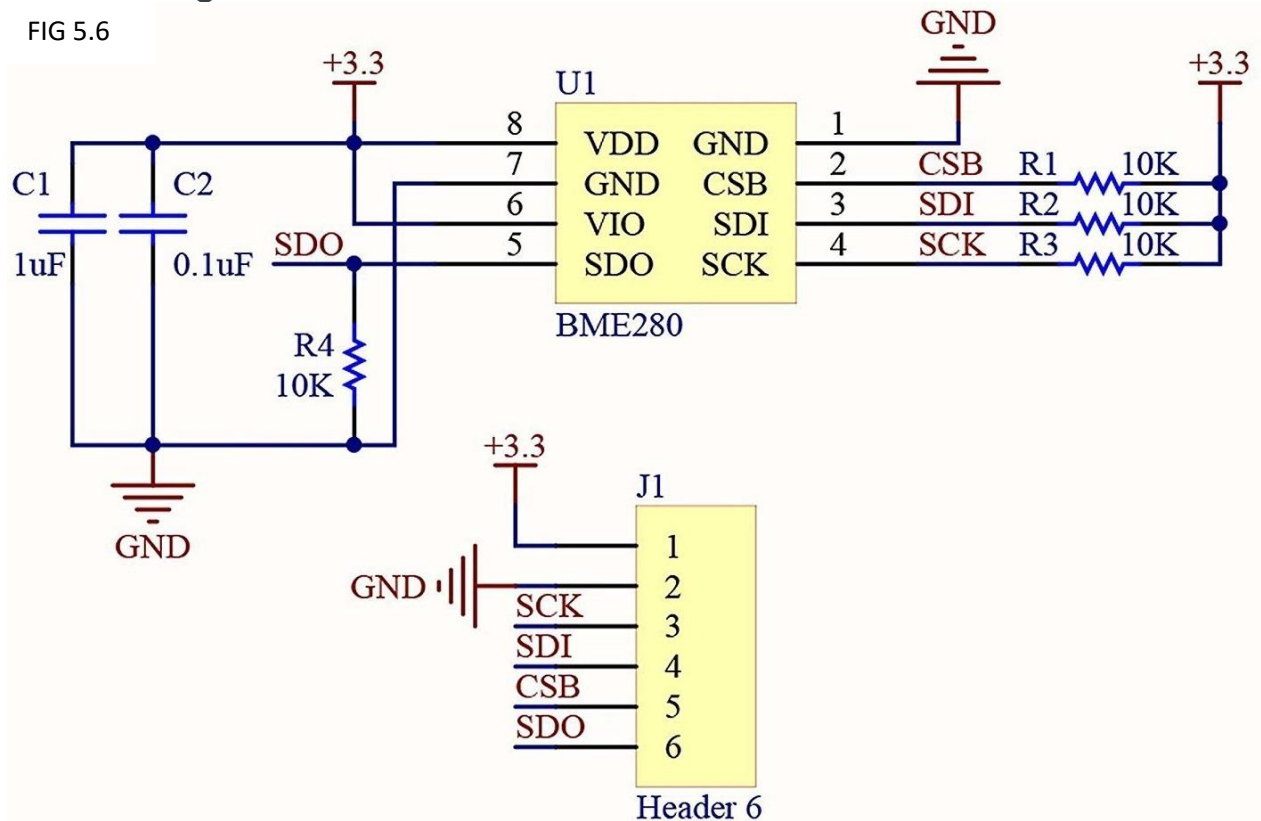
This module makes use of an environmental sensor manufactured through Bosch with temperature, a barometric strain sensor that is the subsequent era improve to the popular BMP085/BMP180/BMP183 Sensor. This sensor is exceptional for all kinds of climate sensing and might even be used in each I2C and SPI; This precision sensor from Bosch is the first-class low-fee, precision sensing answer for measuring barometric pressure with  $\pm 1$  hPa absolute accuracy, and temperature with  $\pm 1.0^\circ\text{C}$  accuracy. Because pressure changes with altitude and the strain measurements are so right; you can additionally use it as an altimeter with  $\pm 1$  meter accuracy.

The BMP280 is the subsequent-generation of sensors and is the improve to the BMP085/BMP180/BMP183 – with a low altitude noise of 0.25m and the equal speedy conversion time. It has the identical specs but can use either I2C or SPI. For easy wiring, go along with I2C. If you want to attach a bunch of sensors without stressful approximately I2C cope with collisions, go with SPI.

Note: This Product is to be had in two special variants (BMP280 and HW-611) with the same working we can ship it randomly.

### Circuit Diagram:

FIG 5.6



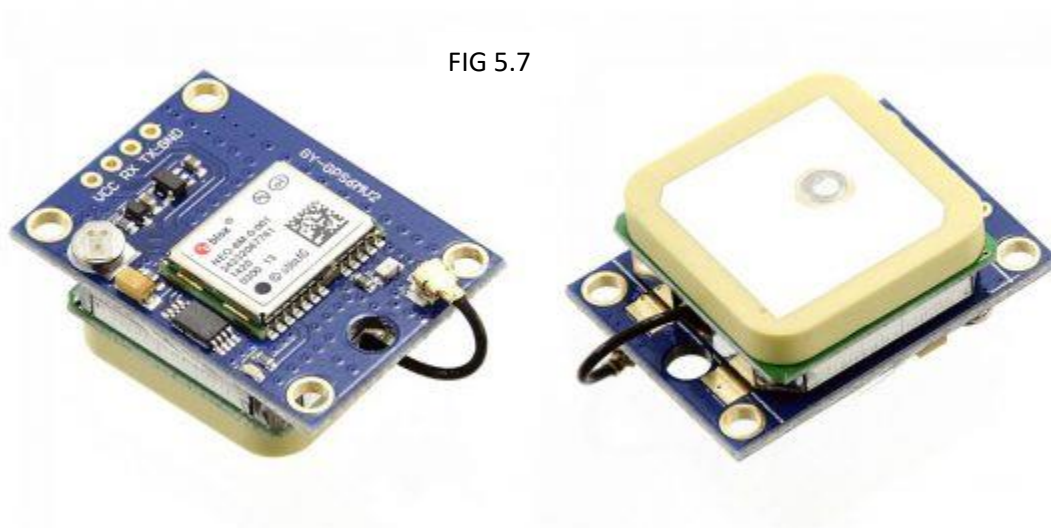
### Specifications and Features:

Get more precise temperature, atmospheric pressure values, and approximate altitude data Enhancement of GPS navigation (e.g., time-to first-fix improvement dead-reckoning, slope detection)

1. Indoor navigation (floor detection, elevator detection)
2. Outdoor navigation, leisure and sports applications
3. Weather forecast
4. Health care applications (e.g., spirometry)
5. Vertical velocity indication (e.g., rise/sink speed)

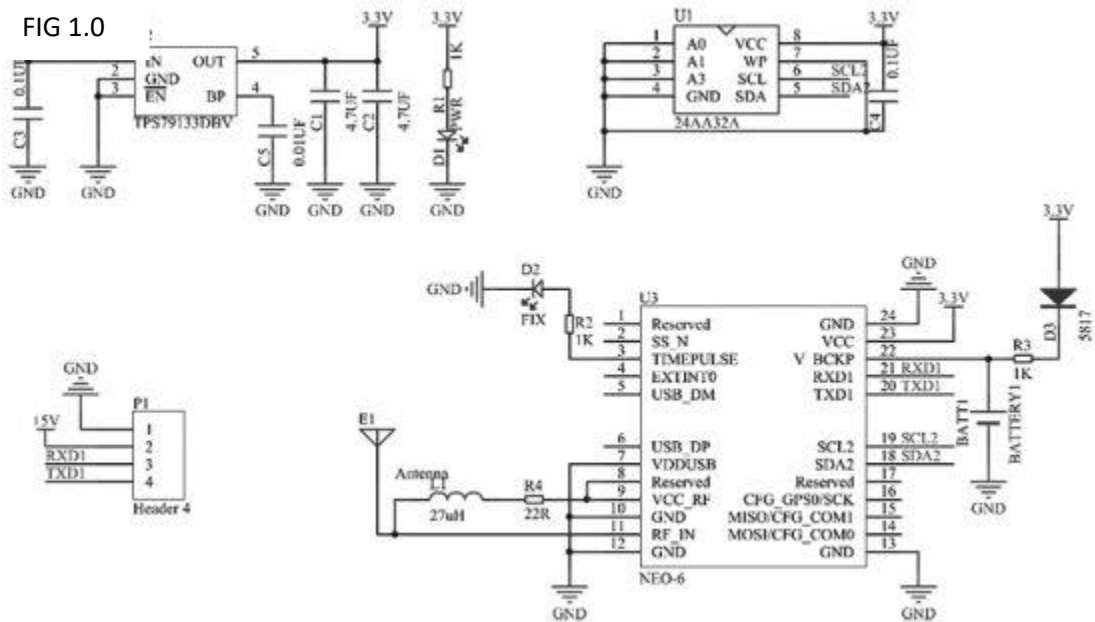
6. Libraries and tutorials available for Arduino and other microcontrollers
7. Operating Voltage: 1.71V to 3.6V – would typically be operated from 3.3V
8. Operating Temperature: -40 to +85 deg. Celsius (full accuracy between 0 and +65 deg. C)
9. Peak current: 1.12mA
10. Operating Pressure: 300 hPa to 1100 hPa
11. Accuracy between 700 to 900hPa and 25 to 40 deg. C:  $\pm 0.12$ hPa and  $\pm 1.0$ m

## 5.7 u-blox NEO-6M GPS module



The u-blox NEO-6M GPS engine on those modules is quite a very good one, and it additionally has excessive sensitivity for indoor programs. Furthermore, there's one MS621FE-compatible rechargeable battery for backup and EEPROM for storing configuration settings. The module works nicely with a DC enter in the 3.3- to 5-V variety (thanks to its integrated voltage regulator). The authentic circuit diagram of the module, borrowed from the net, is shown underneath:

FIG 1.0



As indicated, the GPS modules are primarily based at the u-blox NEO-6M GPS engine. The type variety of the NEO-6M is NEO-6M-zero-001, and its ROM/FLASH version is ROM 7.Zero.3 (PCN reference UBX-TN-11047-1). The NEO-6M module includes one configurable UART interface for serial communication, but the default UART (TTL) baud price right here is nine, six hundred. Because the GPS signal is proper-hand round-polarized (RHCP), the fashion of the GPS antenna may be special from the not unusual whip antennas used for linear polarized signals. The maximum famous antenna kind is the patch antenna. Patch antennas are flat, normally have a ceramic and steel frame, and are set up on a metallic base plate. They are often solid in a housing. For more facts approximately u-blox reference designs, see their website. Remember, the position of the antenna mounting may be very essential for ideal performance of the GPS receiver. When using the patch antenna, it have to be oriented parallel to the geographic horizon. The antenna ought to have full view of the sky, making sure an immediate line of sight with as many visible satellites as feasible.

## 5.8 Dust Sensor- GP2Y1010AU0F

Sharp's GP2Y1010AU0F is an optical air exceptional sensor, designed to feel dust debris. An infrared emitting diode and a phototransistor are diagonally arranged into this tool, to allow it to hit upon the meditated light of dirt in air. It is particularly effective in detecting very best particles like cigarette smoke, and is commonly used in air

cleaner structures. The sensor has a completely low modern-day consumption (20mA max, 11mA regular), and can be powered with as much as 7VDC. The output of the sensor is an analog voltage proportional to the measured dust density, with a sensitivity of 0.5V/zero.1mg/m<sup>3</sup>. This sensor is packaged with a 6-pin wires with JST connector to help join it with your gadget.

FIG 5.8



Model: SGP2Y1010AU

## 5.9 Arduino Pro Mini

The Arduino Pro Mini is a microcontroller board based totally at the ATmega328.

It has 14 virtual enter/output pins (of which 6 may be used as PWM outputs), 6 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers. A six-pin header may be linked to an FTDI cable or Sparkfun breakout board to offer USB power and communication to the board.

The Arduino Pro Mini is intended for semi-everlasting installation in gadgets or exhibitions. The board comes without pre-mounted headers, allowing the use of diverse varieties of connectors or direct soldering of wires. The pin layout is compatible with the Arduino Mini.

There are two model of the Pro Mini. One runs at three.3V and 8 MHz, the alternative at 5V and 16 MHz.

### ***Table no. 5.9 Technical specs***

|                 |             |
|-----------------|-------------|
| Microcontroller | ATmega328 * |
|-----------------|-------------|

|                           |                                                |
|---------------------------|------------------------------------------------|
| Board Power Supply        | 3.35 -12 V (3.3V model) or 5 - 12 V (5V model) |
| Circuit Operating Voltage | 3.3V or 5V (depending on model)                |
| Digital I/O Pins          | 14                                             |
| PWM Pins                  | 6                                              |
| UART                      | 1                                              |
| SPI                       | 1                                              |
| I2C                       | 1                                              |
| Analog Input Pins         | 6                                              |
| External Interrupts       | 2                                              |
| DC Current per I/O Pin    | 40 mA                                          |
| Flash Memory              | 32KB of which 2 KB used by bootloader *        |
| SRAM                      | 2 KB *                                         |
| EEPROM                    | 1 KB *                                         |
| Clock Speed               | 8 MHz (3.3V versions) or 16 MHz (5V versions)  |

(\*) Older boards were equipped with AT mega 168 with this specs:

- Flash memory: 16 KB
- SRAM: 1 KB
- EEPROM: 512 bytes

## CHAPTER 6

### RESULTS AND DISCUSSION

#### Design

The 1U cube satellite model has been designed using the fusion 360 software.

The cube is given 10Cm length and 10Cm width with 5Cm height while keeping the wall thickness to be 5mm. enough space has been given to fit all the electronic shown in the figure below

FIG 6.1

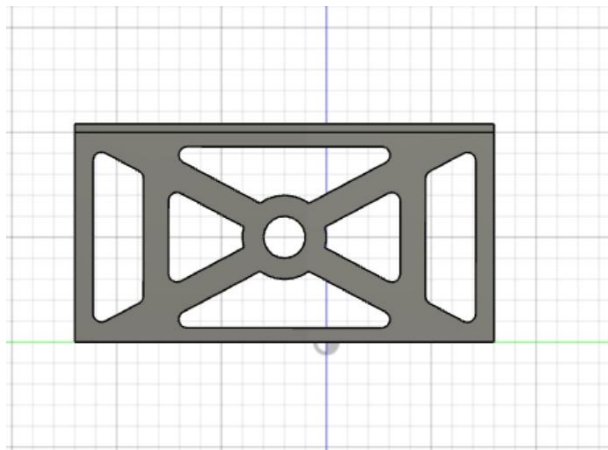
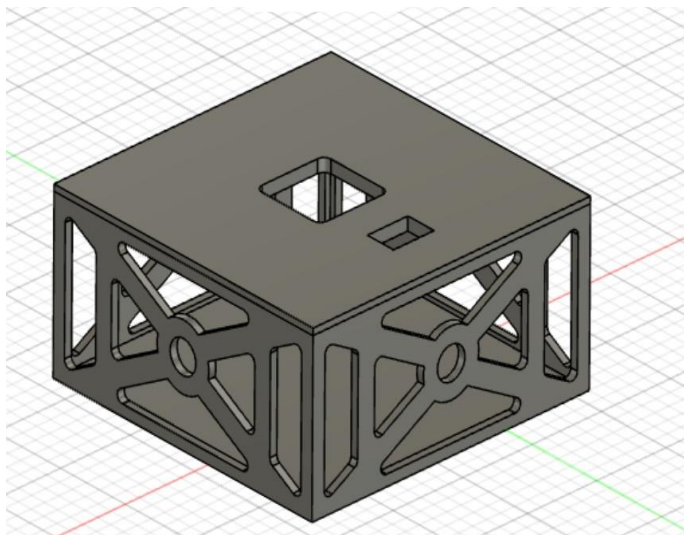
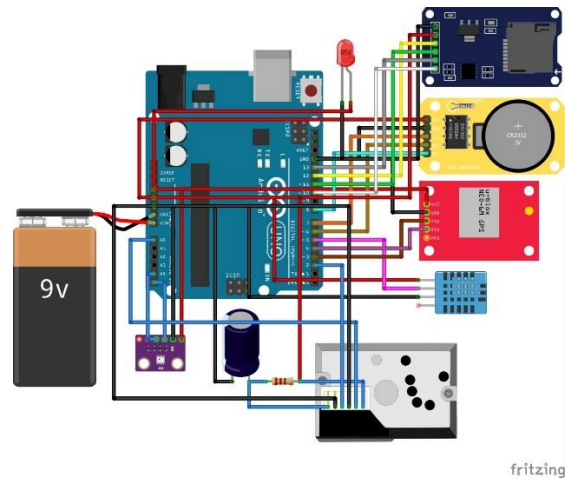


FIG 6.2



All the electronics have been wired as shown in the below figure. We have achieved minimal wiring which reduces the weight of the satellite ultimately

FIG 6.3



For a professional work and to reduce more weight we have designed a breadboard to fit all the electronics in one place. Which is shown in the below figure.

FIG 6.4

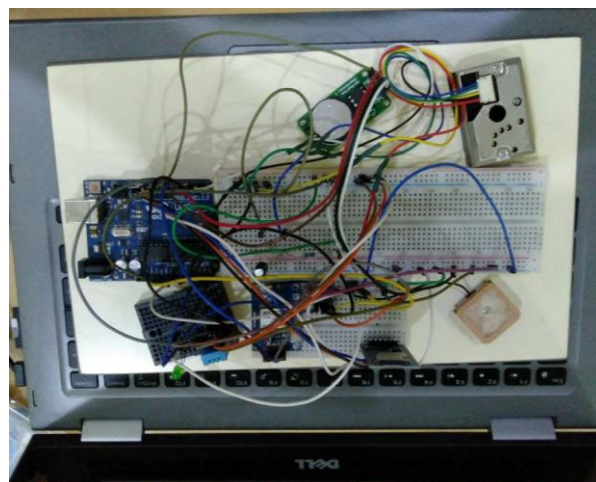
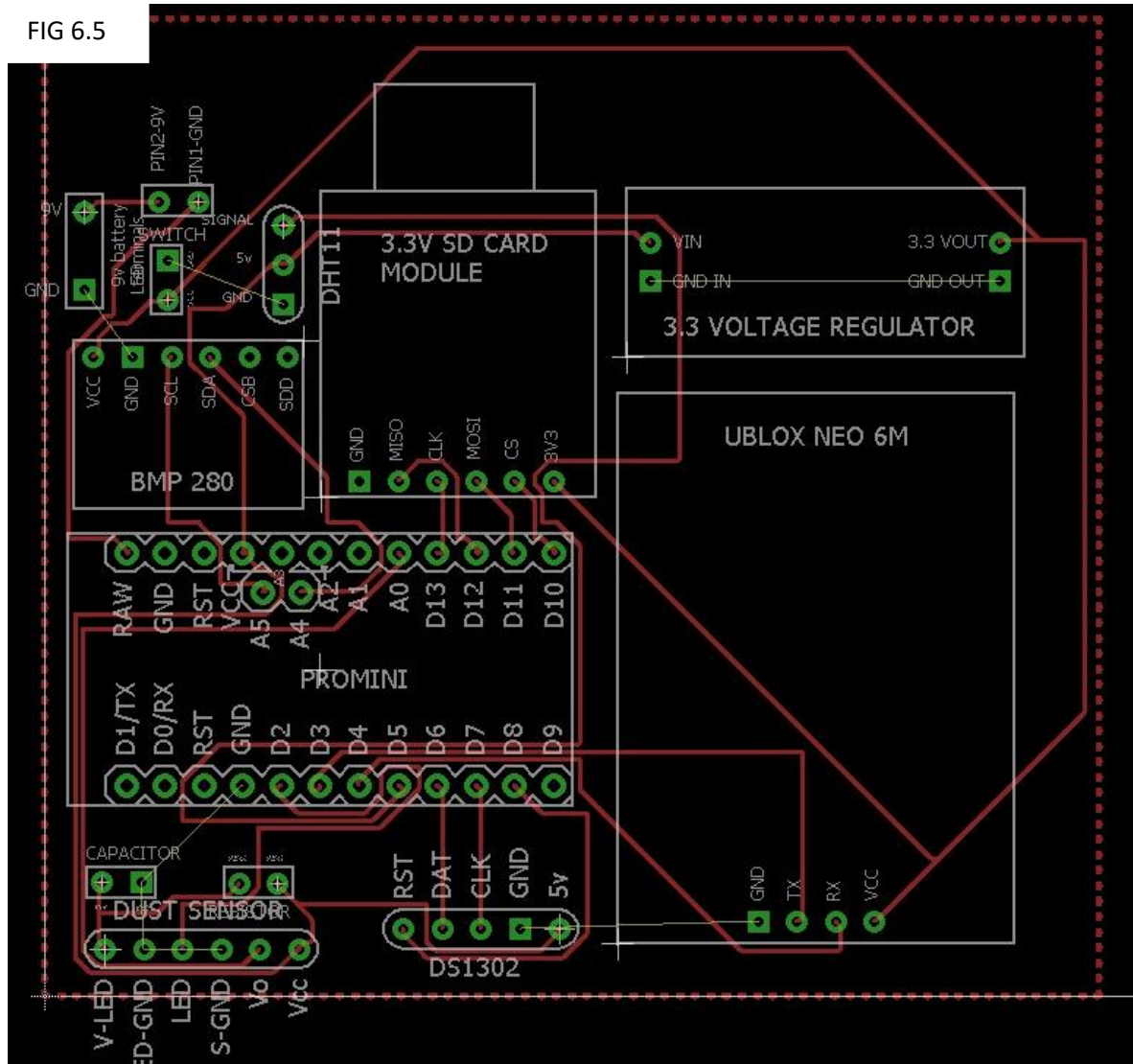


FIG 6.5



## 6.1 SIMULATION

The simulation have been carried out using Fusion 360 event simulation with a selection of stress analysis.

Process of Simulation:

- 1.All the materials have been defined which is plastic in this case.
- 2.All the constraints have been loaded which is all the sides as locked in 3d space
- 3.All the loads in the desired directions have been given
- 4.In this case we have given loads in 3 different directions in 3 different cases
- 5.As shown in the below figures the 1<sup>st</sup> load is given from the top, the 2<sup>nd</sup> load is given from the side while the other has been given from the corner which simulates all the impact forces when dropped from a certain height.

6. After successful simulation, we can find the deformations on the body that can happen in real time environment.

#### 7. Observations:

In Fig we can see that the force of 10N acting from the top doesn't have much impact while maintaining a good safety factor which proves our design to be good enough

As well as from the side, it goes the same way

But from the corner we can observe that there is a larger deformation than the other two but this is because of corner impact and it makes sense.

In order to rectify this issue we might add corner protectors or safety bumpers to withstand the load or impact during a hard landing or crash

FIG 6.6

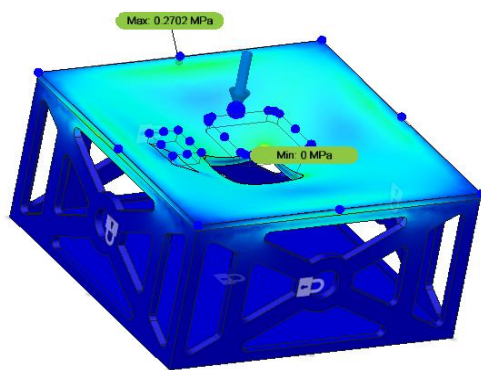


FIG 6.7

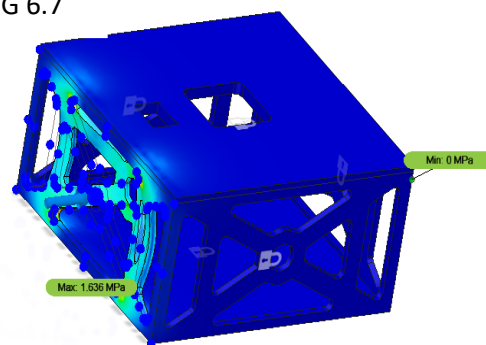
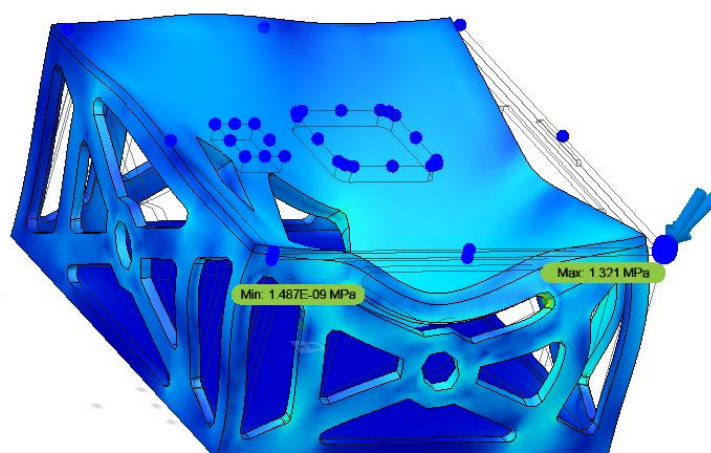
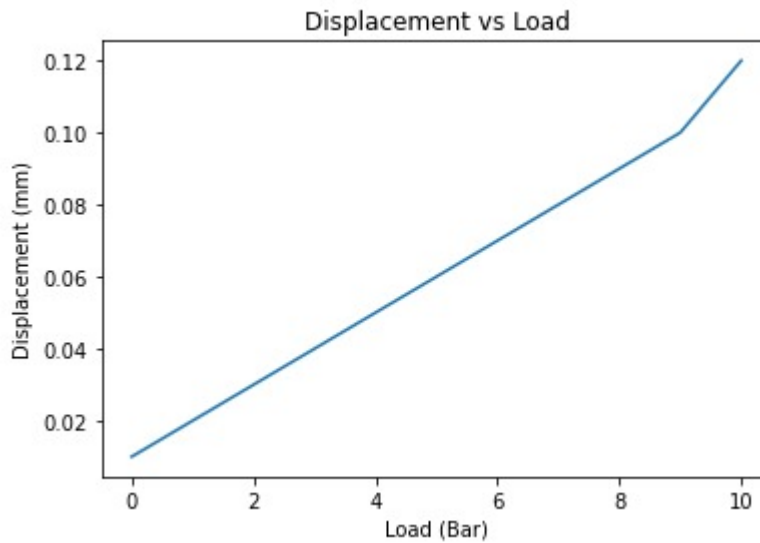


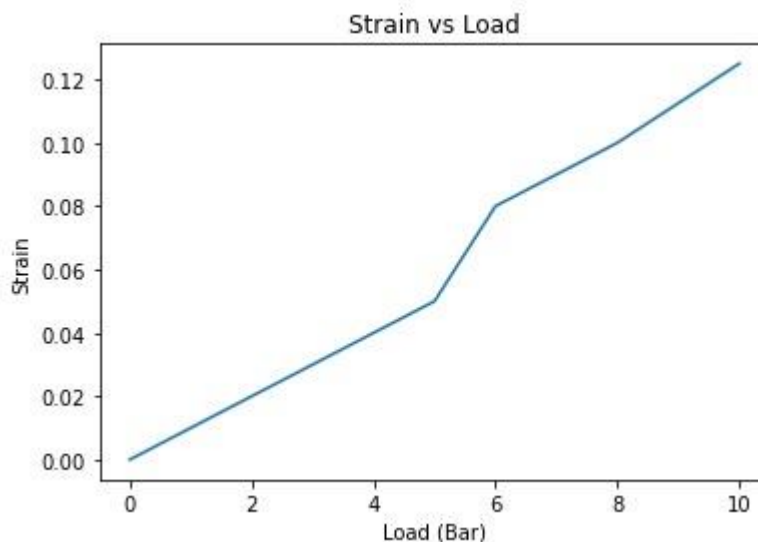
FIG 6.8



## Simulation Graphs

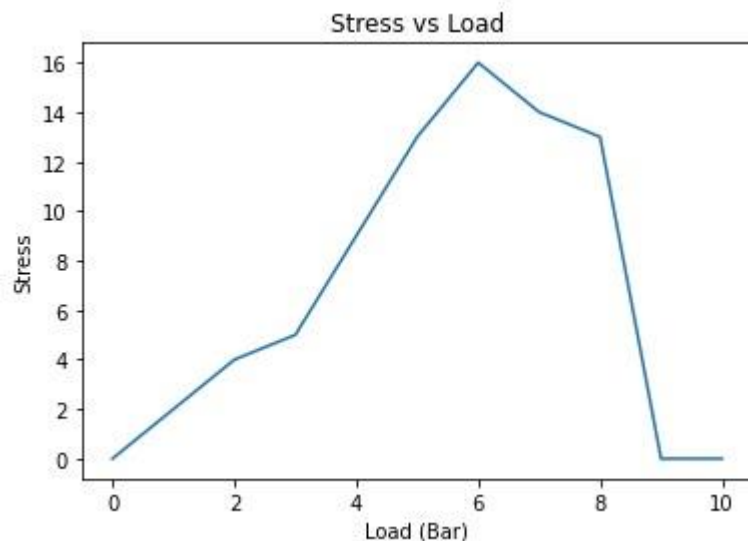


Here as the load is increased on the structure with its sides locked from two ends, the deformation of the structure takes place. Which inturn makes the structure to displace from its original position, hence with the increase in the load , displacement increases gradually. Therefore, we can say that displacement varies linearly with load in this structure.



Here as the load is increased on the structure with its sides locked from two ends, the deformation of the structure takes place. Which inturn the makes structure to displace

from its original position. As a result there is a strain developed in the structure. Hence with the increase in the load , displacement increases gradually which causes the strain to increase. Therefore we can say that strain varies with the load in this structure.



Here as the load is increased on the structure, there will be a resistance developed in the structure which opposes the displacement of the structure. As a result the structure experiences stress. As the load is kept increasing, the stress values increases until the material starts to fail. Once the material starts to break the stress on the structure is reduced. The same is observed in the graph plotted above.

## 6.2 Final Output:

As you can see the following fig

We have a completely 3d printed body which is ready to keep all our electronics

And make a perfect cube sat.

The body dimensions are as follows

Length = 10Cm

Width = 10Cm

Height = 6Cm

Wall thickness = 5 mm

FIG 6.2.1

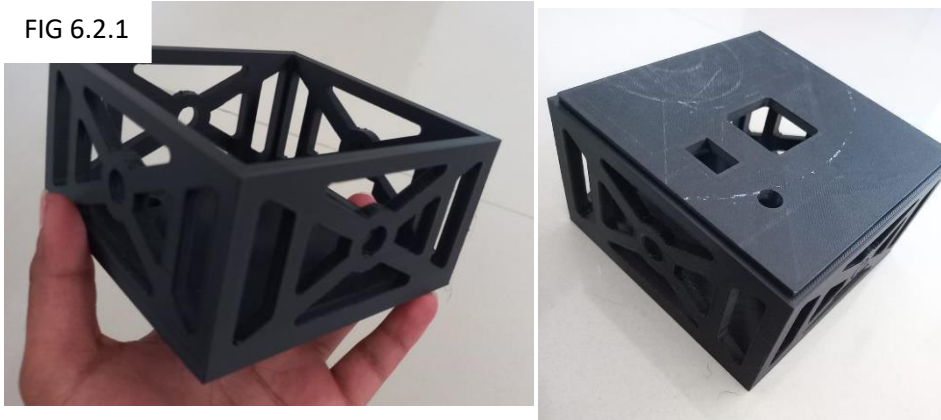


FIG 6.2.2

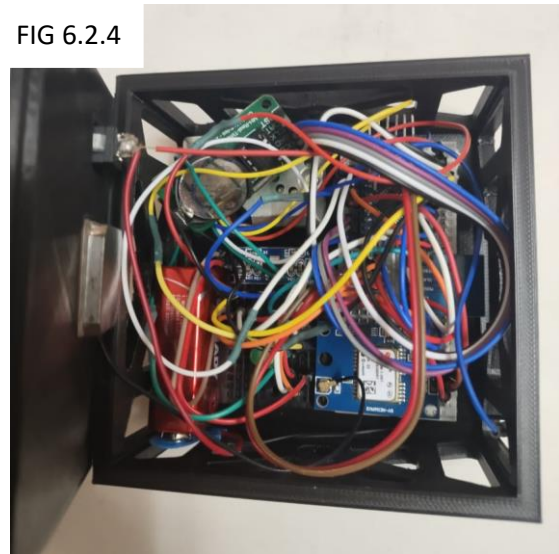
As per the connection diagram we have assembled all our electronics and kept them inside our 3d printed box

The antenna of the gps is visible on the top and a switch is provided to turn on and off the device prior to launch

FIG 6.2.3



FIG 6.2.4



Once we are done with all the connections we will proceed with the code upload

A part of the code has been showcased here

### **6.3 Code explanation:**

We imported all the libraries needed to communicate between the Arduino and all other onboard sensors like GPS, barometer, SD card module, and dust particle sensor

Then we initiate the sensors by defining the pins and baud rate

The main code works like this:

Once the Cube sat reaches a certain altitude the Arduino pro mini starts recording the data from all the sensors in to the SD card installed

The process will be repeated till the balloon carrying the cube satellite gets burst and drops the body back into earth's atmosphere.

We will retrieve the satellite using the last location in the log.

```

#include <TinyGPS++.h> // Include the TinyGPS++ library
TinyGPSPlus tinyGPS; // Create a TinyGPSPlus object
#include "SD.h"
#define GPS_BAUD 9600 // GPS module baud rate. GP3906 defaults to 9600.
#include <Wire.h>
// If you're using an Arduino Uno, RedBoard, or any board that uses the
// 0/1 UART for programming/Serial monitor-ing, use SoftwareSerial:
#include <SoftwareSerial.h>
#define ARDUINO_GPS_RX 4 // GPS TX, Arduino RX pin
#define ARDUINO_GPS_TX 3 // GPS RX, Arduino TX pin
SoftwareSerial ssGPS(ARDUINO_GPS_TX, ARDUINO_GPS_RX); // Create a SoftwareSerial
#define SDFILE_PIN_CS 10
// Set gpsPort to either ssGPS if using SoftwareSerial or Serial1 if using an
// Arduino with a dedicated hardware serial port
#define gpsPort ssGPS // Alternatively, use Serial1 on the Leonardo
#include <SPI.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BMP280.h>
Adafruit_BMP280 bme;
////////////////////////rtc
#include "ThreeWire.h"
#include <RtcDS1302.h>
ThreeWire myWire(6, 7, 8); // IO, SCLK, CE
RtcDS1302<ThreeWire> Rtc(myWire);
////////////////////////dust sensor
int measurePin = 0; //Connect dust sensor to Arduino A0 pin
int ledPower = 2; //Connect 3 led driver pins of dust sensor to Arduino D2

int samplingTime = 280;
int deltaTime = 40;
int sleepTime = 9680;

```

## CHAPTER 7

### 7.1 Summary and Conclusion:

Once the cube satellite is recovered from the drop location we retrieve the SD card

The data from all the sensors will be saved in a txt file in the SD card which contains all the data as shown below

It contains Date & time

Temperature at certain altitude

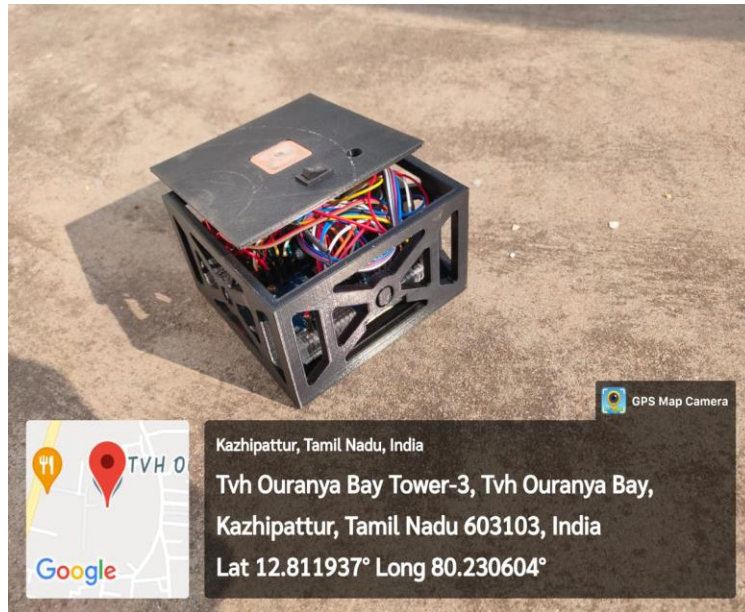
GPS location and speed

Dust density at the height.

Now, coming to our core of the project we use the height, location coordinates and the dust particle sensor reading to calculate the trajectory of our next rocket to be launched.

Hence, by doing this we have successfully used our Cube satellite to measure the dust density and calculate the new trajectory for the rocket to be launched from the same location.

| RTC Date   | RTC Time | BMP Temperature | BMP Pressure    | BMP Altitude | Dust Density | GPS Date | GPS Time    | GPS Altitude | Speed               |
|------------|----------|-----------------|-----------------|--------------|--------------|----------|-------------|--------------|---------------------|
| 16/12/2021 | 22:18:52 | 30.47           | 101363.54 -3.21 | -0.10        | 0/0/2000     | 0:00:00  | 0.00 0.00 0 | 0.000000     | 0.000000            |
| 16/12/2021 | 22:18:53 | 30.47           | 101366.98 -3.50 | -0.02        | 16/12/2021   | 16:48:59 | -21.70      | 0.24 4       | 13.041090 80.132247 |
| 16/12/2021 | 22:18:54 | 30.48           | 101368.86 -3.65 | 0.02         | 16/12/2021   | 16:49:00 | -17.80      | 0.30 4       | 13.041219 80.132225 |
| 16/12/2021 | 22:18:55 | 30.48           | 101366.73 -3.48 | 0.01         | 16/12/2021   | 16:49:01 | -15.80      | 1.23 4       | 13.041243 80.132202 |
| 16/12/2021 | 22:18:56 | 30.48           | 101367.23 -3.57 | -0.01        | 16/12/2021   | 16:49:02 | -14.40      | 1.79 4       | 13.041240 80.132186 |
| 16/12/2021 | 22:18:57 | 30.48           | 101367.07 -3.50 | -0.01        | 16/12/2021   | 16:49:03 | -12.90      | 2.05 4       | 13.041233 80.132186 |
| 16/12/2021 | 22:18:59 | 30.48           | 101367.23 -3.52 | -0.09        | 16/12/2021   | 16:49:04 | -12.40      | 2.21 3       | 13.041217 80.132194 |
| 16/12/2021 | 22:19:00 | 30.48           | 101367.90 -3.57 | -0.00        | 16/12/2021   | 16:49:06 | -12.20      | 2.25 3       | 13.041190 80.132171 |
| 16/12/2021 | 22:19:01 | 30.48           | 101365.89 -3.41 | -0.00        | 16/12/2021   | 16:49:07 | -12.20      | 1.86 3       | 13.041179 80.132171 |
| 16/12/2021 | 22:19:02 | 30.48           | 101366.74 -3.48 | 0.00         | 16/12/2021   | 16:49:08 | -12.40      | 1.74 3       | 13.041174 80.132171 |
| 16/12/2021 | 22:19:03 | 30.48           | 101367.23 -3.52 | -0.03        | 16/12/2021   | 16:49:09 | -12.90      | 1.87 3       | 13.041171 80.132179 |
| 16/12/2021 | 22:19:04 | 30.48           | 101363.84 -3.23 | 0.00         | 16/12/2021   | 16:49:10 | -13.10      | 1.91 4       | 13.041161 80.132179 |
| 16/12/2021 | 22:19:05 | 30.48           | 101364.50 -3.29 | -0.00        | 16/12/2021   | 16:49:11 | -13.50      | 1.81 4       | 13.041140 80.132179 |
| 16/12/2021 | 22:19:06 | 30.48           | 101365.01 -3.33 | 0.02         | 16/12/2021   | 16:49:12 | -13.90      | 1.77 4       | 13.041121 80.132179 |
| 16/12/2021 | 22:19:07 | 30.48           | 101366.08 -3.42 | -0.01        | 16/12/2021   | 16:49:13 | -15.00      | 2.87 4       | 13.041090 80.132186 |
| 16/12/2021 | 22:19:08 | 30.48           | 101366.42 -3.45 | 0.00         | 16/12/2021   | 16:49:14 | -14.90      | 2.13 4       | 13.041095 80.132194 |
| 16/12/2021 | 22:19:09 | 30.48           | 101365.05 -3.33 | -0.00        | 16/12/2021   | 16:49:15 | -14.00      | 2.58 4       | 13.041043 80.132186 |
| 16/12/2021 | 22:19:11 | 30.48           | 101366.57 -3.46 | -0.09        | 16/12/2021   | 16:49:16 | -14.10      | 1.27 4       | 13.041043 80.132186 |
| 16/12/2021 | 22:19:12 | 30.48           | 101367.41 -3.53 | 0.01         | 16/12/2021   | 16:49:18 | -12.90      | 1.35 4       | 13.041007 80.132194 |
| 16/12/2021 | 22:19:13 | 30.48           | 101366.08 -3.42 | -0.00        | 16/12/2021   | 16:49:19 | -11.80      | 1.16 4       | 13.040991 80.132194 |
| 16/12/2021 | 22:19:14 | 30.48           | 101367.08 -3.50 | -0.01        | 16/12/2021   | 16:49:20 | -10.90      | 1.14 4       | 13.040972 80.132186 |
| 16/12/2021 | 22:19:15 | 30.48           | 101364.17 -3.27 | 0.01         | 16/12/2021   | 16:49:21 | -10.30      | 1.33 4       | 13.040955 80.132186 |
| 16/12/2021 | 22:19:16 | 30.48           | 101366.08 -3.42 | 0.00         | 16/12/2021   | 16:49:22 | -9.10       | 2.10 4       | 13.040924 80.132179 |
| 16/12/2021 | 22:19:17 | 30.48           | 101364.23 -3.27 | 0.01         | 16/12/2021   | 16:49:23 | -7.90       | 2.53 4       | 13.040894 80.132164 |
| 16/12/2021 | 22:19:18 | 30.49           | 101364.61 -3.30 | 0.00         | 16/12/2021   | 16:49:24 | -7.20       | 1.85 4       | 13.040884 80.132164 |
| 16/12/2021 | 22:19:19 | 30.48           | 101363.07 -3.17 | 0.00         | 16/12/2021   | 16:49:25 | -4.30       | 2.15 4       | 13.040839 80.132133 |



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