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3U CUBESAT MECHANICAL DESIGN AND SUBSYSTEMS

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Abstract. In this paper, an in-depth analysis of the mechanical design and integration of the 3U CubeSat subsystems is presented, a common form factor in the small satellite community. The study summarises recent research and emphasises developments in material selection, structural integrity, thermal management, and computer-aided design (CAD) techniques. In addition, it explores the integration of crucial subsystems, such as power, communication, and payloads, highlighting the challenges and solutions encountered. This paper aims to provide a comprehensive understanding of the state-of-the-art 3U CubeSat mechanical design and subsystem integration by compiling and evaluating current developments. The insights offered here are essential for researchers and engineers, laying the groundwork for further advancements in CubeSat technology.

Keywords: 3U CubeSats, small satellites, mechanical design, mechanical subsystems, electronic subsystems.

1. Introduction

The importance of small satellites in space exploration is growing, particularly for educational and research missions. CubeSats are compact satellites that follow a standardised unit size and are designed to simplify and streamline satellite construction and deployment. Since their introduction by Cal Poly and Stanford in 1999, CubeSats have evolved from educational tools to versatile instruments for a range of scientific endeavors. A 3U CubeSat, which is just three times the size of a standard 1U CubeSat, offers increased capacity for complex missions and an increased payload.

The 3U configuration extends from the CubeSat standard with dimensions of 34 cm × 10 cm × 10 cm, offering a larger platform for more complex missions while preserving affordability and accessibility. For the 3U CubeSat to survive launch and function well in the harsh conditions of space, its mechanical design is essential.

The use of high-strength, lightweight materials such as aluminum alloys, which offer the required structural integrity without adding undue mass, is essential to the mechanical design. This sturdy construction needs to withstand the high accelerations and vibrations of launch, as well as the harsh vacuum and temperature conditions in orbit. Shock, vibration, thermal vacuum, and other rigorous environmental tests are used to confirm that the CubeSat can survive and operate in space.

In addition, attached or deployable solar panels and payloads must be supported by the mechanical design to maximise CubeSat's operational effectiveness and mission success. These components must be able to successfully deploy in orbit and be safely housed during launch. The 3U CubeSat's mechanical design also has to take into account effective space utilisation and thermal management. To maintain operating temperatures, the satellite has to disperse heat produced by its internal electronics and external solar radiation. This is accomplished by carefully arranging the parts and using radiators, heat sinks, and thermal control materials.

CubeSats advances satellite technology by applying a mechanical specification guide in addition to its operational functions. The paper provides a consistent design and production framework by laying out the requirements for mass, dimensions, and interfaces. From structural measurements to material selections, every element of the CubeSat design complies with these requirements. The 3U CubeSat's design is shaped by the specifications, which ensure a mission-appropriate design and interoperability with multi-launch systems.

2. Literature review

Due to their cost-effectiveness and modular design, CubeSats and the 3U configuration (34 cm × 10 cm × 10 cm) in particular, have become a major advancement in satellite technology. According to [1, 2], these nanosatellites were first created to provide educational institutions inexpensive access to space, but they have been used subsequently for a variety of scientific, governmental, and private purposes. The complexity and expense usually associated with satellite missions are reduced by the standardised form factor, making the integration and launch simple. In this review, materials, structural elements, temperature control, and electronics integration for the mechanical design of the 3U CubeSat are covered.

2.1. Structural materials and design

The primary material used to build the structural frame of 3U CubeSats is aluminium alloys, especially 6061-T6, which is renowned for its exceptional thermal qualities, durability, and high strength-to-weight ratio. Using these materials, the CubeSat can survive the challenging conditions of launch and space environments [3]. To further reduce the weight and improve design flexibility, composite materials and 3D printed components have been focused recently [4].

To provide the required structural strength and mounting places for additional components, the frame usually consists of rails and corner posts. As [1] states, the modular architecture makes it simple to assemble and integrate subsystems, allowing them to be customised to meet various mission requirements. According to the CubeSat Design Specification (CDS), the structure must be compatible with common deployment techniques such as the Poly-Picosatellite Orbital Deployer (P-POD) [2].

2.2. Electronics and onboard systems

Over the past decade, there have been major developments in the electronics of 3U CubeSats. Microcontrollers, application-specific integrated circuits (ASICs), and field-programmable gate arrays (FPGAs) are examples of miniature components that are frequently used to increase processing capacity while preserving power and space [3]. Robust onboard processors with an ARM architecture, for example, facilitate complex data processing and instantaneous decision making. To make the best use of the available space, these components are installed on printed circuit boards (PCBs) that are organised in stacked layouts.

2.3. Power systems

An essential aspect of the design of a 3U CubeSat is power management. Typically, these satellites use photovoltaic cells converting solar energy into electrical power; power generation capabilities are greatly enhanced by advances in solar cell efficiency [5]. Lithium-ion or lithium-polymer batteries, which have a long life cycle and a high energy density, are used to store power. According to [6], power distribution units (PDUs) control the distribution of electricity among different subsystems, ensuring dependable and effective functioning.

2.4. Communication systems

The operation of 3U CubeSats requires sophisticated communication systems. According to [5], these systems usually consist of transceivers that can operate on UHF, VHF, S-band, or X-band frequencies, depending on the needs of the operation. Modular communication protocols and increased data capacity are made possible by innovations such as software-defined radios (SDRs). According to [7], high-gain antennas are used to secure a reliable communication with ground stations and increase signal strength. These antennas include deployable and patch antennas.

2.5. Propulsion and mobility

More complex maneuvers and longer mission durations are now possible for 3U CubeSats due to the recent developments in propulsion technology. To provide precise control of the satellite's orientation and position, propulsion systems, such as electric Hall-effect thrusters, cold gas thrusters, and ion thrusters are used in the design [6]. These systems are small and efficient, fit into the limited space of the 3U form and provide a substantial amount of thrust for station-keeping and orbital adjustments. The CubeSat also rotates in space, using several small reaction wheels [8].

2.6. Thermal management

For 3U CubeSat, thermal management is crucial to keeping payloads and onboard electronics at the ideal operating temperature. Radiators, thermal straps, and coatings are examples of passive thermal management techniques that are often used. As described in [9], these techniques use the surface of the satellite to radiate excess heat into space. Active thermal control systems, such as loop heat pipes and heat pipes, are fitted to optimise heat transfer efficiency for missions with higher thermal loads.

To estimate temperature variations and ensure that all components remain within their operating temperature ranges, thermal modelling and analysis are essential during the design phase. To create efficient thermal control strategies, this modelling takes into account the satellite's orbit, orientation, and mission time [9].

2.7. Payloads and scientific instruments

A range of scientific instruments and sensors can be carried by 3U CubeSats due to their payload capacity. Spectrometers for atmospheric analysis, magnetometers for space weather research, and cameras for Earth observation are typical payloads [10]. CubeSat's modular design makes it simple to integrate and customize a variety of payloads to meet certain mission objectives [7].

2.8. Mechanical interfaces and deployment

Interfaces for payload integration and deployment techniques are part of the 3U CubeSat's mechanical architecture. In order to carry a variety of research instruments, sensors, or communication devices, the payload bay needs to be flexible. According to [1], this adaptability frequently necessitates specialised mounting solutions and vibration isolation to safeguard the sensitive parts during launch.

CubeSat can be safely and precisely launched from the launch box through deployment mechanisms, including spring-loaded deployers and release mechanisms. Strict guidelines must be followed by these systems to guard against damage during deployment. The most widely used deployment device, the P-POD, was created to hold several CubeSats and ensure their safe launch into the orbit [2].

2.9. Environmental testing

To ensure that the 3U CubeSat can survive challenging space conditions, such as high temperatures, mechanical vibrations, and radiation exposure, environmental testing is essential. These tests verify the structural integrity and operational capability of the satellite. They include mechanical shock, vibration, radiation, electromagnetic compatibility (EMC), and thermal vacuum testing. By ensuring that every component can function reliably in space, such extensive testing increases the likelihood of mission success and endurance.

2.10. Advantages of the 3U configuration

The 3U CubeSat arrangement offers several key advantages over smaller CubeSat configurations, mainly due to its larger volume and surface area [11]. These benefits include:

- Increased payload capacity: Allows the use of heavier and more complex instrumentation.
- Enhanced power generation: Increases the solar panel's surface area, allowing for energy-intensive missions.
- Improved thermal management: The increased volume and surface area allows for better temperature control, which is essential to maintain component integrity.
- Greater mission versatility: Allows the integration of advanced mission topologies and numerous payloads.

All of these benefits combined make the 3U CubeSat a highly versatile and capable platform for a variety of space missions.

2.11. Challenges and their solutions for the 3U configuration

Although 3U CubeSats have a number of benefits, they also face challenges:

- Complex deployment mechanisms: More advanced deployment systems are needed. Designing and standardising sophisticated deployment systems that ensure reliable and efficient deployment is crucial.
- Higher launch costs: Higher launch costs are correlated with increased size and mass. To share launch costs, cost-sharing alternatives through co-operative initiatives or rideshare missions are often used.
- Increased power consumption: Power requirements increase with the number of subsystems. By using more modern battery technology and efficient solar panels, the power producing capacity increases.

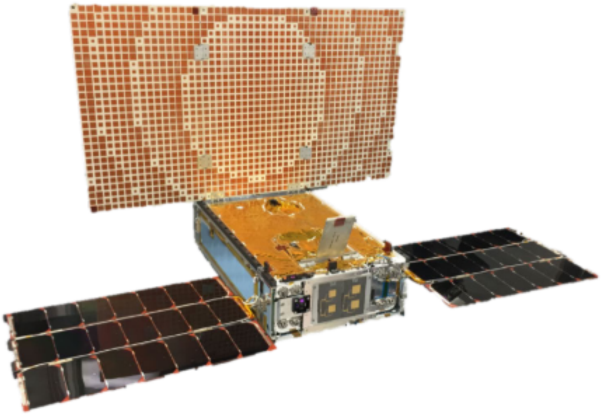

Figure 1. MarCO CubeSat in fully deployed configuration [7].

- Thermal management challenges: Thermal regulation is more difficult with larger volumes. Advanced thermal control devices, such as radiators and heat pipes, are used to regulate temperature variations.
- More demanding radiation shielding: More extensive shielding is required to protect against space radiation. Advanced materials are used to shield against radiation and include components that have been radiation-hardened.
- Design complexity: Longer development times and higher development costs are the result of increased complexity. To accelerate development and reduce costs, off-the-shelf components and modular design techniques are used.

2.12. Applications of 3U CubeSats

The versatility of 3U CubeSats has led to their application in a wide range of fields, including the following:

- Earth observation: 3U CubeSats are used to monitor variations in the environment, urban development, and agricultural operations. They are equipped with high-resolution cameras and sensors. For instance, Planet Lab's Dove satellites use 3U CubeSats to take images of the Earth every day [10].
- Space science: Astrophysical research, planetary exploration, and space weather studies use CubeSats. As part of NASA's Mars insight program, the MarCO CubeSats proved useful for deep-space communication relays [7], see Figure 1 for an illustration of the fully deployed MarCO CubeSat configuration.
- Communication: CubeSats function as test beds for emerging communication technologies and offer communication services in remote locations. Multiple 3U CubeSats were deployed as part of the QB50 project, which tested novel communication methods while conducting research into the lower thermosphere [5].

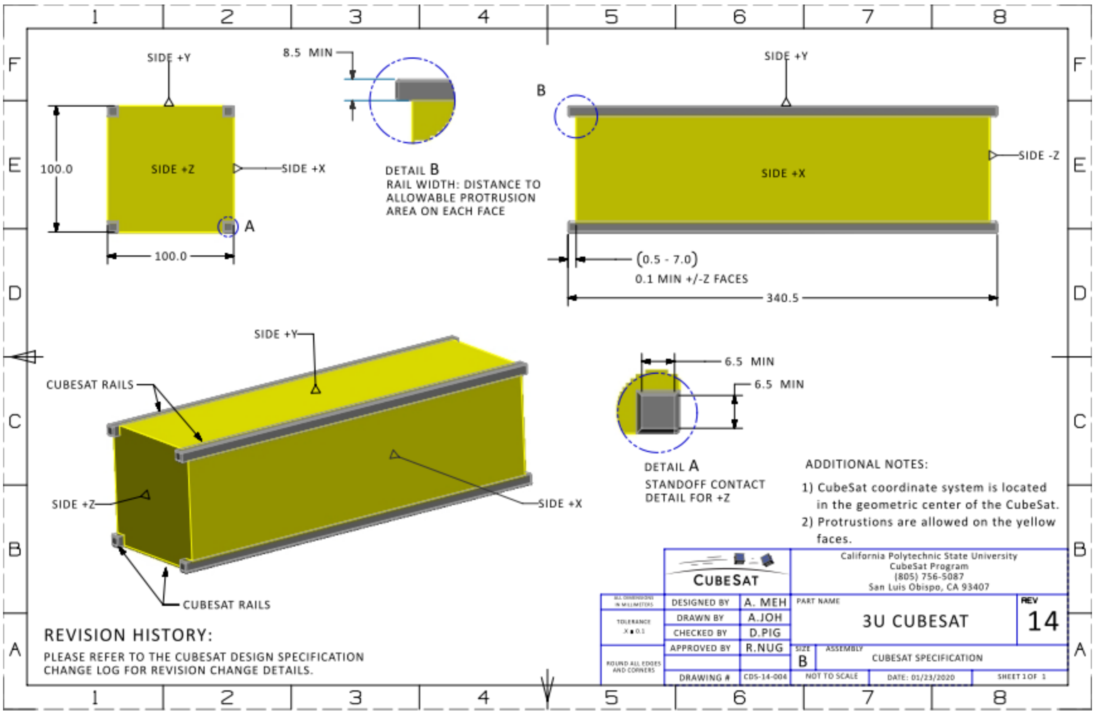

Figure 2. 3U CubeSat physical dimensions [12].

2.13. Future prospects

Future research into swarm technology, in which coordinated constellations of CubeSats carry out difficult tasks collectively, suggests that 3U CubeSats have a bright future [13]. Developments in communication and propulsion technologies are expected to open the door to more ambitious interplanetary travel and more affordable ways to explore other planets and moons [14]. The involvement of private companies in the development of CubeSats for a range of applications will drive further innovation and reduce costs through economies of scale, accelerating the commercialisation of CubeSat technology [15].

Over the past decade, 3U CubeSats have evolved from basic educational instruments to complex systems that can carry out a variety of commercial, scientific, and exploratory missions. Despite the challenges, design and technological developments are improving CubeSats' capabilities, ensuring that they will continue to play a significant role in space exploration for many years.

A variety of space missions require a platform that is both versatile and reliable, which is why the mechanical design of 3U CubeSats carefully balances subsystem integration, thermal management, structural integrity, and material selection. These small satellites are now capable of much more due to the use of lightweight materials, such as aluminum alloys, sophisticated composites, miniaturised electronics, and effective power systems. 3U CubeSats will probably become more significant in space exploration and commercial use as technology advances. In-depth details of the mechanical design and subsystems are covered in the following section.

3. Mechanical design and subsystems

CubeSats are small, standardised-diameter satellites that enable flexible and affordable space missions. Guidelines for ensuring compatibility with launch vehicles and deployment procedures are provided by the CubeSat Design Specification (CDS). This section focuses on the mechanical subsystems and the main structure of a 3U CubeSat with dimensions of 10 cm × 10 cm × 34 cm. This section explains the structural architecture of the CubeSat, which is the mechanical framework of the small satellite.

An essential component of a 3U CubeSat's usefulness and reliability in orbit is its primary structure and mechanical subsystems. The design and development process is aided by the use of lightweight, high-strength materials and standard proportions.

3.1. Design specifications

California Polytechnic State University created the first draft of the CubeSat Design Specification (CDS). The design lifecycle of each CubeSat must adhere to a set of general and specific specifications (Mechanical, Electrical, and Testing) that are provided in this document. The mission-specific CubeSat, the launch vehicle, and other comparable CubeSats are all safe due to the CDS. The following are the CDS requirements for the 3U CubeSat.

To ensure a safe and successful launch, the 3U CubeSat must meet all the requirements and dimensions given by the CDS [12]. The physical dimensions of a 3U Cubesat are listed in Figure 2. As the standard 3U Cubesat launch box is also designed and manu-

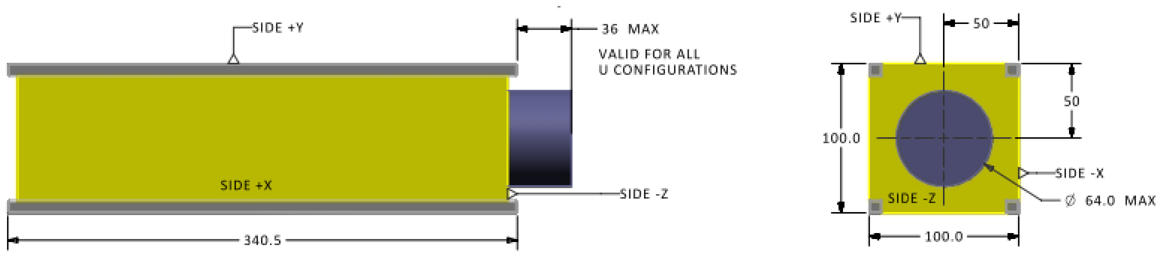

Figure 3. Tuna Can [12].

factured in accordance with these specifications, no 3U Cubesat should be larger than this.

According to the mechanical requirements, stated in CDS [12]:

- The physical dimensions and CubeSat configuration must match with the appropriate section of Figure 2.
- The deployables are limited by the CubeSat, not the dispenser. This criterion is based on what most Launch Providers require.
- Rails must be at least 8.5 mm wide when measured from the edge to the first protrusion on each face. To avoid cold welding in the launch environment and reduce friction during deployment, CubeSat rails need to be flat, smooth, and hard anodised.
- The dispenser rails should be in contact with the rail to a minimum of 75 % of the rail. Roughly 25 % of the rails can be recessed.
- Aluminium alloy is recommended for the CubeSat structure.

The 3U Cubesat has an extra volume known as a Tuna Can that can be used if needed. Figure 3 shows the maximum dimensions of this cylindrical Tuna Can. The 3U CubeSat's top is where the Tuna Cans are primarily attached. This additional space in the 3U Cubesat can be used to manage sensors, antennas, electronics, or other equipment.

3.2. Primary structure of the 3U CubeSat

The frame and panels that make up the main 3U CubeSat structure are what give the satellite its skeleton. All internal and external components of this structure must provide mechanical support and protection.

3.2.1. Structural design

The structural design of a 3U CubeSat needs to take a number of things into account, including mechanical strength, thermal properties, radiation tolerance, and ease of assembly.

Frame Aluminium rails and corner brackets form the frame of a 3U CubeSat, giving it a cubic shape. The frame has to:

- Provide rigidity: Ensure that the structure is intact during launch and operation.
- Facilitate integration: Make it easy to assemble and integrate payloads and subsystems.
- Ensure compatibility: Follow CDS guidelines to ensure deployer compatibility.

Panels Panels function as mounting surfaces for external parts, such as solar cells and antennas, and are connected to the frame. They also offer extra structural support. Aluminium or composite materials are frequently used for the panels in order to balance weight and strength.

Connectors and fasteners All components are firmly attached and CubeSats can be put securely within deployers because of standardised connectors and fasteners. Some common fasteners and connectors are the following:

- Rails: Secure mounting within the deployer is facilitated by standardised rails around the edges of the CubeSat.
- Corner brackets: Assure the CubeSat's structural integrity and provide extra support.
- Fasteners: The frame is put together and the panels are fastened with titanium or stainless steel screws and bolts.

3.2.2. Materials

Aluminium alloys Aluminium alloys, such as 6061-T6 and 7075-T6, are often used because of their excellent strength-to-weight ratios, favourable thermal characteristics, and resistance to corrosion. In addition, anodising is used to improve surface qualities and increase resistance to harsh space conditions.

Composite materials A growing number of CubeSat structures are made of composite materials such as carbon fiber-reinforced polymers (CFRP) because of their exceptional thermal radiation stability and high strength-to-weight ratio. Composites are particularly helpful in lowering the CubeSat's total mass, which is essential for maximising the payload capacity.

3.2.3. Manufacturing techniques

- CNC machining and laser cutting: Used in the fabrication of precise and highly durable aluminium parts.

- 3D printing: Makes it possible to produce intricate geometries quickly and efficiently, which is difficult to achieve using conventional manufacturing techniques.
- Composite layup: Used in the fabrication of strong and lightweight panels and structures made of CFRP.

3.3. Mechanical subsystems

Thermal management, attitude determination and control system (ADCS), and deployment mechanisms are examples of mechanical subsystems.

3.3.1. Thermal control subsystem

- Thermal sensors: Monitor the temperature throughout the CubeSat to ensure that all parts are operating within safe limits.
- Heaters: If critical components drop below operating temperatures, provide additional heat.
- Radiators and heat pipes: Dissipate excess heat to prevent electronic components from overheating.

The detailed study on thermal management, active thermal control, and passive thermal control is covered in Section 2.6.

3.3.2. Deployment mechanisms

For some of the CubeSat designs, once the CubeSat is in orbit, deployment mechanisms are essential to deploy antennas, solar panels, and other payloads.

Spring-loaded mechanisms Structures are deployed by mechanical springs in spring-loaded devices. They must be designed for reliable deployment after the launch and throughout the operation.

Burn wire mechanisms Burn wire mechanisms enable structures to be deployed by cutting a restraining wire with a tiny electric current. Due to its simplicity and reliability, this approach is widely used for Cubesat deployments.

3.3.3. Attitude determination and control system (ADCS)

For missions requiring precise pointing, including Earth observation and communication, ADCS is essential to maintain the orientation and stability of CubeSats.

Components

- Reaction wheel: Alters the satellite's angular momentum to provide precise attitude control.
- Magnetorquer: Utilises the Earth's magnetic field to desaturate reaction wheels and regulates coarse attitude.
- Gyroscope: Measures rotational rates and provides feedback to attitude control algorithms.
- Sun sensor: Provides information about orientation with respect to the Sun.
- Earth sensor: Provides information about orientation with respect to the Earth.
- Electric thruster: Using electric current as fuel generates a small amount of thrust needed for orientation.

Function The ADCS keeps the CubeSat oriented by using control algorithms and sensor feedback. For missions that need precision targeting, including communication and earth observation.

3.4. Electronic subsystems

Its electronic subsystems are essential for a 3U CubeSat to function properly and complete its mission. By handling functions, such as payload operation, data processing, communication, and power management, these subsystems ensure the functioning of the satellite in a harsh orbit environment. Typically, a 3U CubeSat contains the following main electronic subsystems:

3.4.1. Command and data handling (C&DH) subsystem

- Onboard computer (OBC): Serves as the main processor, executing data handling, mission commands, and system monitoring.
- Data storage: Non-volatile memory devices for software, telemetry, and mission data storage.
- Interfaces: Subsystems can be connected by communication interfaces, such as CAN bus, SPI, or I^2C.

3.4.2. Power subsystem (EPS)

- Solar panels: Convert solar energy into electrical power; they are typically mounted outside the CubeSat.
- Batteries: Store the energy produced by the solar panels for later use, when the CubeSat is not exposed to direct sunlight.
- Power distribution unit (PDU): Controls the power distribution to different subsystems, ensuring a steady and controlled power supply.
- Battery management system (BMS): Maintains and safeguards the health of the battery, ensuring ideal cycles of charging and discharging.

3.4.3. Communication subsystem

- Transceivers: Use UHF, VHF, S-band, or X-band frequencies to facilitate communication between the CubeSat and ground control.
- Antennas: The signals for transmitting and receiving must be adjusted to the communication requirements of the CubeSat; they might be fixed or deployable antennas.
- Beacon: Transmits a low-power signal for tracking the location and condition of the CubeSat.

3.4.4. Payload subsystem

- Sensors/instrumentation: Particular to the objectives of the mission, spectrometers, cameras, or scientific equipment can be used.
- Data processing units: Process the data acquired by the payload before transmitting it to the ground control.
- Mechanical interfaces: Structures for payload deployment and mounting as needed.

All of these components work together to provide the 3U CubeSat the ability to perform a variety of commercial, scientific, and research missions, showing the incredible potential of the 3U CubeSat.

3.5. Standard dimensions and interfaces

The CubeSat Design Specification (CDS), which establishes standard dimensions and interfaces for ensuring compatibility with launch vehicles and deployment systems, is as follows:

- Standard dimensions: The dimensions of a CubeSat are 10 cm × 10 cm × 10 cm (1U). Three units tall (10 cm × 10 cm × 34 cm, with the separation springs) make up a 3U CubeSat.
- Rails: Standardised rails that fit into deployers for mounting.
- Mass constraints: Maximum mass restrictions to ensure compatibility with launch vehicles and deployers. As an example, the maximum mass for a 3U CubeSat is approximately 4 kg.
- Volume constraints: Strict volume restrictions to make sure that the CubeSat fits inside the deployer.
- Deployment compatibility: CubeSats must meet the interface standards for safe deployment and fit into standardised deployers (such as the P-POD).

3.6. Analysis and simulations

- Structural analysis: To ensure that the structure can endure launch and operational conditions, finite element analysis (FEA) is used to simulate stress and load distribution.
- Thermal analysis: Thermal simulations ensure that the CubeSat's components are operating within suitable temperature limits by analysing how well it can manage the heat in orbit.
- Vibration analysis: This ensures that the structure is robust and can withstand the launch conditions. To ensure that every component is safe and operational during the launch and while in orbit, these replicate the intense shocks and vibrations encountered during the launch.
- Electromagnetic compatibility (EMC) analysis: Ensures that electronic parts comply with legal requirements and don't interfere with eachother. To avoid electromagnetic interference that can affect the CubeSat's functionality and to mitigate the magnetic field of Earth, this analysis is essential.
- Radiation analysis: 3U CubeSat radiation analysis determines the effects of solar particle events, trapped radiation belts, and galactic cosmic rays. Reliability is ensured by using radiation-hardened components and shielding.
- Mission analysis: Verifies mission performance and feasibility by simulating orbital maneuvers, payload operations, and mission scenarios.

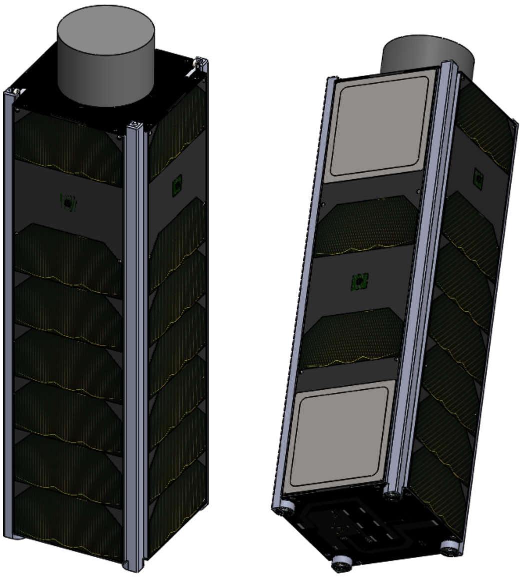

Figure 4. Isometric view of the 3U CubeSat CAD model.

3.7. CAD model

Solidworks 2022 was used to create the CAD model for the mechanical design of the 3U CubeSat. The mechanical design was created according to the CDS specifications [12], using Netsat 3U CubeSat [8] and UWE-4 1U Cubesat [16] as references. The 3U CubeSat isometric view is shown in Figure 4.

"Rails" refers to the 3U CubeSat's four side supporting columns. Electric thrusters, deployment switches, and separation springs for the 3U Cubesat are included in the rails constructed in this project. The rails support the internal electronics and external panels of the 3U Cubesat in a manner that complies with CDS requirements [12]. In order to keep the 3U CubeSat's size as small as possible, the rails are constructed in an L-shaped design. Aluminium alloy is used mostly for the 3U CubeSat rails, as shown in Figure 5.

Four electric thrusters have been attached to the bottom side of the 3U CubeSat. Solar sensors and solar cells are accommodated in the three side panels. While the front panel of the 3U CubeSat accommodates solar cells, additional sensors, and two antenna patches, as shown in Figure 4. The 3U CubeSat panels are also suitable for use as PCB boards to make connections between the 3U CubeSat's electronics, onboard computer, solar cells, antennas, and battery.

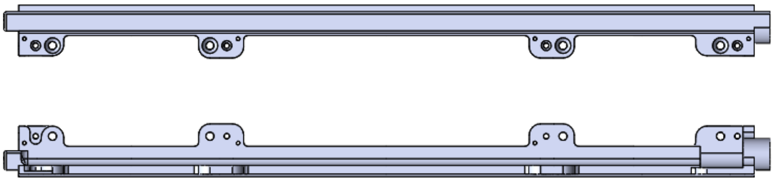

Figure 5. 3U CubeSat rails.

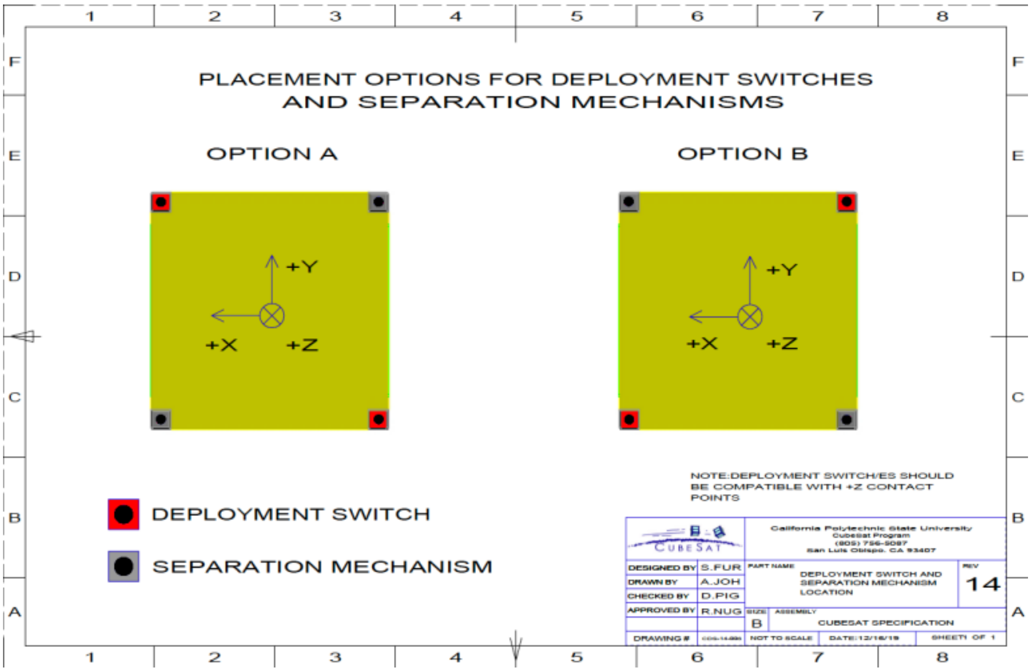

Figure 6. Recommended deployment switches and separation spring locations [12].

3.8. Deployment switches and separation spring

The deployable solar panels, antennas, and payloads are deployed using deployment switches and separation springs. Using the deployment switch and the separation spring mechanism, the CubeSat also launches into space from the launching box. Moreover, these techniques can be used to share a dispenser with another CubeSat if multiple CubeSat configurations are in operation. The container that the rocket uses to safely launch the Cubesat into space is called a launching box or deployment box.

According to CDS [12], the deployment switch and separation spring on top of the CubeSat can be located using either of the two designs, as shown in Figure 6. The top view of the 3U CubeSat is shown in Figure 7, where the deployment switches and the separation spring locations on the top of the 3U CubeSat rails are shown.

3.9. 3U CubeSat deployer

A launch box, which is often referred to as a CubeSat deployer, is a device that is used to launch CubeSats from a launch vehicle, rocket payload, or larger spacecraft into orbit. When the deployment requirements are met, the launch box releases the CubeSat into orbit, acting as a protective container during the launch. These requirements can be: achieving a particular velocity, attaining a given altitude, or arriving at a predetermined orbit location within the mission's plan.

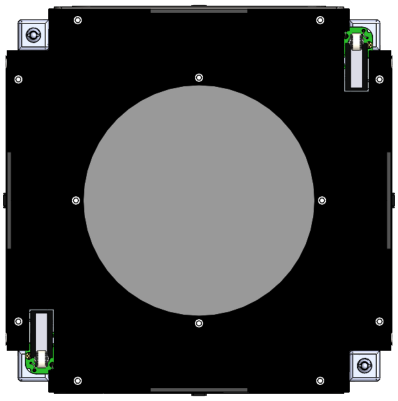

Figure 7. Top view of 3U CubeSat CAD model.

CubeSat deployers come in a variety of forms, from basic spring-loaded devices to more advanced systems that allow several CubeSat deployments from a single launch. While some deployers are carried as supplementary payloads on larger spacecrafts, others are integrated into the launch vehicle's body.

The size and weight of the CubeSat, mission-specific requirements, and the capabilities of the launch vehicle or spacecraft all play a significant role in the launch box selection process. Organisations and companies that specialise in small satellite deployments, such as ISISpace or NanoRacks, provide a variety of deployment box options to meet various specific requirements.

An affordable 3U European launch adapter developed by ISISpace Group, the ISIPOD, is intended to be used with its launch services and is capable of carrying multiple varieties of CubeSats, as shown in Figure 8. It can also be carried by a variety of launch vehicles. The deployer can also be bought separately in case a Cubesat developer has planned a launch independently. Depending on its construction, the ISIPOD provides simple and well-defined interfaces for internal and external communication between the CubeSats and the launch vehicle. Inside the rockets, the CubeSats are fully enclosed in the ISIPOD and only after the launch vehicle approves the launch, the deployer is opened and the CubeSat is pushed out into space from the deployer [17].

4. Conclusion

The mechanical design and subsystem integration of a 3U CubeSat has been covered in detail in this paper, with an emphasis on building a robust and effective structure that can meet a variety of mission requirements. I have created a design that maximises the available area for subsystem placement while maintaining structural integrity through the use of sophisticated CAD modeling tools. Fundamental problems were fixed, resulting in an efficient and reliable CubeSat design.

The subsystem integration design placed a strong emphasis on the ease of assembly and compatibility, ensuring that the payload, power, and communication components operate flawlessly inside the small 3U form factor. The outcomes demonstrate notable improvements in the subsystem integration and mechanical design procedures, providing a feasible solution for the upcoming CubeSat missions.

The paper provides a comprehensive summary and methodology of the present knowledge and techniques for the 3U CubeSat design, which advances the ongoing development of small satellite technology. The conclusions of the research can be used to improve CubeSat performance and reliability, which will support a variety of space exploration and technology demonstration applications. To improve the potential of 3U CubeSats, future research will continue to address the challenges that have been identified while researching and using emerging technologies and methods.

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Figure 8. ISIPOD CubeSat deployer [17].

Conflict of interest

The author declares that there are no conflicts of interest with respect to the usage and publication of this paper.

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