Undergraduate Design of a Proprietary, Low-Cost "QUbeSat"

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Introduction

CubeSats are small satellites belonging to a class called nanosatellites, which are determined by their standardized form factor and low weight. One CubeSat 'unit' is approximately 10x10x10 cm and weighs less than 2kg. Because of their small size and relatively low cost, CubeSats are ideal academic projects. They require the application and integration of knowledge and skills across many engineering disciplines.

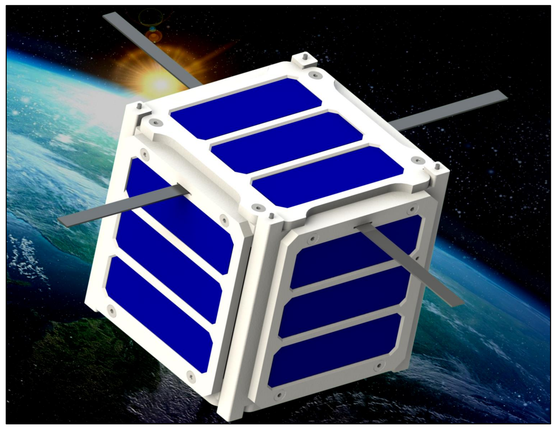

Figure 1: SolidWorks rendering of the QUbeSat in post-launch configuration with antennas deployed

Problem Statement

Design a CubeSat that will test an additively manufactured frame material, collect on-orbit frame temperature data, and transmit that data to a ground station. The CubeSat should be high-quality, durable, meet the requirements for launch laid out in the Cal Poly and NASA handbooks, and must not exceed $2000. The project should be completed by the end of the spring semester (May 2023).

Final Design & Systems

a	XY Solar Panel Base	x 4
b	XY Solar Panel Cover	x 4
c	Z Solar Panel Base	x 2
d	Z Solar Panel Cover	x 2
e	Solar Cell	x 18
f	Antenna System	x 1
g	Antenna	x 4
h	Pillar Wall	x 2
i	Bottom Support	x 1
j	Printed Circuit Board	x 3
k	Lithium-Ion Battery	x 4
l	M3x0.5 Heat Set Insert	x 33
m	M3x0.5 Steel Screw	x 33
n	Separation Switch	x 2
o	Separation Spring	x 2

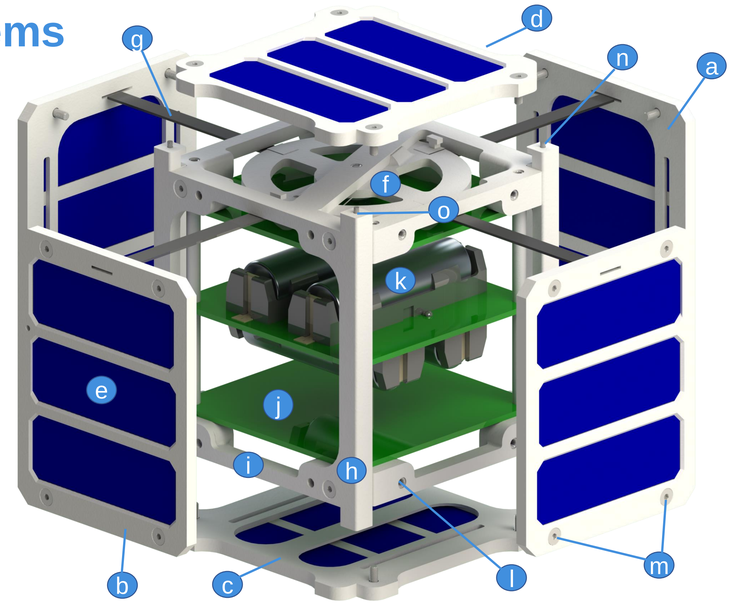

Figure 2: QUbeSat exploded view

System Workflow

The proprietary Antero 840CN03 ESD thermoplastic frame houses the main systems on their respective printed circuit boards. An array of solar cells is used in the electric power system to charge lithium-ion batteries which energize a Raspberry Pi Pico data handling system. The Pico commands subsystems, collects temperature data from thermistors, stores data, and exchanges information with the communications system. The communication system uses a radio and crossed-dipole antenna to transmit data to a ground station.

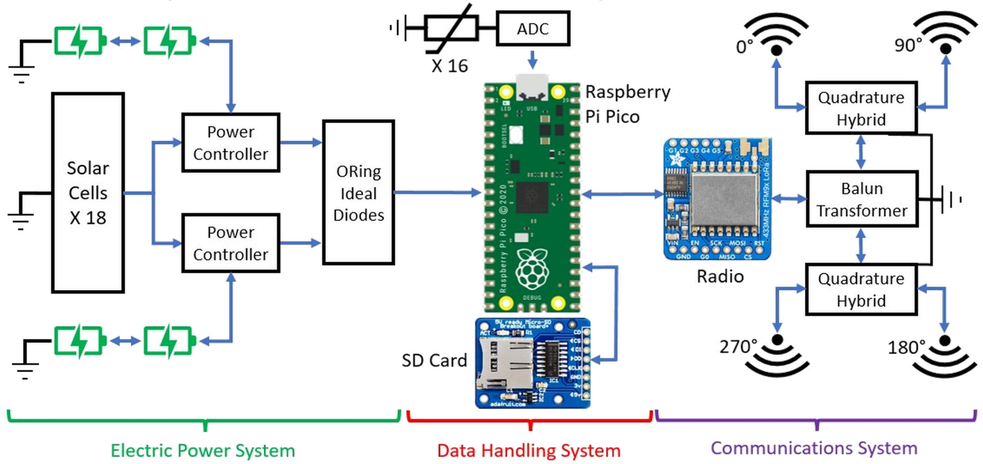

Figure 3: QUbeSat subsystem functions described in flow chart format

Engineering Specifications

Table 1. Engineering Characteristics and Target Values

Engineering Characteristic	Priority	Target	Units
High Temperature Requirement	1	> 100	°C
Low Temperature Requirement	1	< -54	°C
Vibration Resistance	2	> 2000	Hz
Mass	2	< 1.33	kg
Cost	3	< 2000	$
Rail Surface Roughness	4	< 1.6	µm
Volume	5	== 1000	cc
Frame Material Density	6	< 3	g/cc
Axial Distance of Center of Mass to Geometric Center	7	< 2	cm

Conclusions

A proprietary frame, antenna deployment system, and solar panel assembly can be efficiently designed with complex geometries enabled by additive manufacturing at a lower weight and cost than OTS parts.

Future Work

This project focused on hardware development. The circuitry and computer systems were not as progressive. Future teams could analyze the fundamental systems and knowledge created during this iteration to improve the data handling and communications systems. The next iteration can be more advanced and robust, and a flight ready assembly can be produced.

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