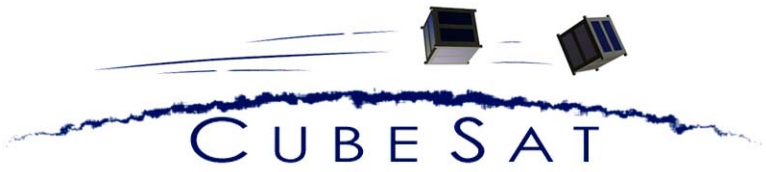
CubeSat Design Specification

(CDS)

Revision 9



Release State		Additional Restrictions	
X	Public		
	Internal		Confidential
	Controlled		ITAR
	Work in Progress		
	Inactive		

Revision	Date	Authored by	Notes
8.1	05/26/04	Amy Hutputtanasin	
9	5/15/05	Armen Toorian	Updated specification.

Last printed 3 June 2004

Overview

The CubeSat Project is a international collaboration of over 40 universities, high schools, and private firms developing picosatellites containing scientific, private, and government payloads. A CubeSat is a 10 cm cube with a mass of up to 1 kg. Developers benefit from the sharing of information within the community. If you are planning to start a CubeSat project, please contact California Polytechnic State University (Cal Poly). Visit the CubeSat website at http://cubesat.calpoly.edu for more information.

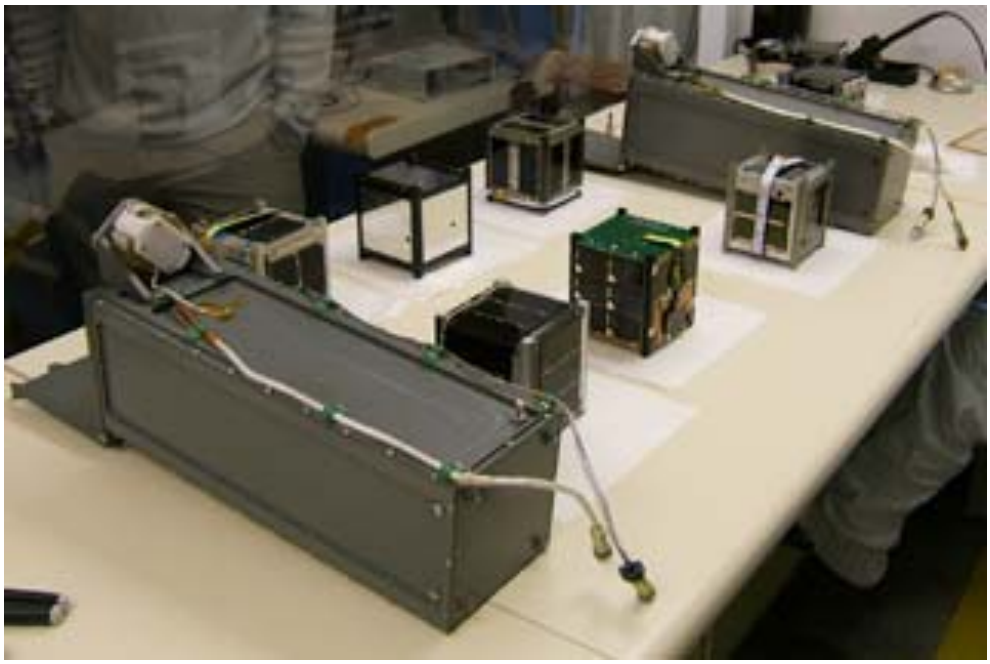


Figure 1: Six CubeSats and their deployment systems.

The primary mission of the CubeSat Program is to provide access to space for small payloads. The primary responsibility of Cal Poly as a launch coordinator is to ensure the safety of the CubeSats and protect the launch vehicle (LV), primary payload, and other CubeSats. CubeSat developers should play an active role in ensuring the safety and success of CubeSat missions by implementing good engineering practice, testing, and verification of their systems. Failures of CubeSats, the P-POD, or interface hardware can damage the LV or a primary payload and put the entire CubeSat Program in jeopardy. As part of the CubeSat Community, all participants have an obligation to ensure safe operation of their systems and to meet the design and testing requirements outlined in this document.

P-POD Interface

The Poly Picosatellite Orbital Deployer (P-POD) is Cal Poly's standardized CubeSat deployment system. It is capable of carrying three standard CubeSats and serves as the interface between the CubeSats and LV. The P-POD is an aluminum, rectangular box with a door and a spring mechanism. CubeSats slide along a series of rails during ejection into orbit. CubeSats must be compatible with the P-POD to ensure safety and success of the mission, by meeting the requirements outlined in this document. Additional unforeseen compatibility issues will be addressed as they arise.

Figure 1: Cross section of the P-POD.

General Responsibilities

1. CubeSats **must not** present any danger to neighboring CubeSats in the P-POD, the LV, or primary payloads:
    - All parts must remain attached to the CubeSats during launch, ejection and operation. No additional space debris may be created.
    - CubeSats must be designed to minimize jamming in the P-POD.
    - Absolutely no pyrotechnics are allowed inside the CubeSat.
2. NASA approved materials should be used whenever possible to prevent contamination of other spacecraft during integration, testing, and launch.
3. The newest revision of the CubeSat Specification is always the official version
    - Developers are responsible for being aware of changes.
    - Changes will be made as infrequently as possible bearing launch provider requirements or widespread safety concerns within the community.
    - Cal Poly will send an update to the CubeSat mailing list upon any changes to the specification.
    - CubeSats using an older version of the specification *may* be exempt from implementing changes to the specification on a case-by-case basis.

Figure 1: Poly Picosatellite Orbital Deployer (P-POD)

Cal Poly holds final approval of all CubeSat designs. Any deviations from the specification must be approved by Cal Poly launch personnel. **Any CubeSat deemed a safety hazard by Cal Poly launch personnel may be pulled from the launch**.

Dimensional and Mass Requirements

CubeSats are cube shaped picosatellites with a nominal length of 100 mm per side. Dimensions and features are outlined in the CubeSat Specification Drawing (Attachment 1). General features of all CubeSats are:

- Each single CubeSat may not exceed 1 kg mass.
- Center of mass must be within 2 cm of its geometric center.
- Double and triple configurations are possible. In this case allowable mass 2 kg or 3 kg respectively. Only the dimensions in the Z axis change (227 mm for doubles and 340.5 mm for triples). X and Y dimensions remain the same.

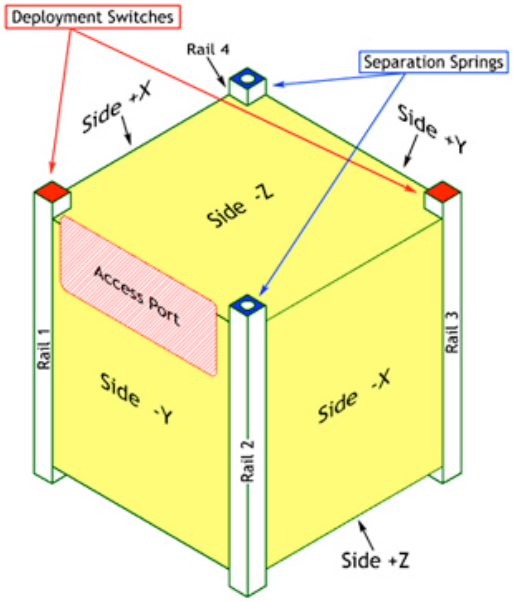


Figure 2: CubeSat isometric drawing.

Structural Requirements

The structure of the CubeSat must be strong enough to survive maximum loading defined in the testing requirements and cumulative loading of all required tests and launch. The CubeSat structure **must** be compatible with the P-POD.

- Rails must be smooth and edges must be rounded to a minimum radius of 1 mm.
- At least 75% (85.125 mm of a possible 113.5mm) of the rail must be in contact with the P-POD rails. 25% of the rails may be recessed and **NO** part of the rails may exceed the specification.
- All rails must be hard anodized to prevent cold-welding, reduce wear, and provide electrical isolation between the CubeSats and the P-POD.
- Separation springs must be included at designated contact points (Attachment 1). Spring plungers are recommended (McMaster-Carr P/N: 84985A76 available at http://www.mcmaster.com). A custom separation system may be used, but must be approved by Cal Poly launch personnel.
- The use of Aluminum 7075 or 6061-T6 is suggested for the main structure. If other materials are used, the thermal expansion must be similar to that of Aluminum 7075-T73 (P-POD material) and approved by Cal Poly launch personnel.
- Deployables must be constrained by the CubeSat. The P-POD rails and walls are **NOT** to be used to constrain delpolyables.

Figure 3: Spring plunger.

Electrical Requirements

Electronic systems must be designed with the following safety features.

- No electronics may be active during launch to prevent any electrical or RF interference with the launch vehicle and primary payloads. CubeSats with rechargeable batteries must be fully deactivated during launch or launch with discharged batteries.
- One deployment switch is required (two are recommended) for each CubeSat. The deployment switch should be located at designated points (Attachment 1).
- Developers who wish to perform testing and battery charging after integration must provide ground support equipment (GSE) that connects to the CubeSat through designated data ports (Attachment 1).
- A remove before flight (RBF) pin is required to deactivate the CubeSats during integration outside the P-POD. The pin will be removed once the CubeSats are placed inside the P-POD. RBF pins must fit within the designated data ports (Attachment 1). RBF pins should not protrude more than 6.5 mm from the rails when fully inserted.

Operational Requirements

CubeSats must meet certain requirements pertaining to integration and operation to meet legal obligations and ensure safety of other CubeSats.

- CubeSats with rechargeable batteries must have the capability to receive a transmitter shutdown command, as per FCC regulation.
- To allow adequate separation of CubeSats, antennas may be deployed 15 minutes **after** ejection from the P-POD (as detected by CubeSat deployment switches). Larger deployables such as booms and solar panels may be deployed 30 minutes **after** ejection from the P-POD.
- CubeSats may enter low power transmit mode (LPTM) 15 minutes **after** ejection from the P-POD. LPTM is defined as short, periodic beacons from the CubeSat. CubeSats may activate all primary transmitters, or enter high power transmit mode (HPTM) 30 minutes **after** ejection from the P-POD.
- Operators must obtain and provide documentation of proper licenses for use of frequencies. For amateur frequency use, this requires proof of frequency coordination by the International Amateur Radio Union (IARU). Applications can be found at www.iaru.org.
- Developers must obtain and provide documentation of approval of an orbital debris mitigation plan from the Federal Communications Commission (FCC). Contact Robert Nelson at rnelson@fcc.org
- Cal Poly will conduct a minimum of one fit check in which developer hardware will be inspected and integrated into the P-POD. A final fit check will be conducted prior to launch. The CubeSat Acceptance Checklist (CAC) will be used to verify compliance of the specification (Attachment 2). Additionally, periodic teleconferences, videoconferences, and progress reports may be required.

Testing Requirements

Testing must be performed to meet all launch provider requirements as well as any additional testing requirements deemed necessary to ensure the safety of the CubeSats and the P-POD. All flight hardware will undergo qualification and acceptance testing. The P-PODs will be tested in a similar fashion to ensure the safety and workmanship before integration with CubeSats. At the very minimum, all CubeSats will undergo the following tests.

- Random vibration testing at a level higher than the published launch vehicle envelope outlined in the MTP.
- Thermal vacuum bakeout to ensure proper outgassing of components. The test cycle and duration will be outlined in the MTP.
- Visual inspection of the CubeSat and measurement of critical areas as per the CubeSat Acceptance Checklist (CAC).

Qualification

All CubeSats must survive qualification testing as outlined in the Mission Test Plan (MTP) for their specific launch. The MTP can be found on the CubeSat website. Qualification testing will be performed at above launch levels at developer facilities. In some circumstances, Cal Poly can assist developers in finding testing facilities or provide testing for the developers. A fee may be associated with any tests performed by Cal Poly. CubeSats must **NOT** be disassembled or modified after qualification testing. **Additional testing will be required if modifications or changes are made to the CubeSats after qualification.**

Acceptance

After delivery and integration of the CubeSats, additional testing will be performed with the integrated system. This test assures proper integration of the CubeSats into the P-POD. Additionally, any unknown, harmful interactions between CubeSats may be discovered during acceptance testing. Cal Poly will coordinate and perform acceptance testing. No additional cost is associated with acceptance testing. After acceptance testing, developers may perform diagnostics through the designated P-POD diagnostic ports, and visual inspection of the system will be performed by Cal Poly launch personnel. The P-PODs **WILL NOT** be deintegrated at this point. If a CubeSat failure is discovered, a decision to deintegrate the P-POD will be made by the developers in that P-POD and Cal Poly based on safety concerns. The developer is responsible for any additional testing required due to corrective modifications to deintegrated CubeSats.

Contacts

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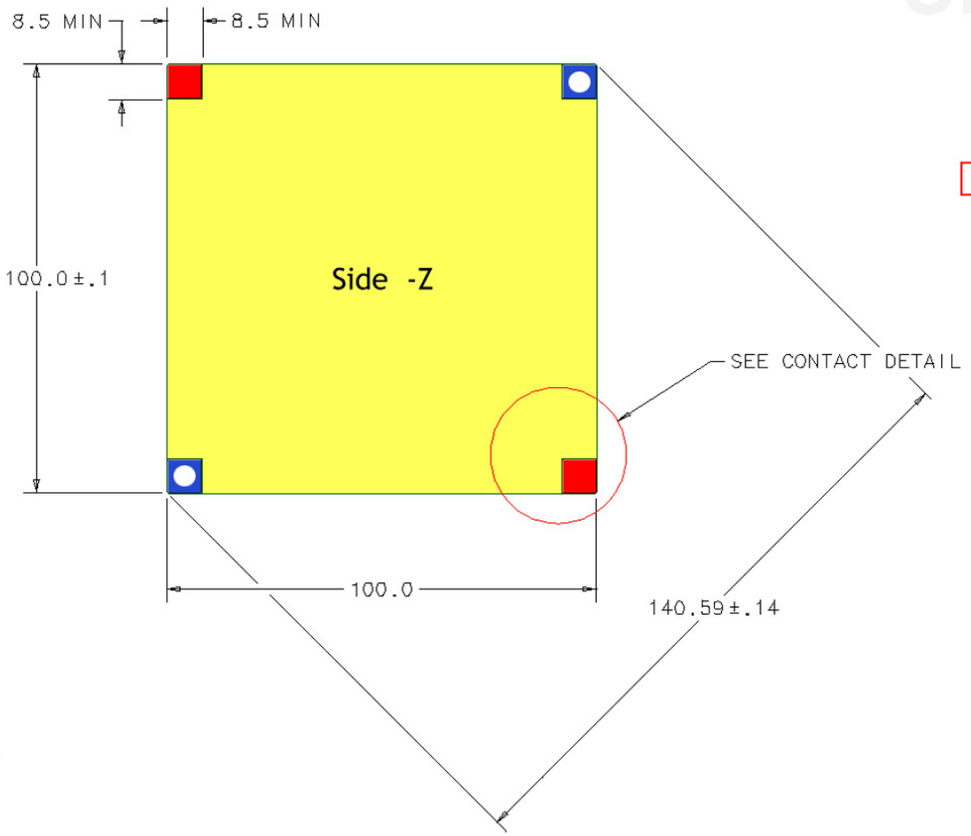
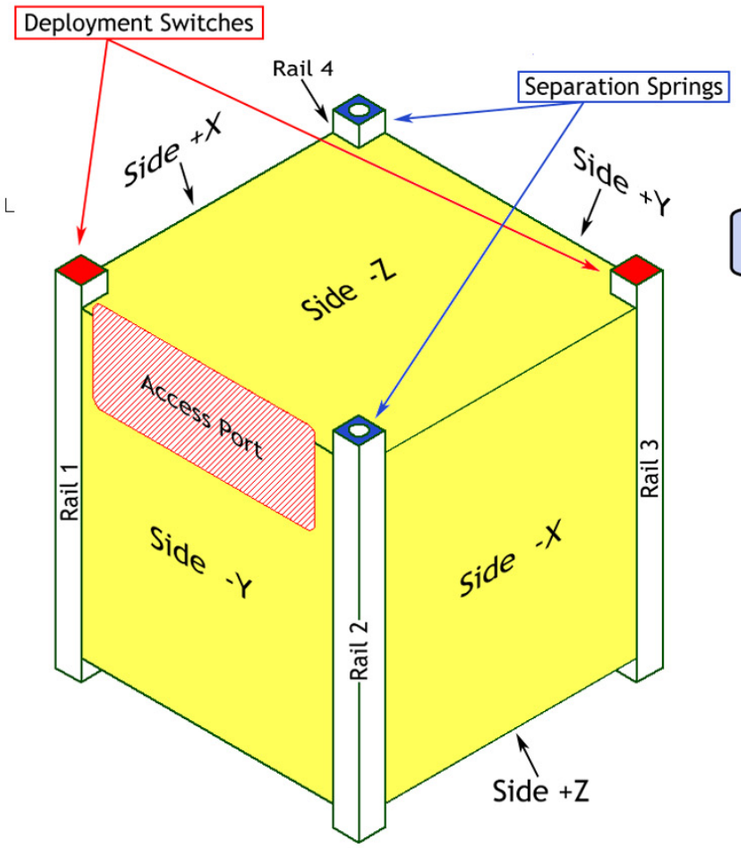
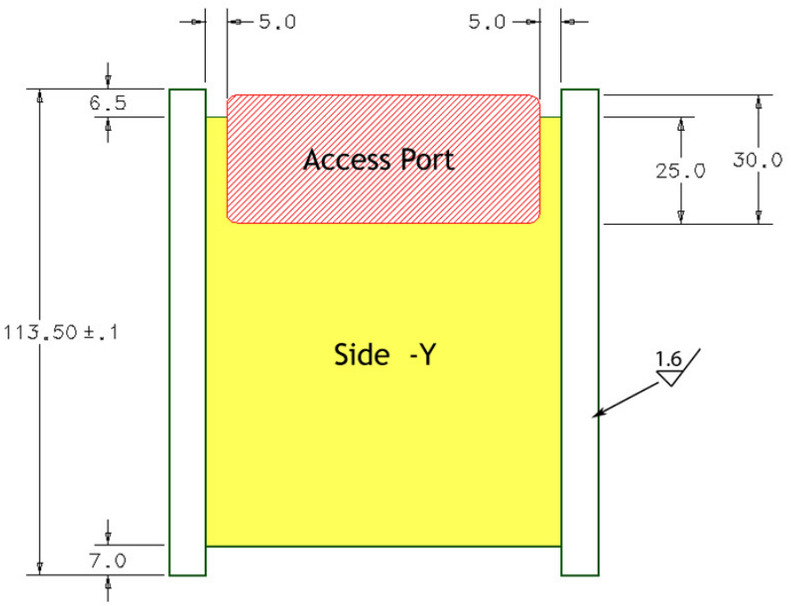
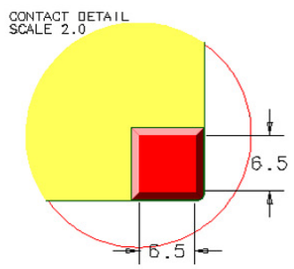
A	Original CubeSat Specification.	Nash Clemens 6/24/03
A1	Revised CubeSat Specification.	Nash Clemens 7/25/04
B	Layout and notes modifications.	Armen Toorian 7/30/04









Additional Notes:

- No external components other than the rails may touch the inside of the P-POD.
- Must incorporate a Remove Before Flight pin OR launch with batteries fully discharged.
- Components on shaded sides may not extend more than 6.5 mm normal to the surface.
- Rails must be either hard anodized OR made of a material other than aluminum.
- Separation Springs can be found at McMaster Carr (P/N: 84985A76)
- At least one (1) deployment switch must be incorporated on all CubeSats.
- CubeSats cannot weigh more than 1 kg.
- Center of gravity must be less than 2 cm from the geometric center.

CUBESAT
California Polytechnic State University

All dimensions in millimeters unless otherwise noted.

Round all edges and corners.

+/- 0.1 mm or better.

Part Name: CubeSat Specification

Revision: B

California Polytechnic State University
Aerospace Engineering Department
San Luis Obispo, CA 93407
(805) 756 - 5087

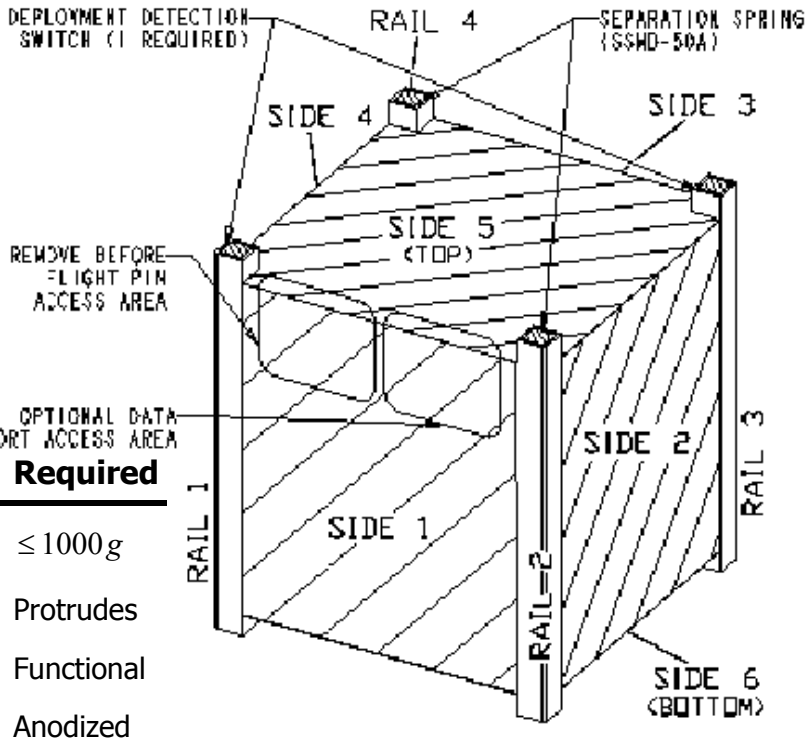
Drawn on: July 30, 2004

Scale: NOT TO SCALE

Cubesat Acceptance Checklist

Revision Date: April 4, 2004
Author: Armen Toorian

This document is intended to be used concurrently with the Cubesat Integration Procedure (CIP)



List Item	Actual	Required
Mass		$\leq 1000g$
Remove Before Flight		Protrudes
Spring Plungers		Functional
Rails		Anodized
Deployment Switches		Functional
Width [x-y]		
Side 1		$100.0 \pm 0.1mm$
Side 2		$100.0 \pm 0.1mm$
Side 3		$100.0 \pm 0.1mm$
Side 4		$100.0 \pm 0.1mm$
Height [z]		
Rail 1		$113.5 \pm 0.1mm$
Rail 2		$113.5 \pm 0.1mm$
Rail 3		$113.5 \pm 0.1mm$
Rail 4		$113.5 \pm 0.1mm$
Diagonal [x-y]		
Top 1&3		$141.2^{+0}_{-1.5}mm$
Top 2&4		$141.2^{+0}_{-1.5}mm$
Bottom 1&3		$141.2^{+0}_{-1.5}mm$
Bottom 2&4		$141.2^{+0}_{-1.5}mm$

Authorized By:	Testing Info:
IT #1: _____	Date: _____
IT #2: _____	Passed: **Y / N**