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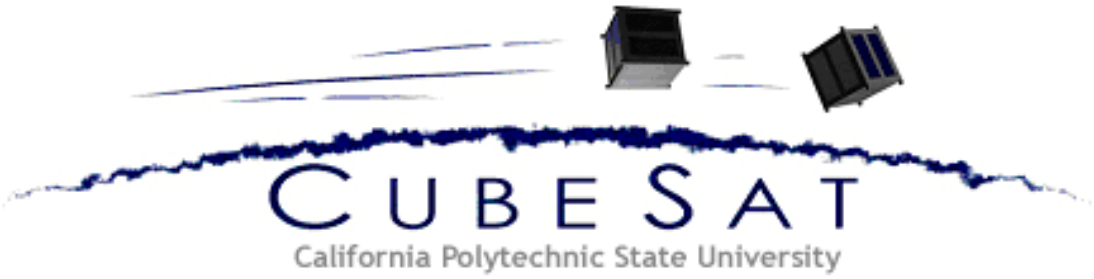
CubeSat Design Specification

(CDS)



CHANGE HISTORY LOG

Effective Date	Revision	Author	Description of Changes
N/A	8	Simon Lee	N/A
5/26/05	8.1	Amy Hutputanasin	Formatting updated.
5/15/06	9	Armen Toorian	Information and presentation revised.
8/2/07	10	Wenschel Lan	Information updated.
10/02/08	11	Riki Munakata	Format, Design specification and Mk.III P-POD compatibility update.

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APPENDIX

List of Acronyms

CAC	CubeSat Acceptance Checklist
Cal Poly	California Polytechnic State University, San Luis Obispo
CDS	CubeSat Design Specification
cm	Centimeters
FCC	Federal Communication Commission
GSE	Ground Support Equipment
HPTM	High Power Transmit Mode
IARU	Internation Amateur Radio Union
in	Inches
kg	Kilograms
LPTM	Low Power Transmit Mode
LV	Launch Vehicle
mm	Millimeters
MTP	Mission Test Plan
P/N	Part Number
P-POD	Poly Picosatellite Orbital Deployer
RBF	Remove Before Flight
Rev.	Revision
SSDL	Space Systems Development Lab

1. Introduction

1.1 Overview

Started in 1999, the CubeSat Project began as a collaborative effort between California Polytechnic State University (Cal Poly), San Luis Obispo, and Stanford University's Space Systems Development Laboratory (SSDL). The purpose of the project is to provide a standard for design of picosatellites to reduce cost and development time, increase accessibility to space, and sustain frequent launches. Presently, the CubeSat Project is an international collaboration of over 100 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 Cal Poly. Visit the CubeSat website at http://cubesat.calpoly.edu for more information.

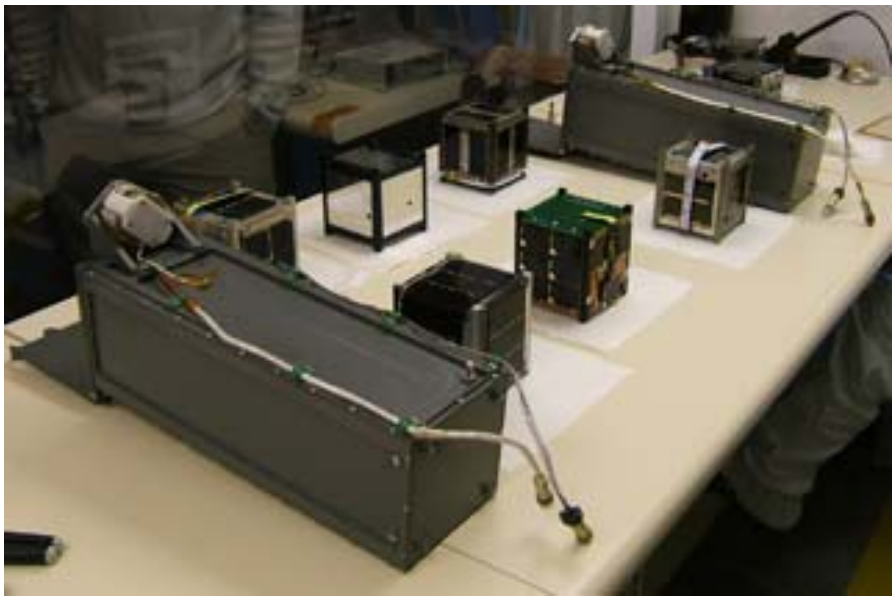


Figure 1: Six CubeSats and their deployment systems.

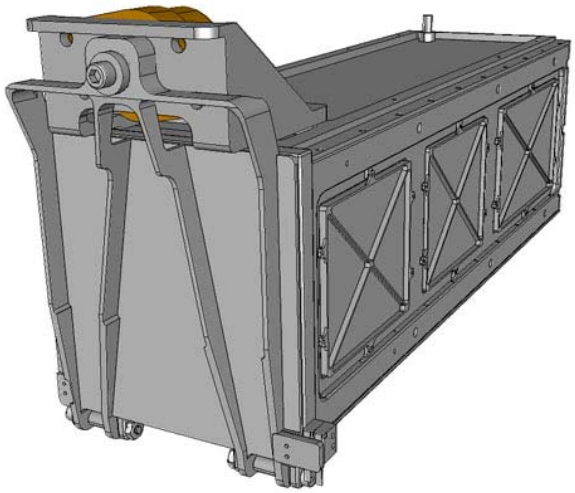
1.2 Purpose

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 and the developer of the Poly Picosatellite Orbital Deployer (P-POD), is to ensure the safety of the CubeSat 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 minimum testing requirements outlined in this document. Requirements in this document maybe superseded by launch provider requirements.

2. Poly Picosatellite Orbital Deployer

2.1 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 a rectangular box with a door and a spring mechanism. The P-POD is made up of anodized aluminum. 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. The P-POD is backward compatible, and any CubeSat developed within the design specification of CDS rev. 9 and later, will not have compatibility issues. Developers are encouraged to design to the most current CDS to take full advantage of the P-POD features. Additional unforeseen compatibility issues will be addressed as they arise.



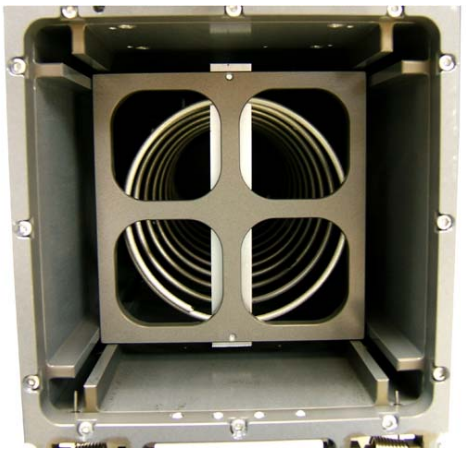


Figure2a and 2b: Poly Picosatellite Orbital Deployer (P-POD) and cross section

2.2 General Responsibilities

2.2.1 CubeSats shall not present any danger to neighboring CubeSats in the P-POD, the LV, or primary payloads:

2.2.1.1 All parts shall remain attached to the CubeSats during launch, ejection and operation. No additional space debris shall be created.

2.2.1.2 CubeSats shall be designed to minimize jamming in the P-POD.

2.2.1.3 Absolutely no pyrotechnics are allowed inside the CubeSat.

2.2.2 NASA approved materials should be used whenever possible to prevent contamination of other spacecraft during integration, testing, and launch.

2.2.3 The newest revision of the CubeSat Design Specification is always the official version

2.2.3.1 Developers are responsible for being aware of changes.

2.2.3.2 Changes will be made as infrequently as possible bearing launch provider requirements or widespread safety concerns within the community.

2.2.3.3 Cal Poly will send an update to the CubeSat mailing list upon any changes to the specification.

2.2.3.4 CubeSats using an older version of the specification *may* be exempt from implementing changes to the specification on a case-by-case basis.

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

3. CubeSat Specification

3.1 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 (Appendix A). General features of all CubeSats are:

3.1.1 Each single CubeSat may not exceed 1 kg mass.

3.1.2 Center of mass must be within 2 cm of its geometric center.

3.1.3 Double and triple configurations are possible. In these cases masses 2 kg or 3 kg respectively are allowable. 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.

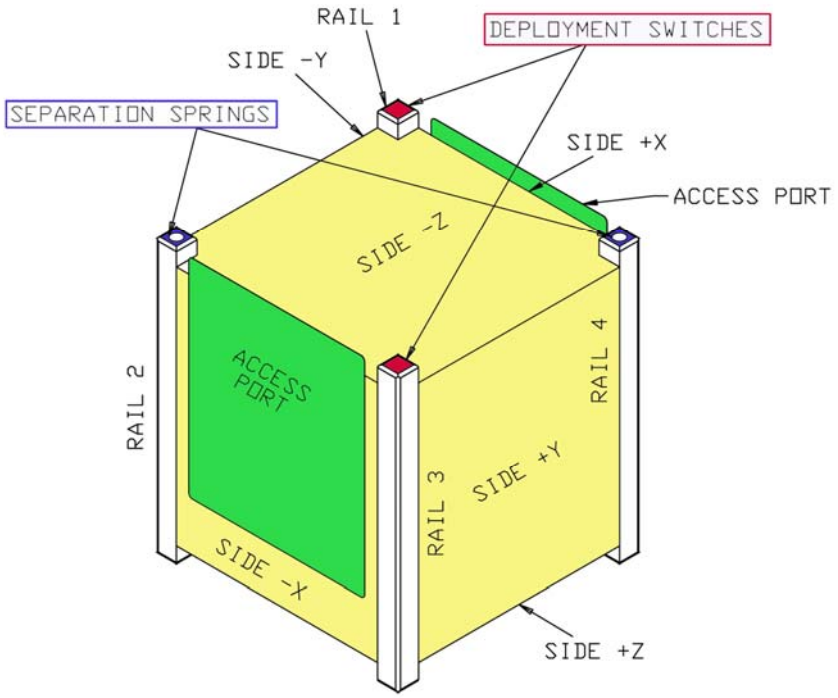


Figure 3: CubeSat isometric drawing

3.2 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.

3.2.1 The CubeSat shall be 100.0±0.1 mm wide (X and Y) and 113.5+0.1 mm tall (Z).

3.2.2 Rails must be smooth and edges must be rounded to a minimum radius of 1 mm.

3.2.3 No external components other then the rails shall be in contact with the internals of the P-POD.

3.2.4 Each rail shall be a minimum of 8.5 mm wide.

3.2.5 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.

3.2.6 All rails must be hard anodized to prevent cold-welding, reduce wear, and provide electrical isolation between the CubeSats and the P-POD.

3.2.7 Separation springs must be included at designated contact points (Appendix A). Spring plungers are highly 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.

3.2.8 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.

3.2.9 Deployables must be constrained by the CubeSat. The P-POD rails and walls are **NOT** to be used to constrain delpolyables.

3.2.10 The CubeSat shall meet all other requirements noted in Appendix A.

Figure 4: Spring plunger

3.3 Electrical Requirements

Electronic systems must be designed with the following safety features.

3.3.1 No electronics shall be active during launch to prevent any electrical or RF interference with the launch vehicle and primary payloads. CubeSats with rechargeable batteries shall be fully deactivated during launch or launch with discharged batteries.

3.3.2 One deployment switch is required (two are recommended) for each CubeSat. The deployment switch should be located at designated points (Appendix A).

3.3.3 Deployment switch shall be compatible with +Z contact point(s).

3.3.4 Developers who wish to perform testing and battery charging after integration must provide ground support equipment (GSE) that connects to the CubeSat through designated access ports (Appendix A).

3.3.5 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 integrated into the P-POD. RBF pins must fit within the designated data ports (Appendix A). RBF pins should not protrude more than 6.5 mm from the rails when fully inserted.

3.4 Operational Requirements

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

3.4.1 CubeSats with rechargeable batteries shall have the capability to receive a transmitter shutdown command, as per Federal Communications Commission (FCC) regulation.

3.4.2 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.

3.4.3 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.

3.4.4 CubeSats may activate all primary transmitters, or enter high power transmit mode (HPTM) 30 minutes **after** ejection from the P-POD.

3.4.5 Operators shall 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.

3.4.6 Developers shall obtain and provide documentation of approval of an orbital debris mitigation plan from the FCC. Contact Robert Nelson at rnelson@fcc.org

3.4.7 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 (Appendix B).

3.4.8 Periodic teleconferences, videoconferences, and progress reports may be required.

4. 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 the CubeSats. At the very minimum, all CubeSats will undergo the following tests.

4.1.1 Random vibration testing at a level higher than the published launch vehicle envelope outlined in the Mission Test Plan (MTP).

4.1.2 Thermal vacuum bakeout to ensure proper outgassing of components. The test cycle and duration will be outlined in the MTP.

4.1.3 Visual inspection of the CubeSat and measurement of critical areas as per the CAC (Appendix B).

4.2 Qualification

All CubeSats must survive qualification testing as outlined in the MTP for their specific launch. Qualification testing will be performed 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 testing.**

4.3 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 P-PODs and CubeSats.

5. Contacts

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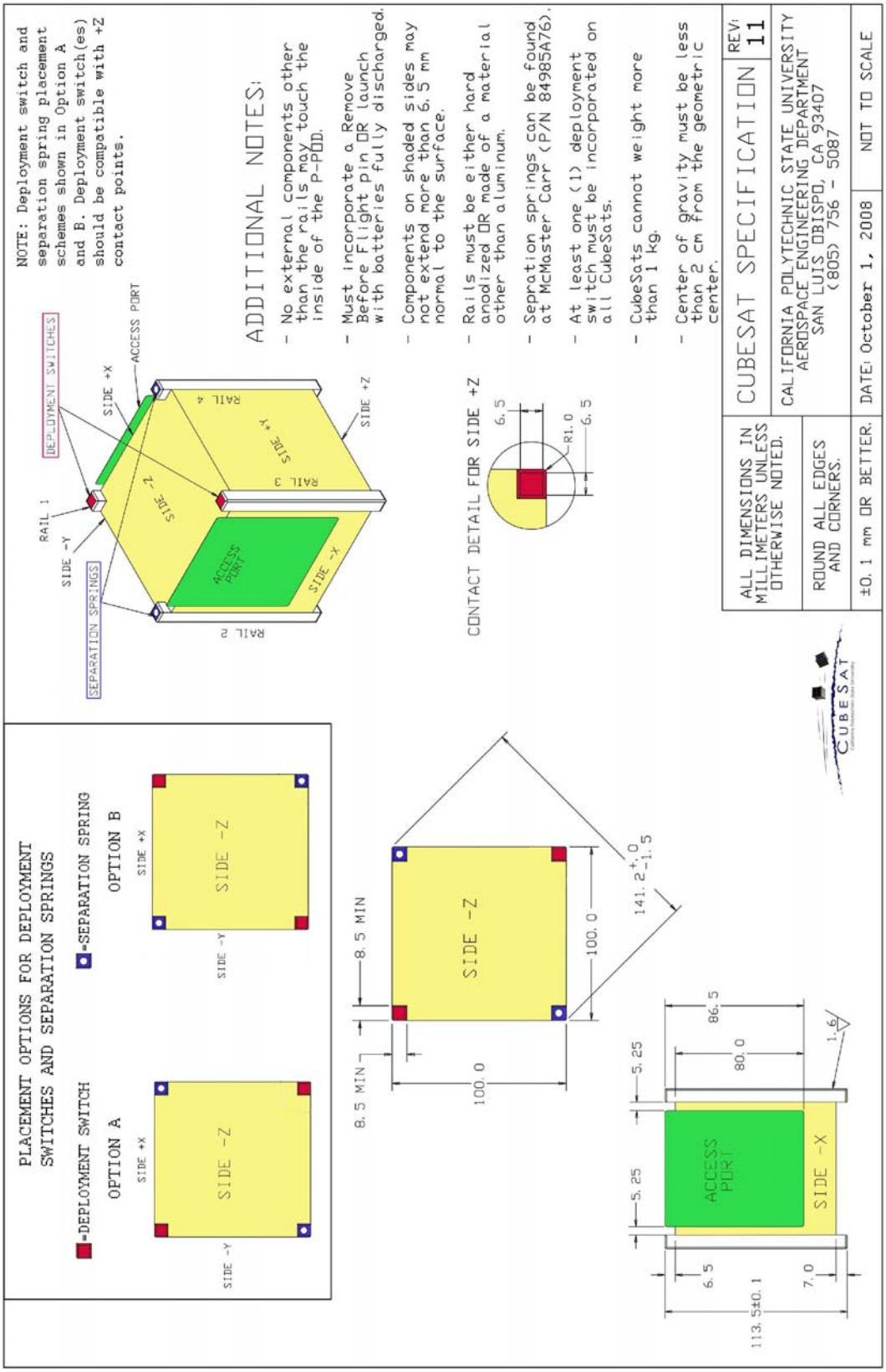
Appendix A: CubeSat Design Specification Drawing

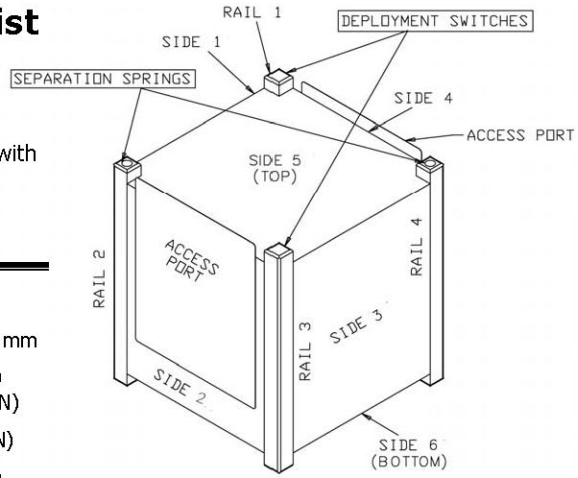


Appendix B: CubeSat Acceptance Checklist

CubeSat Acceptance Checklist

Revision Date: August 1, 2007
Author: Wenschel Lan

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 $\leq$ 6.5 mm
Spring Plungers	_____	Option (A/B) Functional (Y/N)
Rails	_____	Anodized (Y/N)
Deployment Switches	_____	Option (A/B) Functional (Y/N)
Width [x-y], Top		
Side 1	_____	$100.0 \pm 0.1mm$
Side 2	_____	$100.0 \pm 0.1mm$
Side 3	_____	$100.0 \pm 0.1mm$
Side 4	_____	$100.0 \pm 0.1mm$
Width [x-y], Middle		
Side 1	_____	$100.0 \pm 0.1mm$
Side 2	_____	$100.0 \pm 0.1mm$
Side 3	_____	$100.0 \pm 0.1mm$
Side 4	_____	$100.0 \pm 0.1mm$
Width [x-y], Bottom		
Side 1	_____	$100.0 \pm 0.1mm$
Side 2	_____	$100.0 \pm 0.1mm$
Side 3	_____	$100.0 \pm 0.1mm$
Side 4	_____	$100.0 \pm 0.1mm$

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

List Item	Actual	Required
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	_____	$141.2^{+0}_{-1.5}mm$
Protrusions		
Side 1	_____	$6.5 + 0.0mm$
Side 2	_____	$6.5 + 0.0mm$
Side 3	_____	$6.5 + 0.0mm$
Side 4	_____	$6.5 + 0.0mm$
Side 5	_____	$6.5 + 0.0mm$
Side 6	_____	$6.5 + 0.0mm$