EXOLAUNCH

SPACE. LET US TAKE YOU THERE

TestPod

User Manual

Revision 2.0 | October 2022

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Introduction

1.1 Purpose

This User Guide describes features of the Exolaunch TestPod and defines the interface requirements for the Cubesat for developers, who are utilizing the TestPod for mechanical testing, fit-check purposes or shipping. The TestPod is designed and based on Exolaunch's EXOpod Cubesat Deployer and complies with the Cubesat Design Specification Rev. 14.

1.2 Quality Assurance

Quality assurance for the Exolaunch TestPod is ensured at every step of production. The entire production process fulfils the highest quality assurance requirements. The facilities which manufacture Exolaunch products such as the TestPod are certified with ISO 9001:2015 standard, which requires regular inspection of the manufacturing and assembly facilities and ensures a stable quality of the final product.

1.3 Applicability

This document is applicable until it is cancelled or replaced by another issue. This User Guide is a living document open for all corrections and amendments which occur in the lifetime of the TestPod.

2

Exolaunch TestPod

2.1 Introduction

The Exolaunch TestPod has been developed to facilitate mechanical testing of Cubesats. It allows performing the full mechanical qualification of a Cubesat inside the TestPod. The TestPod can be easily mounted on a shaker table or other testing devices and creates a realistic environment, with all mechanical interfaces being the same as in the EXOpod deployer that is used during an actual launch. This has an additional benefit of enabling the TestPod to perform Cubesat fit-checks and also allowing a Cubesat to be shipped safely in a TestPod if required. The system offers both a combination of the highest reliability and user-friendliness.

This document describes the family of TestPods suitable for Cubesats from 1U to 16U, Exolaunch has detailed documentation on each of the different TestPod sizes that it offers, which is avaliable upon request.

2.2 Components and Features

The main components of the 3U, 8U and 16U TestPods are shown in Figure 2. It features

- A clamping mechanism
- Set screws
- Access windows
- A rigid chassis
- Several mounting interfaces

Sizing Features

Using adapters, it is possible to fit smaller Cubesats inside a larger TestPod. Typically, this involves a Cubesat going to the next sized up TestPod, for example a 1U CubeSat or 2U Cubesat using a 2U or 1U adapter inside a 3U TestPod. These adapters are standard U sizes, but can be customized if the Cubesat is uniquely sized. The adapters are inserted into the TestPod before the Cubesat is integrated.

Figure 1:
3U TestPod with 1U and 2U adapters

Clamping Mechanism

The clamping mechanism pushes several clamping feet along the TestPod's rails inwards when the door is closed. This compensates for any tolerance gaps that may exist between the TestPod and the Cubesat in the lateral directions. The Cubesat is held in place safely and unwanted movement is prevented. The same clamping mechanism is also utilized in Exolaunch's EXOpod Deployer.

Set Screws

The set screws on the door of the TestPod compensate for dimensional tolerances in the deployment axis and help fix the satellite in place after the door is closed. This follows a similar purpose to the clamping mechanism and helps prevent unwanted movement. The door itself is closed and secured by two screws (this position is taken by RBF pins on the deployer).

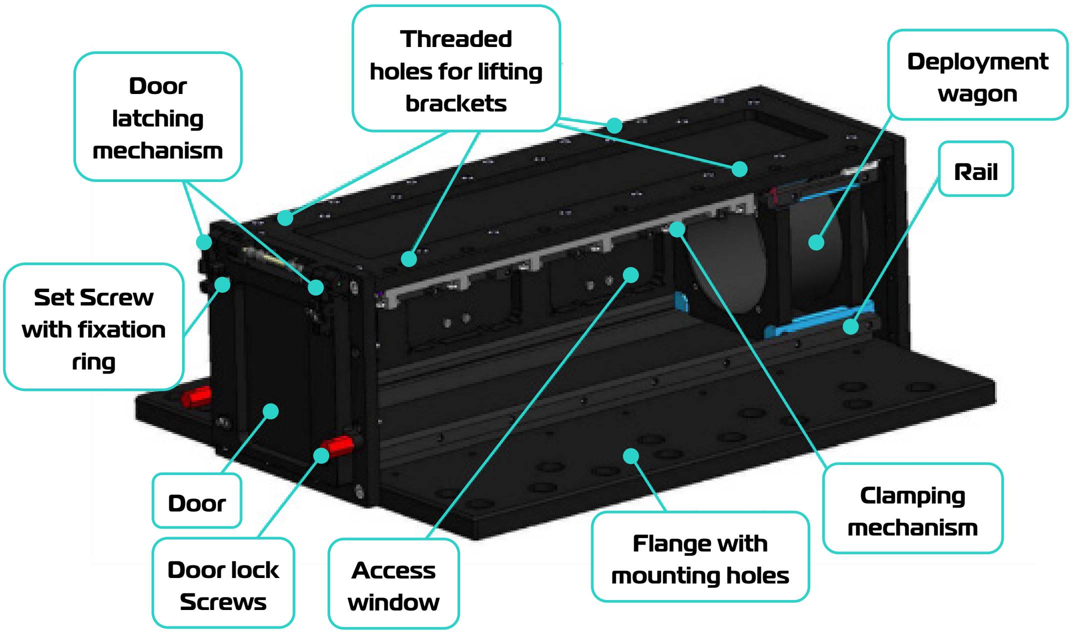
Access Windows

There can be up to 16 access windows in total, depending on the size of the TestPod. These access windows are present on both sides of the TestPod and allow access to the Cubesat during testing, permitting accelerometer placement and visual inspection. Access windows on the TestPod are located in the same place as the EXOpod.

Chassis

The TestPod's stiff construction guarantees structural integrity and longevity. The flange is part of the structure and allows easy mounting of the TestPod on the shaker table with several individual mounting hole patterns.

Figure 2: Components and features of the 3U TestPod. Components are the same regardless of the TestPod size



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TestPod Porperties and Interfaces

3.1 Physical Dimensions and Mass Properties

The outer dimensions of the three different sizes of TestPod are showing in Figures 3 to 5.

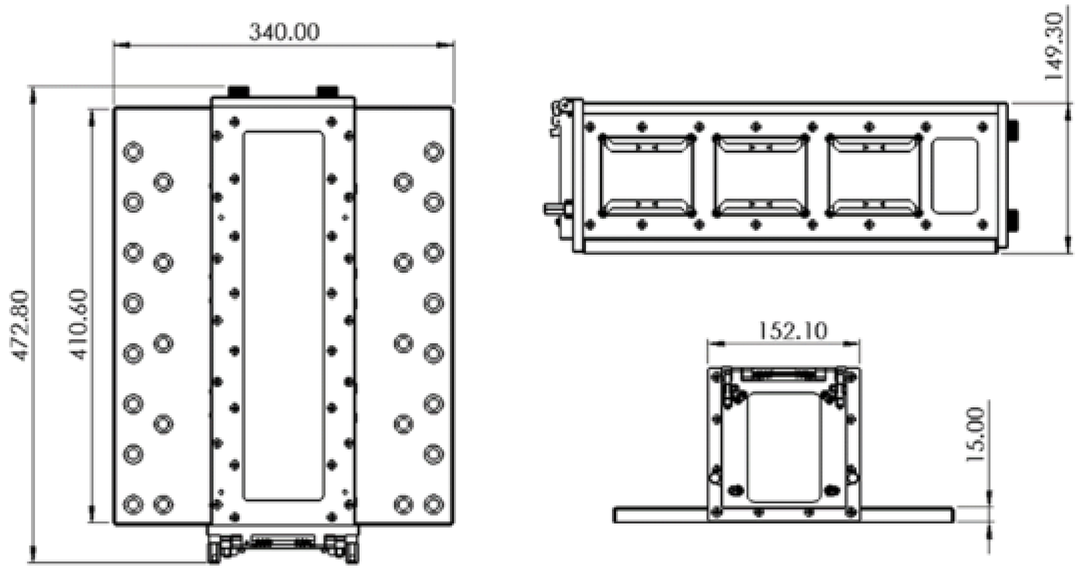


Figure 3: Outer envelope of the 3U TestPod

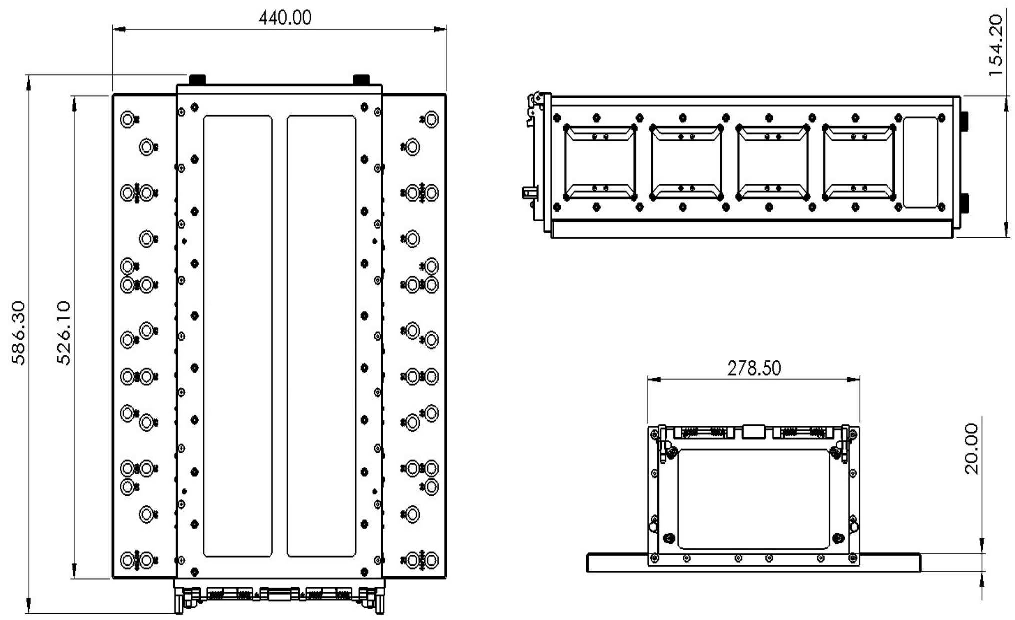


Figure 4: Outer envelope of the 8U TestPod

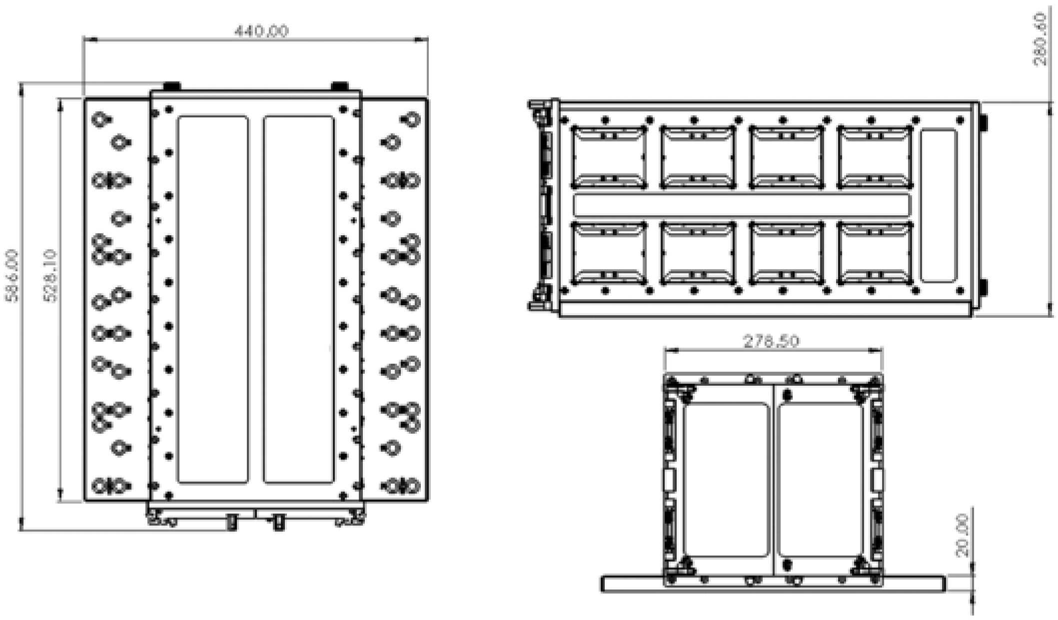


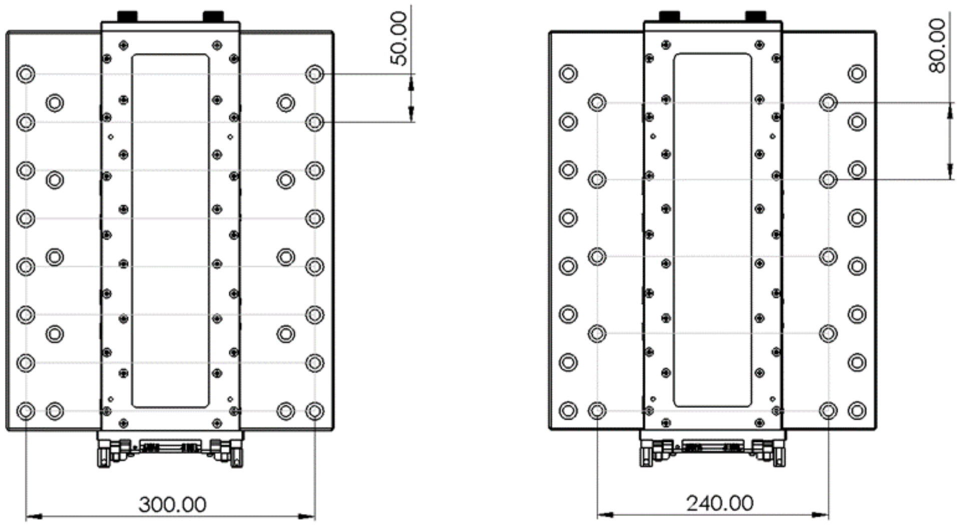
Figure 5: Outer envelope of the 16U TestPod

3.1.1 Mounting Interfaces

The 3U TestPod features two mounting hole patterns as shown in Figure 6, with the mounting hole patterns of the 8U and 16U shown in Figure 7. All the mounting holes are Ø11 mm through-holes for M10 screws with a nominal tightening torque of **40.0 Nm**. The mounting holes have an Ø 18 mm, 5 mm deep counterbore for the screwhead. It is not intended for every screw to be used to fasten the TestPod to the shaker table.

Note: A purchased TestPod can optionally be manufactured with a different hole pattern if required.

Figure 6: Mounting interfaces of the 3U TestPod



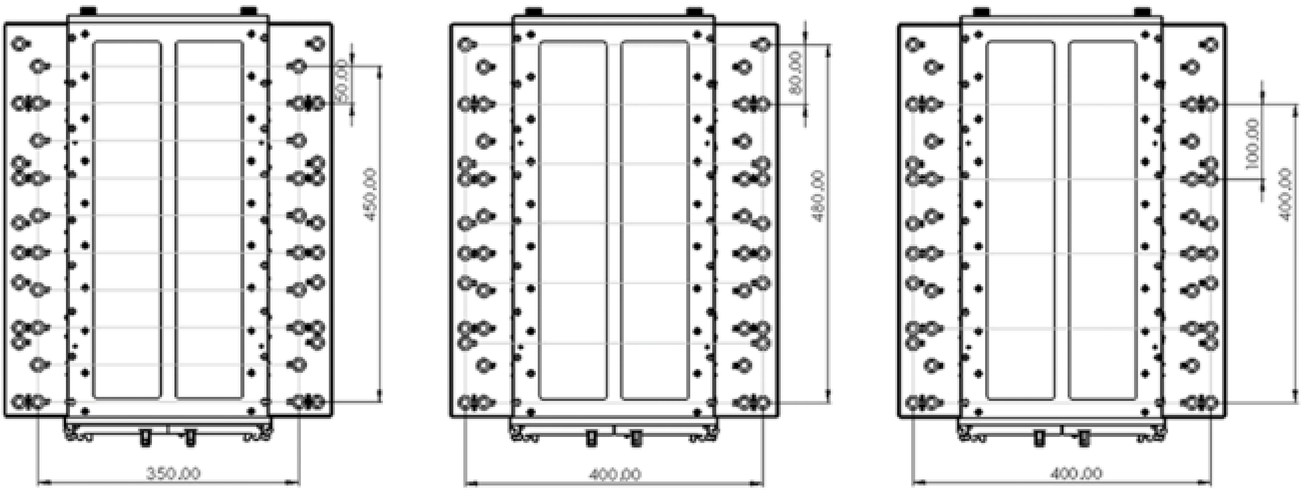


Figure 7: Mounting interfaces of the 8U and 16U TestPod

3.1.2 Lifting Points

Every TestPod has four threaded holes on the top side which can be used to attach lifting brackets. The location of the holes are shown in Figure 2, with an example mounting shown below in Figure 8. The screws are tightened to **1.0 Nm**.

The brackets are strong enough to carry the weight of a fully loaded TestPod with significant margin for lifting any additional masses, such as the adapter plates.

Figure 8:
Installed lifting brackets
on the 3U TestPod

3.1.3 Structural Characteristics and Lifetime

The primary structure of the TestPod was designed for rigidity and durability allowing for a high number of test cycles. The natural frequencies of the different TestPod models are shown below Figure 9. These frequencies have been determined from a 0.2 g sine sweep test with no mass inside the TestPod.

The number of test cycles that can be run in a TestPod is only limited only by the rails. A general limit is difficult to define, since the wear on the rails depends mainly on the condition of the Cubesat rails tested inside the TestPod. Experience shows that a set of rails can be used for 10 - 15 full campaigns or more, provided that the Cubesat is fully compliant with the CDS and integration and de-integration is performed with care. Figure 12 shows examples of worn out rails (photo shows an EXOpod deployer).

Figure 9: Resonances frequencies of the 3U Testpod

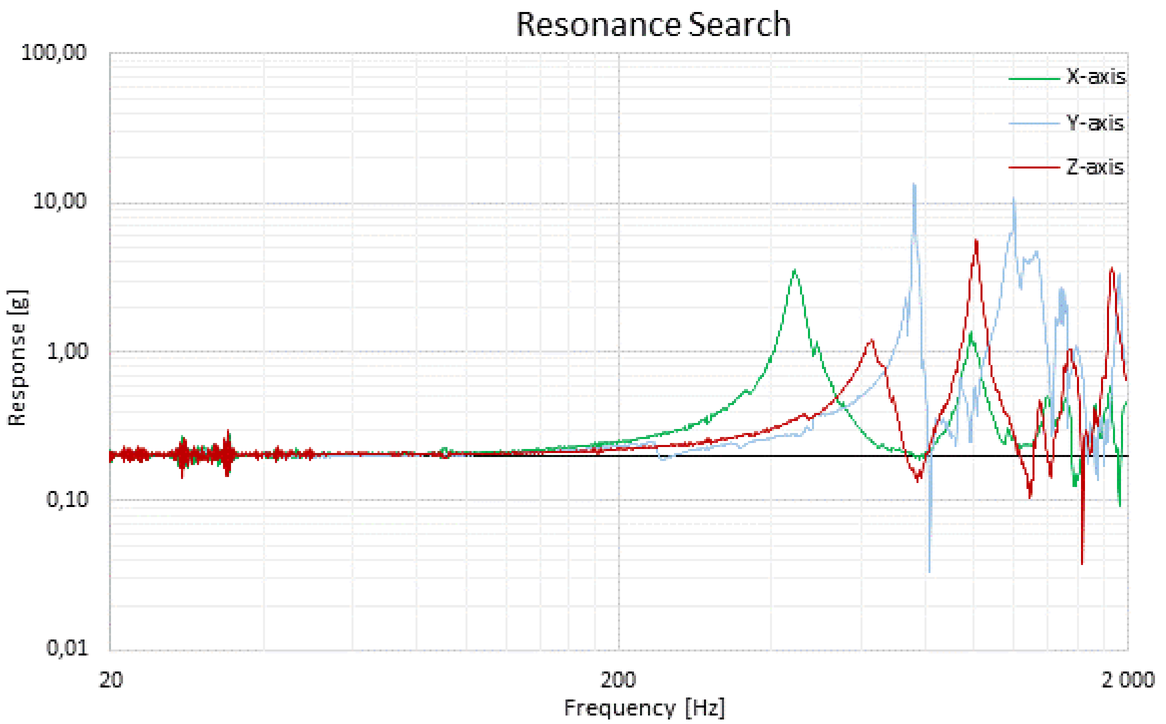


Figure 10:
Resonances frequencies of the 8U Testpod

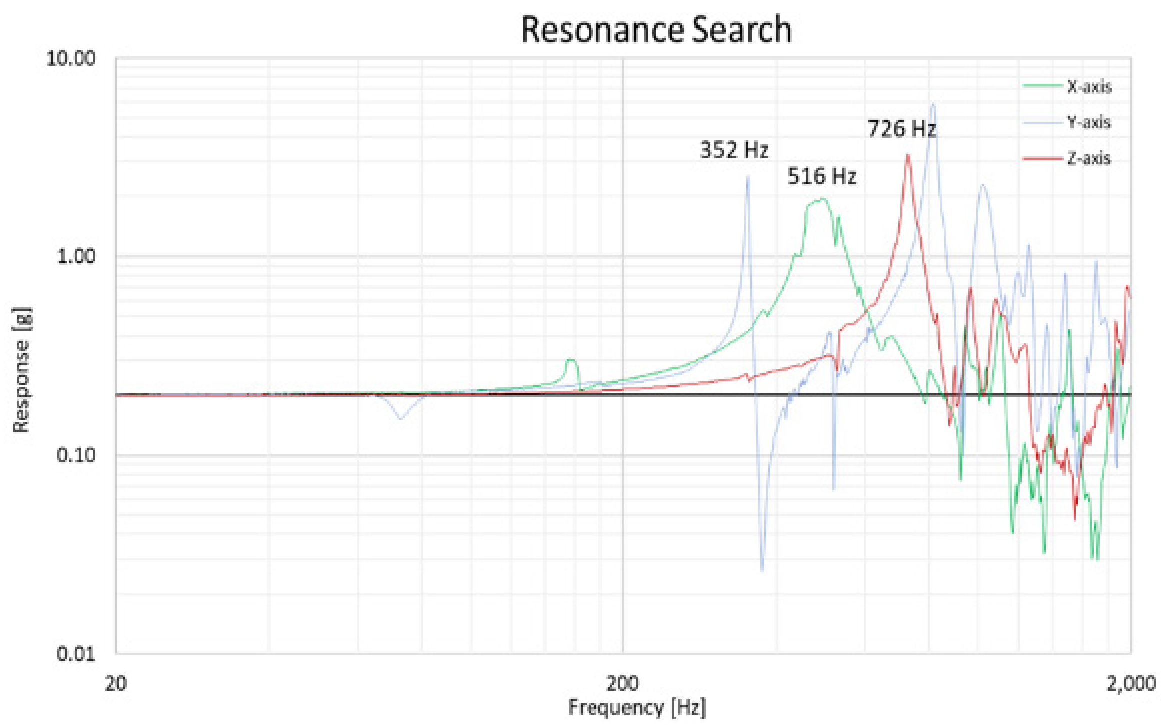


Figure 11:
Resonances frequencies of the 16U Testpod

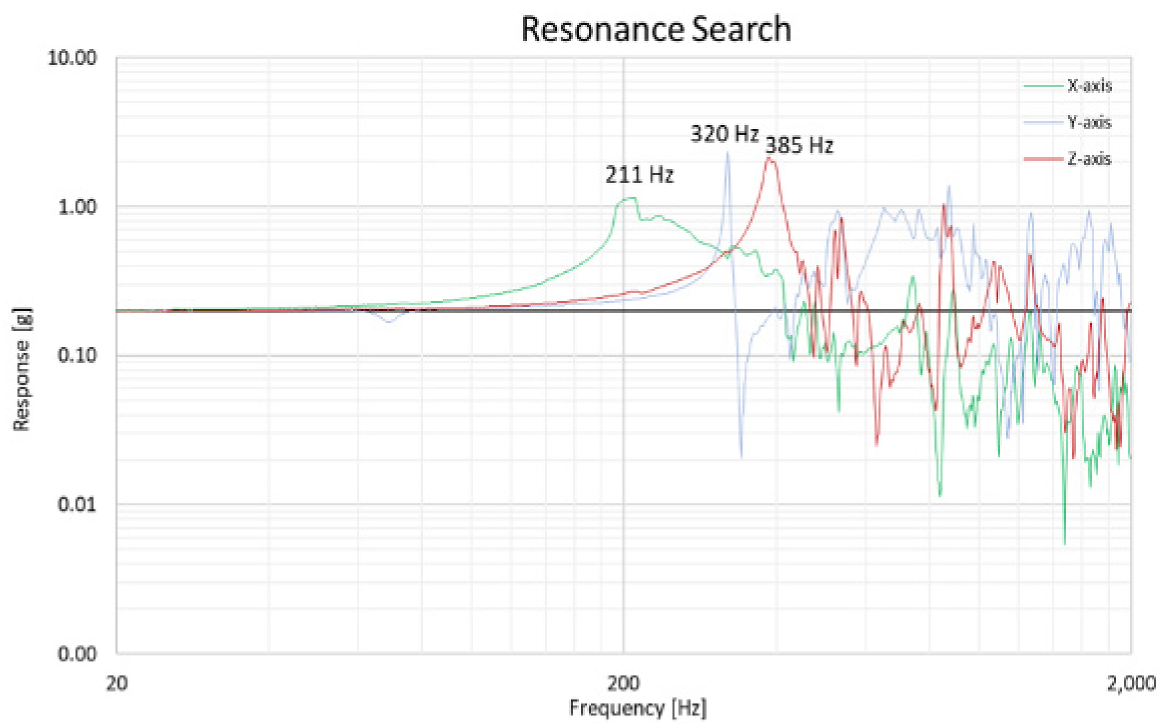


Figure 4 and Figure 5 show the location of the all electrical interfaces of the EXObox.

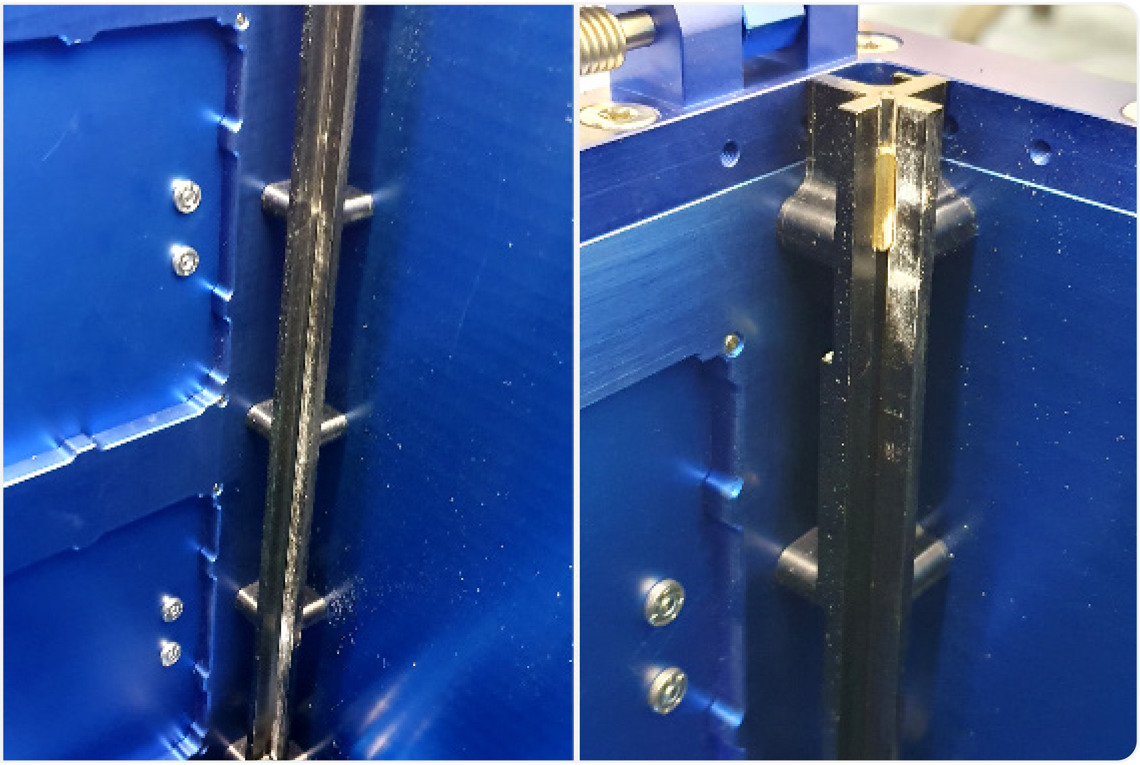


Figure 12: Example of strong wear marks on rails (Photos show Exolaunch EXOpod deploymer)

3.1.4 Flight Representativeness

The CDS does not specify requirements for flight representativeness of a TestPod or test support device of any kind. The stiffness of the TestPod structure, which is significantly higher when compared to a typical deployment system on the market, does have an influence on load transmissibility and levels experienced by the Cubesat. However, this difference is typically accepted by various launch providers and altering the test levels is not required. The internal mechanical interface in the TestPod is identical to those of an Exolaunch EXOpod deployer.

3.2 Cubesat Interfaces

3.2.1 Introduction

The Exolaunch TestPod has been developed to follow the Cubesat Design Specification (CDS). However, changes have been implemented which allow for integrating Cubesats that exceed some dimensions which are specified in the CDS, while still accommodating fully CDS-compliant Cubesats.

Cubesats are constrained by three separate elements on the deployers: the rails, the deployment wagon, and the set screws located on the doors. The deployment wagon is the same as in the EXOpod Deployer, only without the deployment spring.

3.2.2 Maximum Cubesat Volume

General requirements of Cubesats are provided in the Cubesat Design Specification Rev. 13. However, Cubesats in Exolaunch's TestPods and Deployers are allowed to exceed some of the constraints imposed by the CDS.

The maximum allowable volume for various Cubesat sizes are outlined in Figure 13 and Table 1. Surface parallelism and roughness are given in Figure 14. The red areas (rails) mark the Cubesat interfaces with the TestPod; these dimensions must be followed in order for the Cubesat to fit inside the TestPod. The grey volume can be used by the Customer in any desired way. The yellow area represents the so-called Tuna Can, and may also be used by the Customer.

The CDS states that Aluminum 7075, 6061, 5005 and/or 5052 shall be used for both the main Cubesat structure and the rails. **The rails must additionally be hard anodized**, and no other processes or materials shall be used. Any deviation from the CDS, such as but not limited to, the use of different materials or surface finishes, i.e. other forms of anodizing or a chromate conversion dual finish, may inflict damage to the rails.

If the TestPod has been rented from Exolaunch, any such deviation shall be communicated with and approved in writing.

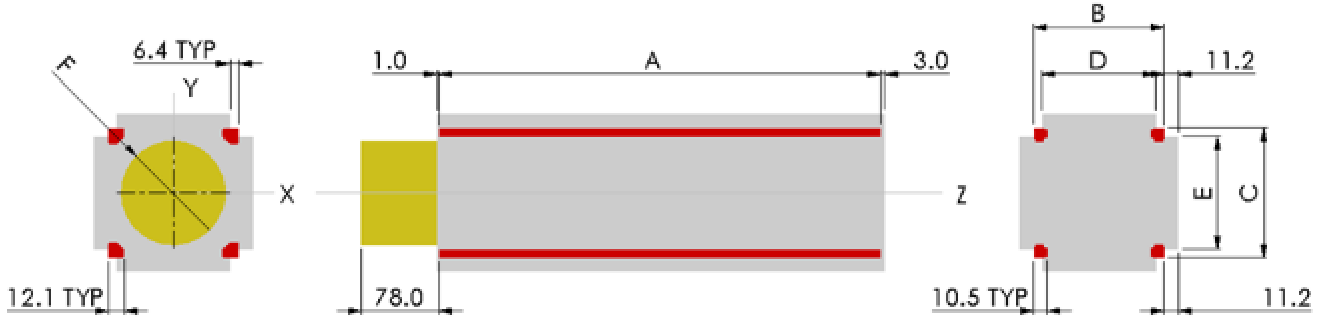


Figure 13: Maximum allowable outer dimensions for Cubesats launched in an EXOpod. Contact areas with the deployer are marked red. Pictured in the figure is an example is of a 3U Cubesat.

Table 1: Maximum Cubesat Dimensions for different TestPod sizes

Description	Letter	3U TestPod	8U TestPod			16U TestPod	
		1U/2U/3U	6U	6U XL	8U	12U	16U
CubeSat Rail Length (Z) [mm]	A	1U: 113.5 2U: 277.0 3U: 340.5	340.5	365.9	454	340.5	454.0
CubeSat Rail Width (X) [mm]	B	100.0	226.3	226.3	226.3	226.3	226.3
CubeSat Rail Height (Y) [mm]	C	100.0	100.0	100.0	100.0	226.3	226.3
Maximum Space Between Rails (X) [mm]	D	87.2	213.5	213.5	213.5	213.5	213.5
Maximum Space Between Rails (Y) [mm]	E	87.2	87.2	87.2	87.2	213.5	213.5
Tuna Can Diameter (except 5th tuna can)	F	82.0	82.0	87.0+**	87.0	82.0	87.0
12U Tuna Can Depth (except 5. tuna can)	G	60.0	60.0	-	-	-	-
16U Tuna Can Depth (except 5. tuna can)	G	-	-	-	77.0	77.0	77.0
Number of Tuna Cans	-	1	2	2	2	5*	5*
Distance Between Tuna Cans [mm]	-	-	126.3	126.3	126.3	126.3	126.3
Maximum Mass [kg], RPM	-	6.0	12	12	15	22	24
Maximum Mass [kg], BPM							29
Rail Parallelism [mm]	-	0.05					
Surface Roughness [µm]	-	1.6					

***The fifth tuna can is located at the center of the deployment wagon with a diameter of 62 mm and a height of 67 mm.**

****The adapter used to accommodate a 6U XL can be modified to fit custom dimensions.**

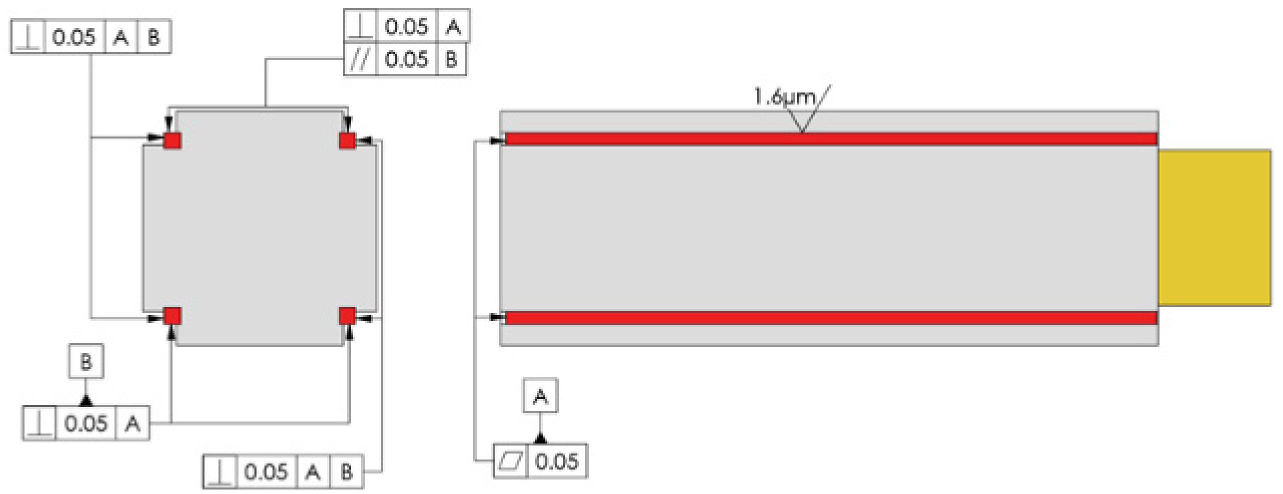


Figure 14: Cubesat Rail Surface roughness and parallelism

3.2.3 Access Windows

The Access Windows are located on both sides of the TestPod and total 6, 8 or 16 depending on the model of the TestPod. These access windows allow for quick and easy access to the Cubesat after its integration for attaching accelerometers, visual inspection, or for a quick functional test using external ports at any point during a test campaign. The exact dimensions and location of these Windows for the 16U TestPod are shown in Figure 15. Measurements start in the deployment wagon plane and from the guidance rails, which are the contact planes of a Cubesat.

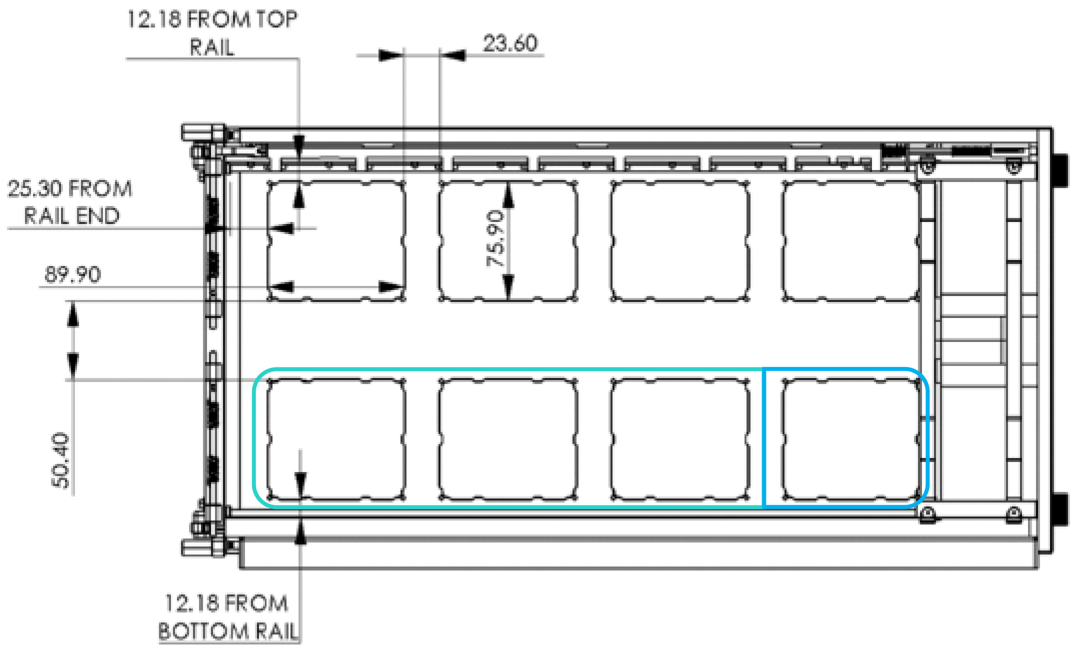


Figure 15: Dimensions of the TestPod access windows using a 16U TestPod as an example. Dimensions are the same across different TestPod sizes. Green Square represents windows which would be present on a 3U TestPod, Green and Blue for an 8U TestPod.

3.2.4 Rails and Clamps

The rails are made of hard-anodized aluminum. As a mechanical interface they are identical to the rails used in Exolaunch's EXOpod Cubesat deployers. This provides a flight-like environment for the satellite. To fix the satellite in the X and Y directions (perpendicular to the direction of deployment) Exolaunch utilizes an array of adjustable clamps on one of the upper rails that serve to restrain and hold the Cubesat stable when the TestPod's doors are closed, see Figure 16. These clamps compensate for any loose tolerances and prevent the satellite from shaking and rattling around during transportation and testing.

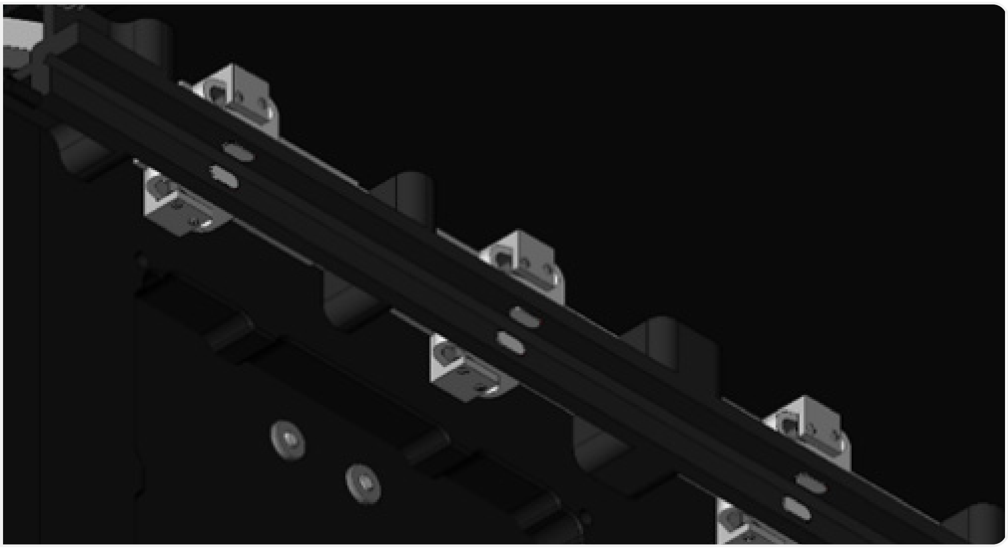


Figure 16:
Clamping Mechanism

3.2.5 Deployment Wagon

The deployment wagon is situated between the back wall of the TestPod and the Cubesat. In the EXOpod Deployer it serves to keep the spring in the correct orientation ensuring that the spring force is delivered correctly to the Cubesat. In the TestPod, the deployment wagon does not carry a spring. It serves only as a mechanical interface and is fixed in place using four knurled screws located on the back side of the TestPod. When these screws are removed, a set of pusher tools can be used to facilitate Cubesat de-integration, Figure 17.

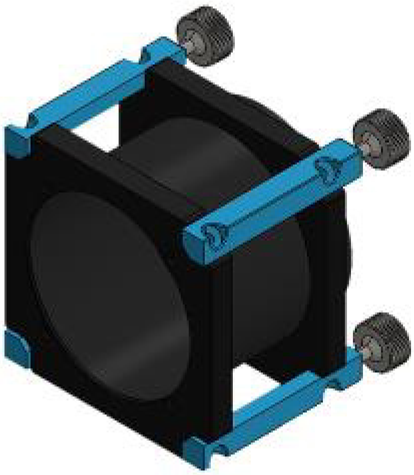


Figure 17:
Left: Deployment Wagon for the 3U TestPod with knurled screws for fixation.
Right: Pusher tools to facilitate de-integration of the Cubesat.

3.2.6 Door with Set Screws

The Cubesat is fixed in the direction of deployment by the deployment wagon at the back of the TestPod with four set screws located on the TestPod door. These are circled on the 3U TestPod as an example shown below in Figure 18. The set screws are carefully tightened one by one to adapt to the individual size of each satellite. Unlike the clamping mechanism, the set screws do not apply any force onto the satellite but are only used to bridge any loose tolerance gaps.

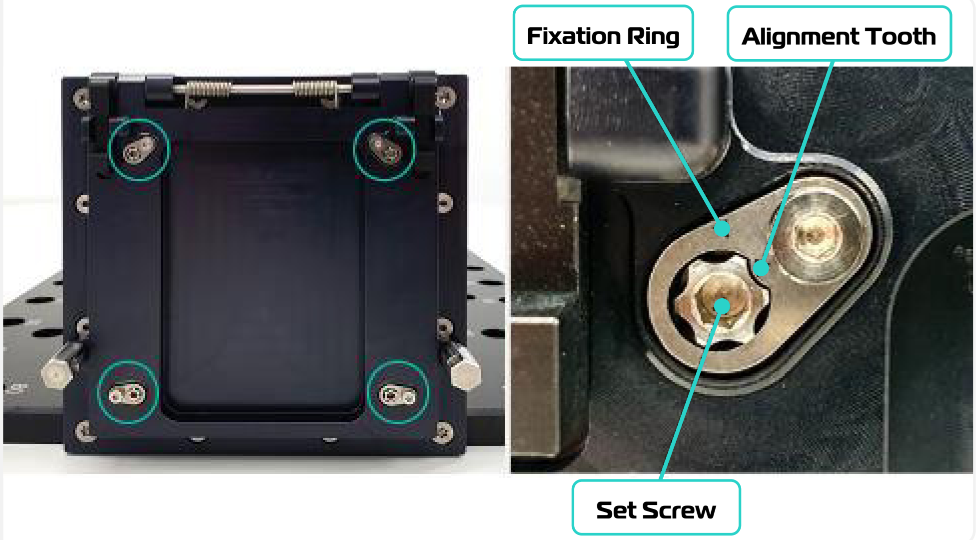


Figure 18:
Door with set screws used to fix the satellite in the Z-direction

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