

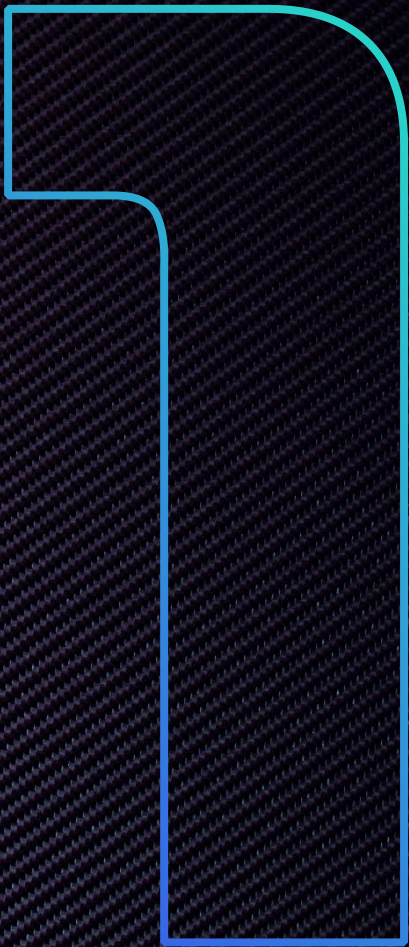


Nova TestPod

User Manual

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Introduction

1.1 Purpose

This User Manual defines the interface requirements between a CubeSat and Exolaunch Nova TestPod which is used for mechanical testing or for fit-check purposes. The TestPod's design is based on the Exolaunch EXOpod Nova CubeSat Deployer and complies with the CubeSat Design Specification (CDS) Rev. 14.



Figure 1:
Overview of the 4U, 8U and 16U EXOpod Nova TestPods

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 Manual is a living document open for all corrections and amendments which occur in the lifetime of the TestPod.



Exolaunch Nova TestPod

2.1 Introduction

The Exolaunch Nova 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, with all mechanical interfaces being identical to the EXOpod Nova deployer used during launch. This has an additional benefit of enabling the TestPod to perform CubeSat fitchecks 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. An Operator Manual will be provided to TestPod users separately on a need basis.

2.2 Components and Features

The main components of the 4U, 8U and 16U TestPods are shown in Figure 2. A detailed description is provided in Chapter 3:

- › A clamping mechanism with adjustable set screws
- › Access windows
- › A rigid chassis with different mounting interfaces
- › Slot adapters to accommodate any CubeSat size
- › Integration table for easy and safe integration

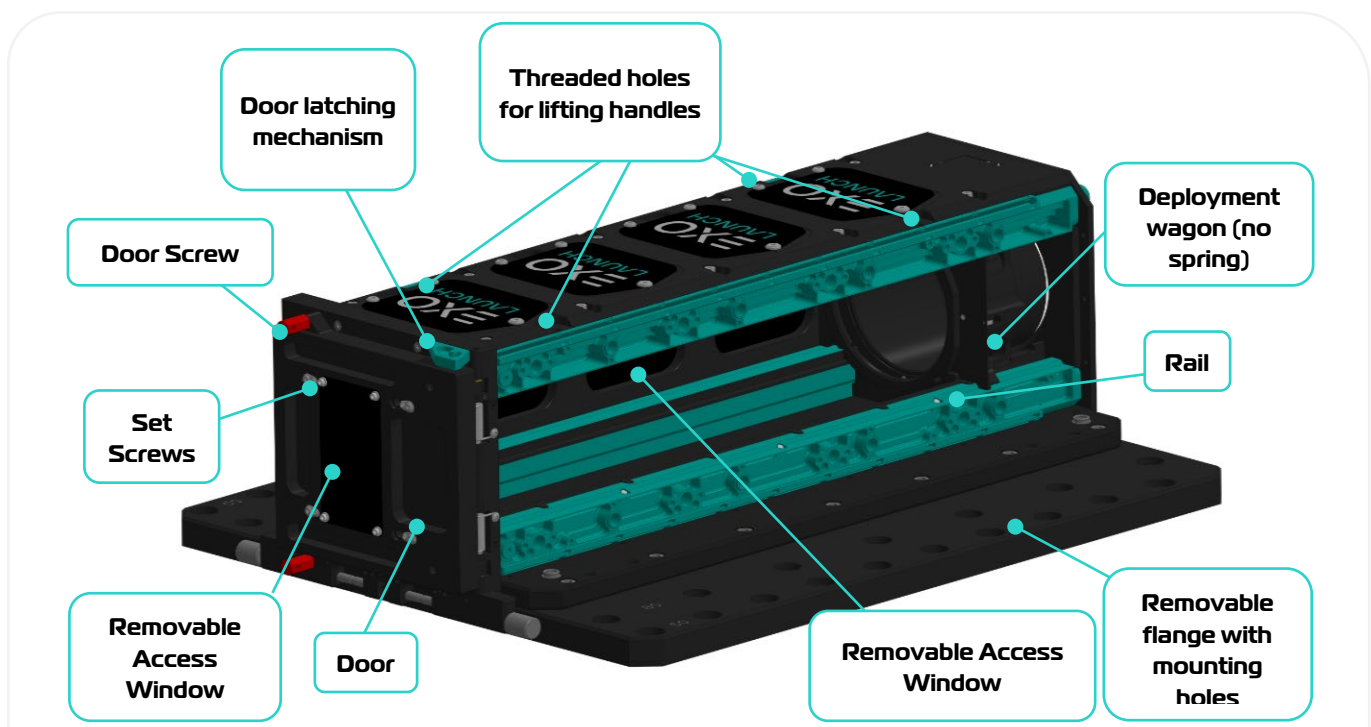


Figure 2:
Components and features of the 3U TestPod. Components are the same for all sizes.



TestPod Properties and Interfaces

3.1 Physical Dimensions and Mass Properties

The outer dimensions of the three different sizes of TestPods including the removable shaker adapter plate are shown in Figure 3 to Figure 5

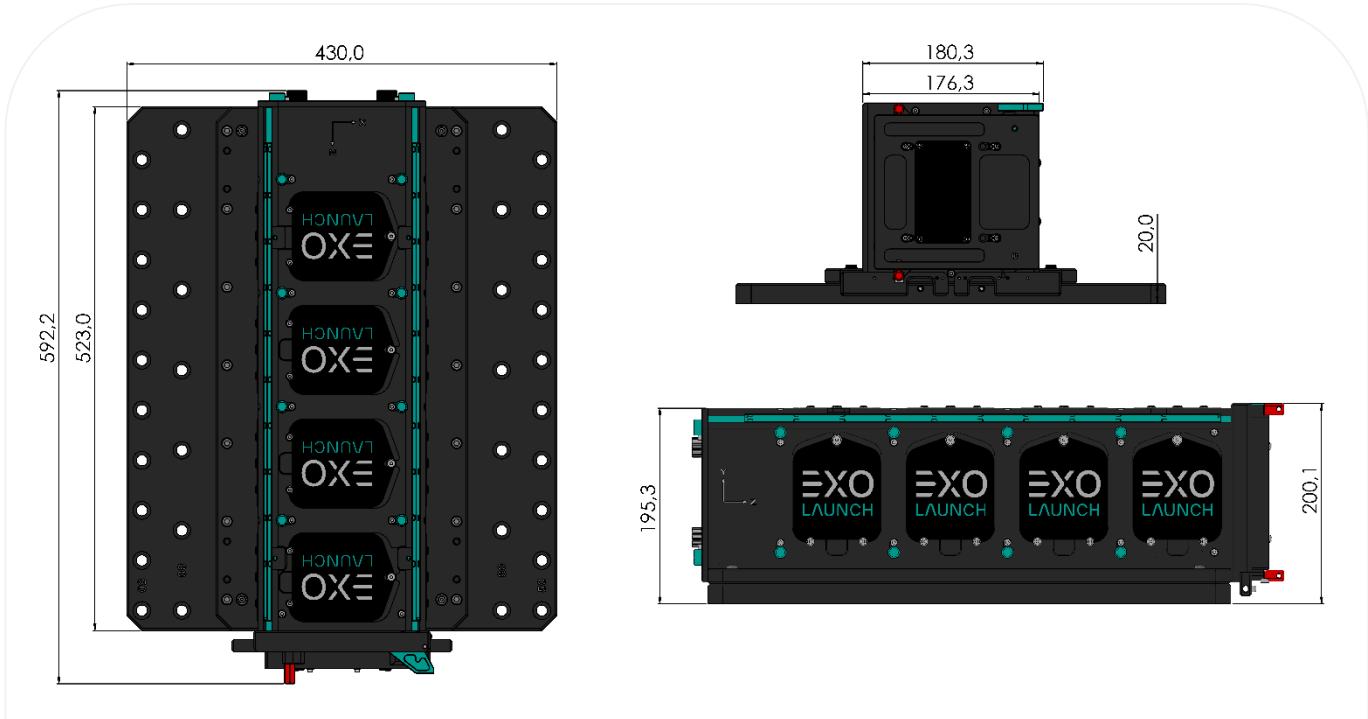


Figure 3:
Outer envelope of the 4U TestPod.

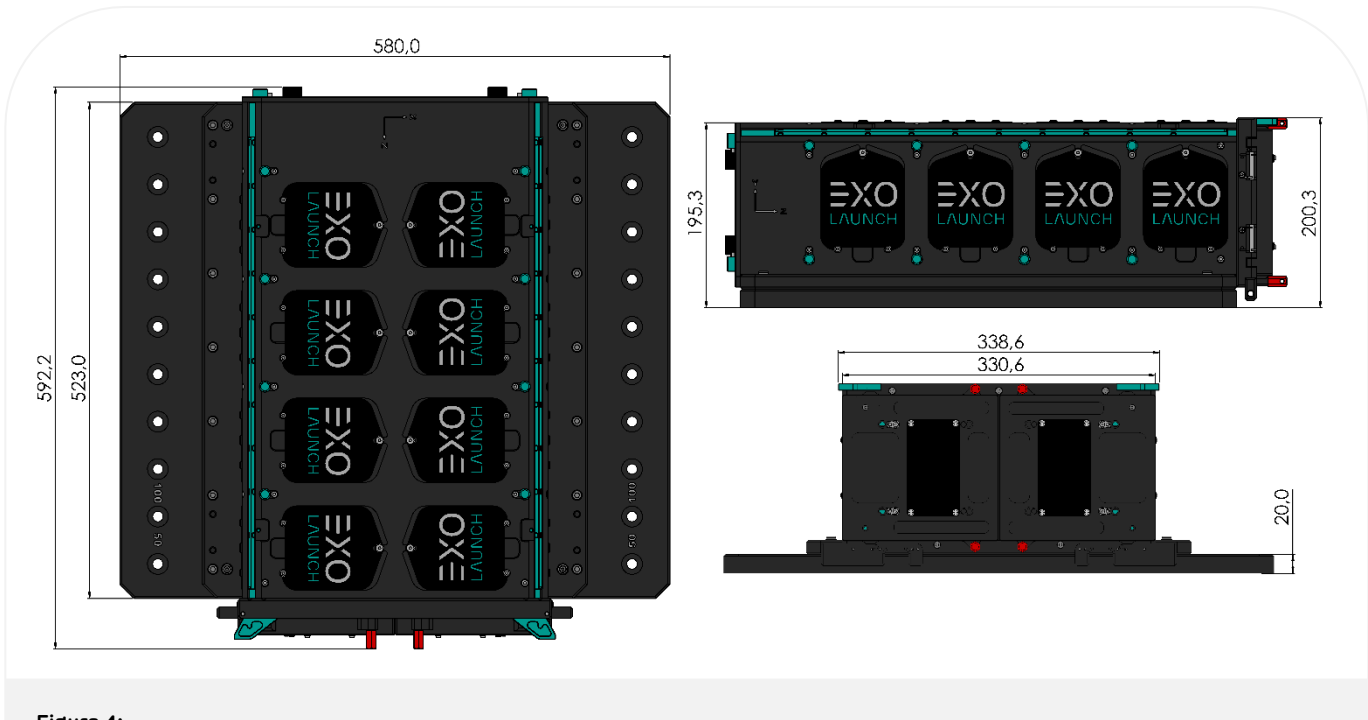


Figure 4:
Outer envelope of the 8U TestPod.

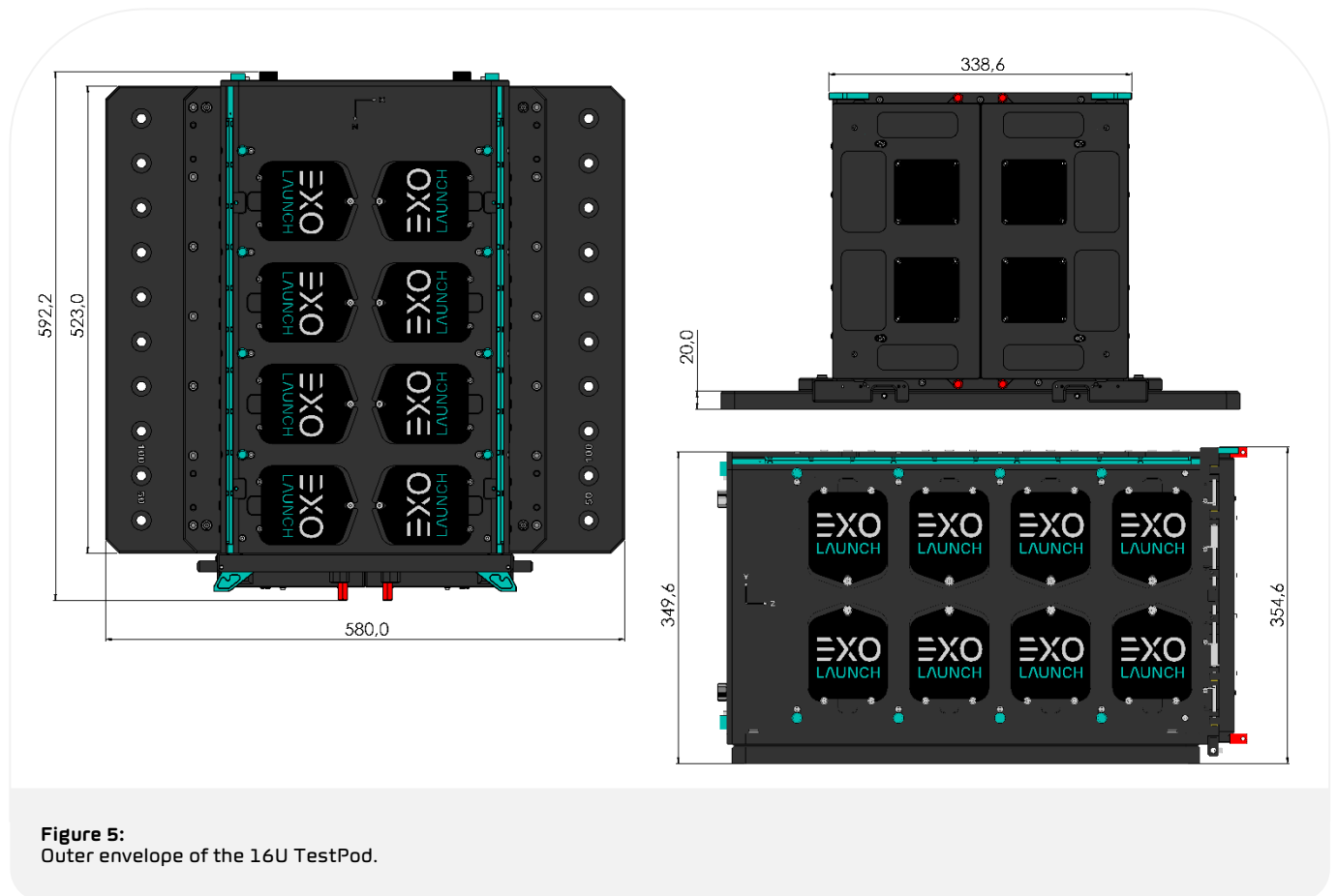


Figure 5:
Outer envelope of the 16U TestPod.

The mass of the three different sizes of TestPods including the removable shaker adapter plate are shown in Table 1.

Table 1: TestPod mass with and without the shaker adapter plate

Unit	TestPod Mass [kg]	Shaker Plate Mass [kg]	Total Mass [kg]
Nova TestPod 4U	13.4	10	23.4
Nova TestPod 8U	20	14.3	34.3
Nova TestPod 16U	26.7	14.3	41

3.1.1 Mounting Interfaces

The Nova TestPod family comes with a variety of different stock adapter plates compatible with different shaker interfaces, see Table 2.

Exolaunch can design and produce plates with additional interfaces if required. Customers may choose to design a custom adapter plate in coordination at their own risk. Close coordination with and a review by Exolaunch is required to ensure that the plate is compatible with the TestPod itself, which has several protruding features which the plate needs to accommodate.

Mounting holes which are not covered by the TestPod, have a 5 mm deep counterbore for the screwhead, covered mounting holes have a 13 mm deep counterbore. **Note:** A purchased TestPod can be manufactured with any hole pattern.

Detailed drawings of the listed shaker adapter plates are shown in Chapter 4.

Table 2: Available Shaker Adapter Plates.

#	4U Nova TestPod	8U and 16U TestPod	Compatible Fastener Size	Recommended Fastener Torque
1	100x100 mm		M10 (or M8 with washer)	≥40 Nm
2	80x80 mm grid		M10 (or M8 with washer)	≥40 Nm
3	2x2 inch grid		3/8 inch and 1/2 inch	≥29.5 ft-lbs
4	3 inch and 6 inch circle		3/8 inch	≥29.5 ft-lbs

3.1.2 Lifting Points

Every TestPod has four threaded holes on the top side which can be used to attach lifting handles. An example mounting is shown Figure 6. The screws are torqued to **1.0 Nm**. The handles are strong enough to carry the weight of a fully loaded TestPod with significant margin for lifting any additional masses, such as the adapter plate. For heavy lifts, the use of a crane is strongly advised.

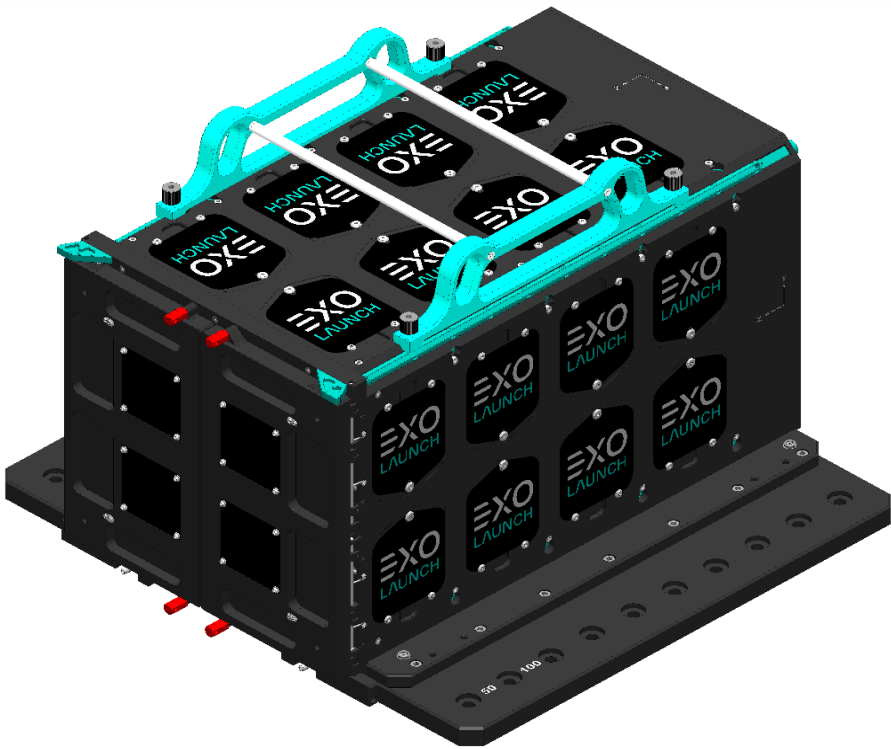
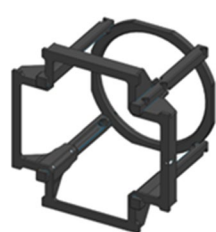


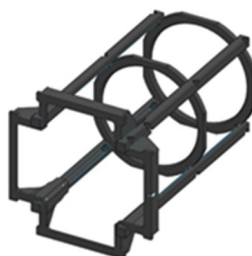
Figure 6:
Installed lifting handles with crossbars on the 16U TestPod.

3.1.3 Slot Adapters

Using adapters, it is possible to fit smaller CubeSats inside a larger TestPod. For example, a 1U CubeSat or 2U CubeSat using a 3U or 2U adapter inside a 4U 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.



1U



2U



6U XL

Figure 7:
Examples of slot adapter sizes

3.1.4 Flight Representativeness and Transfer Functions

The CubeSat Design Specification does not outline requirements for flight representativeness of a TestPod or test fixture. The internal mechanical interface in the TestPod is identical to that of an EXOpod Nova deployer which allows the TestPod to be used for fitcheck purposes. The stiffness of the TestPod structure is significantly higher when compared to the EXOpod Nova deployer or any other typical deployment systems on the market. This, in combination with a different mounting interface, does have an influence on load transmissibility and levels experienced by the satellite. This difference is widely accepted by satellite manufacturers and launch providers in the scope of mechanical testing of CubeSats. Altering test levels to account for structural differences and dampening effects of the TestPod is not required. In some cases, when a more accurate representation of flight environments is deemed necessary, a test in a fully flight-like separation system may be offered as a special service at extra cost.

Generic transfer functions are not available as load transfer will always depend on the as-manufactured dimensions of the TestPod and CubeSat. Some examples transfer functions recorded during vibration tests with customer satellites can be provided on request.

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.

3.2.2 Maximum CubeSat Volume

CubeSats in Exolaunch Nova TestPods and deployers are allowed to exceed some of the constraints in the CDS. For example, Exolaunch Nova TestPods and deployers allow features to extend between 25-39.5 mm from the rails depending on the size of the CubeSat.

The maximum allowable dimensions for any CubeSat size are outlined in Figure 10 and Figure 11 as well as Table 3. The teal-colored areas (rails) mark the CubeSat interfaces with the TestPod; these dimensions must be followed for the CubeSat to fit inside the TestPod. The grey volume can be used in any desired way with the blue area representing the so-called Tuna Can.

The CDS states that Aluminum 7075, 6061, 5005 and/or 5052 shall be used for both the main CubeSat structure and the rails. However, the rails must additionally be hard anodized. 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 be incompatible with the Nova TestPod or deployer. Any deviation from these requirements shall be approved by Exolaunch in written form.

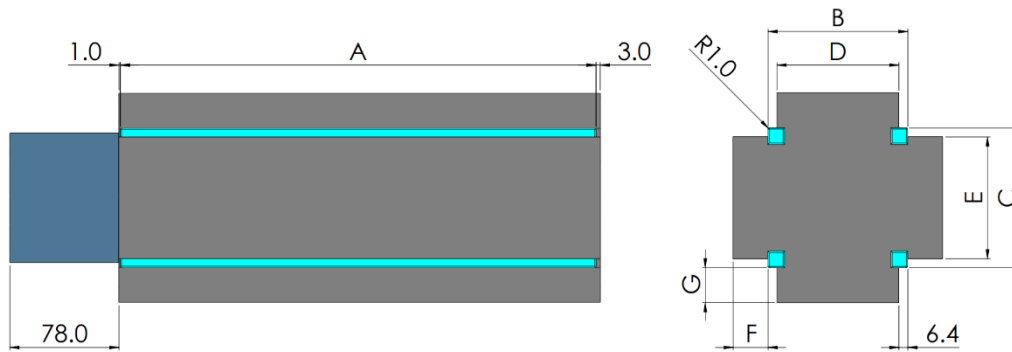


Figure 8:
Maximum allowable dimensions for CubeSats tested in a Nova TestPod. Contact areas are marked in mint green

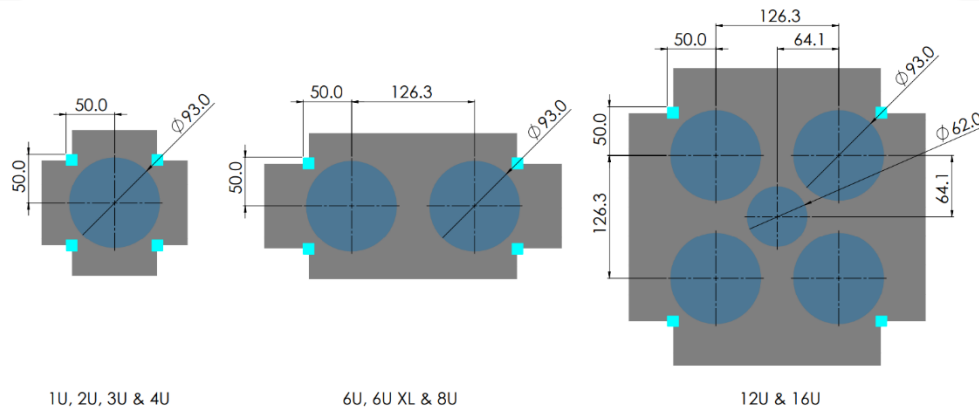


Figure 9:
Maximum allowable tuna can dimensions for CubeSats launched in an EXOpod Nova or Nova TestPod

Table 3: Maximum CubeSat dimensions

Description		Units	Letter	1U, 2U, 3U, 4U	6U, 6UXL, 8U	12U	16U
CubeSat Rail Length (Z)	[±0.5 mm]	mm	A	1U: 113.5 2U: 227.0 3U: 340.5 3UXL: 365.9* 4U: 454.0	6U: 340.5 6UXL: 365.9* 8U: 454.0	12U: 340.5 12UXL: 365.9*	454.0
CubeSat Rail Width (X)	[±0.1 mm]		B	100.0	226.3	226.3	
CubeSat Rail Height (Y)	[±0.1 mm]		C		100.0		
Max Space Between Rails (X)			D	87.2	213.5	213.5	
Max Space Between Rails (Y)			E		87.2		
Max Protrusion from Rail (X)			F	25.0	39.5	39.5	
Max Protrusion from Rail (Y)			G		25.0		
Rail Cross-section		mm	-	10x10**			
Number of Tuna Cans		-	-	1	2	4***	4***
Distance Between Tuna Cans		mm	-	-	126.3		

*The XL standard is defined differently by different standards. Exolaunch can provide adapters for any definition of "XL", but this must be coordinated in advance.

** If satellite -Z panel is protruding further than the tip of the rail, a min. cross-section must be ensured to avoid collision with TestPod rail.

***The 12U and 16U S1 Nova has an additional, fifth tuna can be located in the center between the four larger tuna cans, see Figure 9. The depth usable depth of this tuna can is 67 mm with a 62 mm diameter.

3.2.3 Access Windows

The access windows are located on the three outer faces of the TestPod allowing for easy and quick access to the satellite after integration for attachment of accelerometers, visual inspection or for a quick functional test using external ports during any point of the testing campaign. The exact dimensions and location of the windows are shown in Figure 10. The nominal torque for the access windows is 1 Nm.

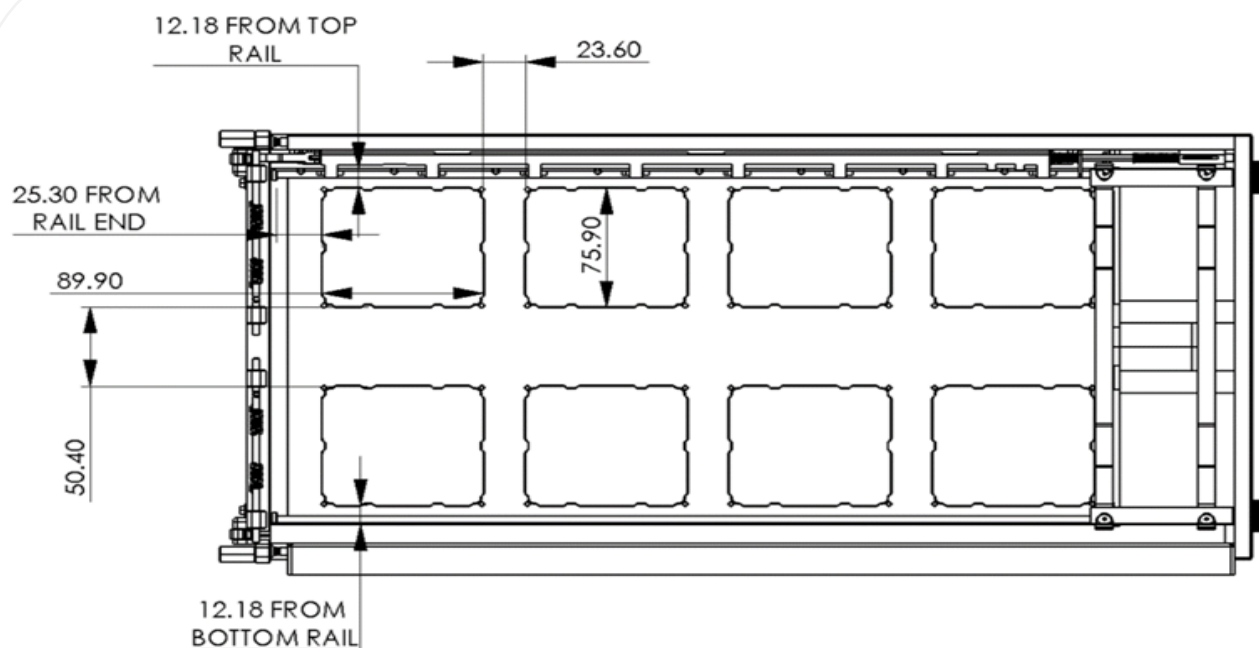


Figure 10:

Dimensions of the TestPod access windows using a 16U TestPod as an example. Dimensions are the same across different TestPod sizes.

3.2.4 Rails and Clamping Mechanism

The CubeSat rails are the primary interface between the satellite and TestPod. The Nova TestPod uses the same clamping system as the EXOpod Nova. Exolaunch has developed a unique clamping system which is highly effective at constraining the satellite in the X and Y directions, thereby preventing it from shaking and rattling during transportation and launch. This clamping force is achieved by moving clamping surfaces on up to three guidance rails inwards towards the CubeSat. The mechanism engages as the door is closed, and the force increases linearly with a decreasing opening angle of the door.

The total clamping force of the mechanism varies depending on the size of the slot as well as on the size of the Cubesat within the allowable tolerances. 3U slots have a clamping mechanism on a single rail. 6U/8U slots use two clamping rails and 12U/16U use three, although the second and third active rail will only have a unidirectional force acting on the Cubesat. The principle is illustrated in Figure 11. As an example, a 6U Cubesat on the lower end of the allowable size or 99.9 mm x 226.2 mm will experience a total clamping force of 1431 N, while the force will increase to up to 4365 N as the rail dimensions approach 100.1 mm x 226.4 mm in size. A change in clamping force has a notable impact on the transfer function and is one of the reasons why FE-modelling of coupled systems incl. CubeSat, CubeSat deployers and TestPods is not advised (for more information check the Nova User Manual).

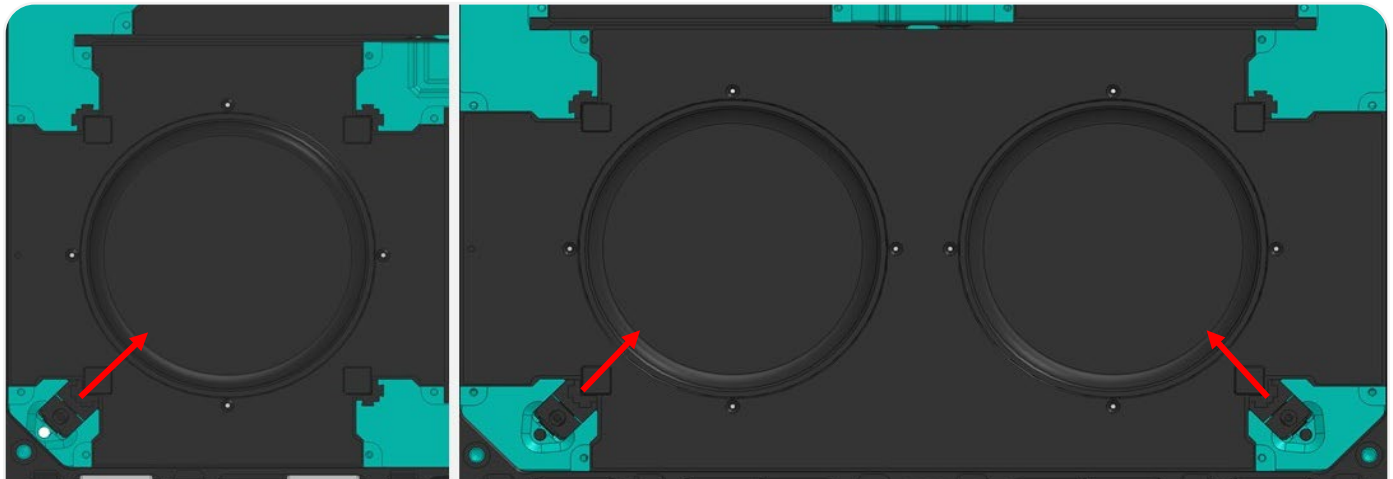


Figure 11:
Clamping forces direction in 4U (left) and 8U (right) CubeSat slots

3.2.5 Deployment Wagon

The deployment wagon is situated between the back wall of the TestPod and the CubeSat. In the Exolaunch Deployer it serves to keep the spring in the correct orientation and ensures that the spring force is delivered correctly to the CubeSat. In the TestPod, the deployment wagon does not carry a spring. It serves as a mechanical interface and is fixed in place using four knurled screws located on the back side of the TestPod. Nominal tightening torque for the knurled screws **1.0 Nm**. When these screws are removed, a set of pusher tools can be used to facilitate the CubeSat's de-integration. Both the deployment wagon and the pusher tools are shown below in Figure 14.

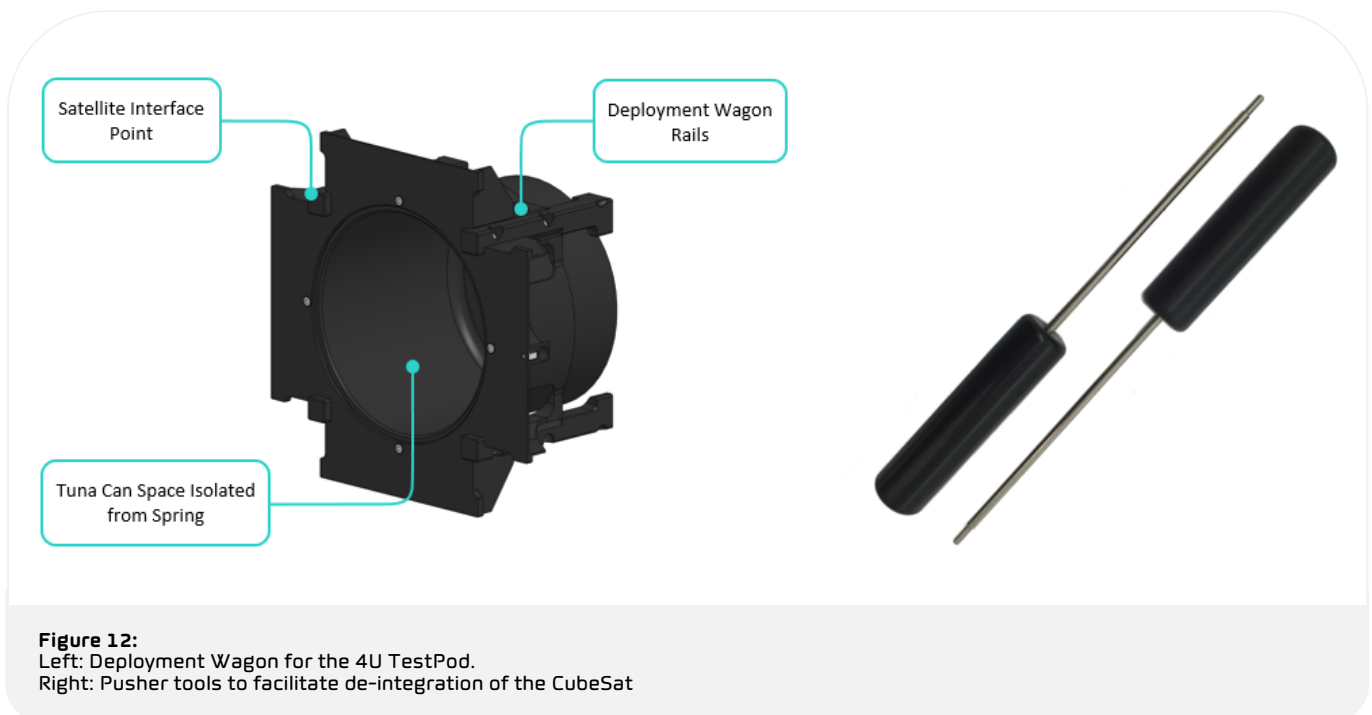
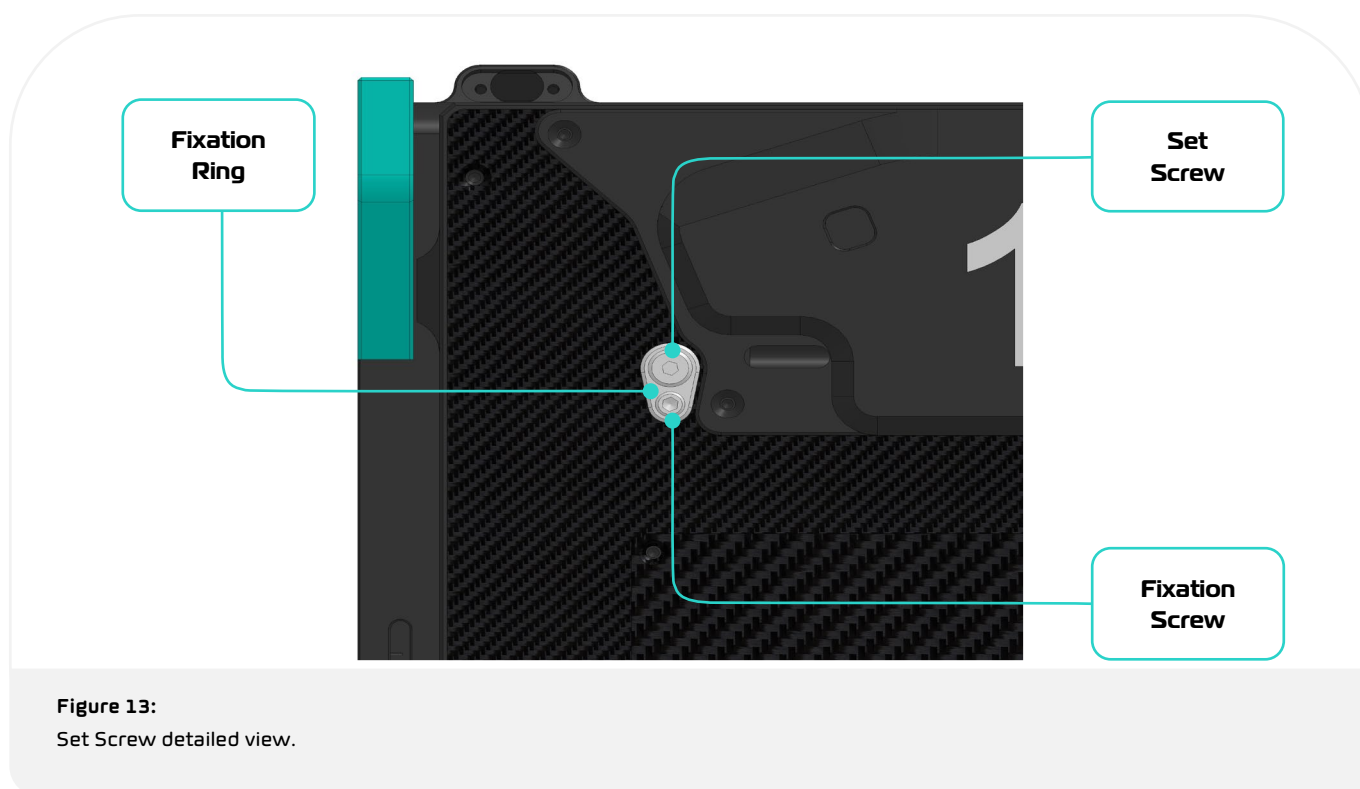


Figure 12:
Left: Deployment Wagon for the 4U TestPod.
Right: Pusher tools to facilitate de-integration of the CubeSat

3.2.6 Door with Set Screws

CubeSats are secured inside the slot by means of a clamping mechanism, which applies a clamping force in the X and Y directions. CubeSats are further constrained in the Z-direction by the combination of the Deployment Wagon and the adjustable set screws located on the slot doors (see Figure 13). Once a satellite is placed inside TestPod, the door is closed, and the set screws are then tightened. This eliminates any gap created by loose tolerances, thus prohibiting any movement in the deployment direction.

Each set screw is prevented from loosening by means of a fixation ring. When the fixation ring is engaged, it is deformed such that both the set screw and the fixation ring screw are both under increased running torque, thus retaining both fasteners.



3.2.7 Chassis

The TestPod is designed to be stiff and durable to maximize lifetime and reliability. This has the benefit of decoupling resonance frequencies from those of CubeSat. The removable shaker adapter plate allows for a quick exchange of plates and therefore offers a wider variety of shaker interfaces.

3.2.8 Integration Table

For easier integration into the TestPod, Exolaunch has developed an Integration Table, see Figure 16. The Integration Table rails align with the TestPod rails to slide in the CubeSat quickly and safely. A detailed description of the integration process is provided to customers using the Nova TestPods in a separate document.

The Nova TestPod is further compatible with a similar integration table which was developed for the EXOpod Nova CubeSat deployer, allowing for safe and seamless integration from the TestPod into the Nova deployer, e.g. if the TestPod was used for shipment.

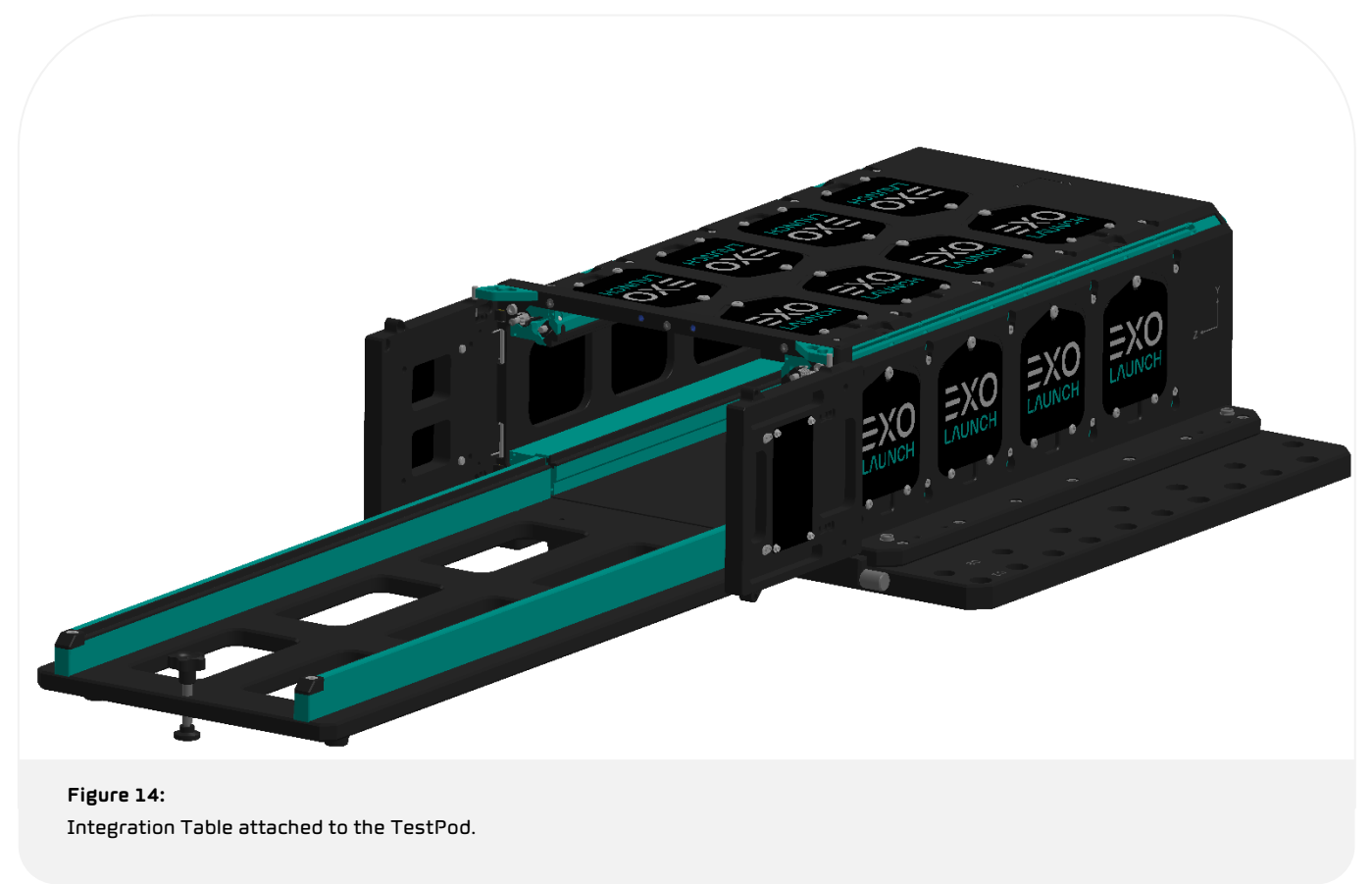


Figure 14:
Integration Table attached to the TestPod.

3.2.9 Transportation

For transportation purposes, the bottom plate that attaches the TestPod to the shaker table can be removed. This improves the mobility of the TestPod and simplifies transportation.



Figure 15:
Bottom plate removed for transportation.

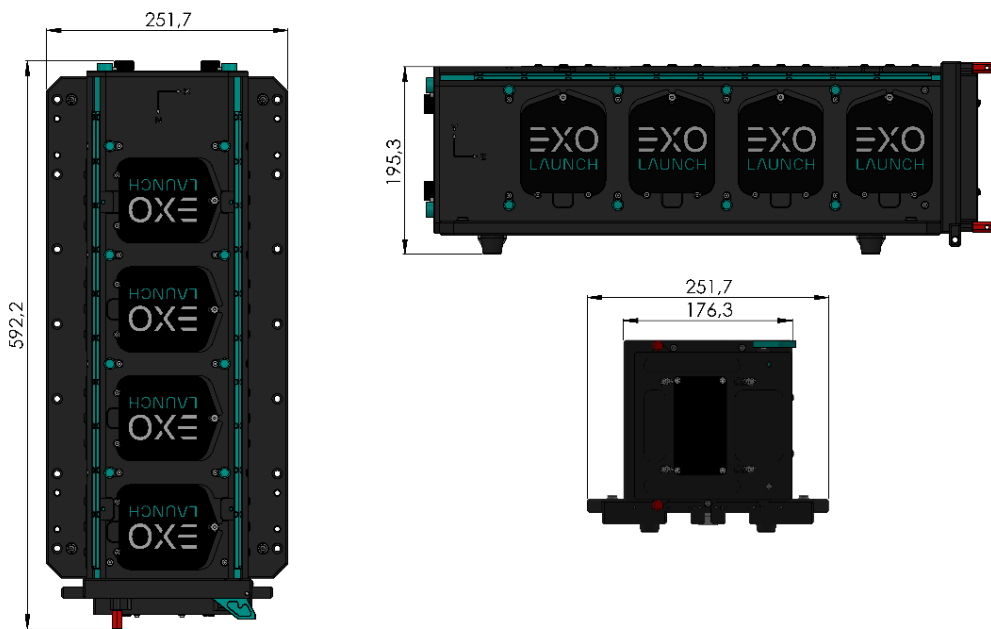


Figure 16:
Outer envelope of the 4U TestPod without the bottom plate.

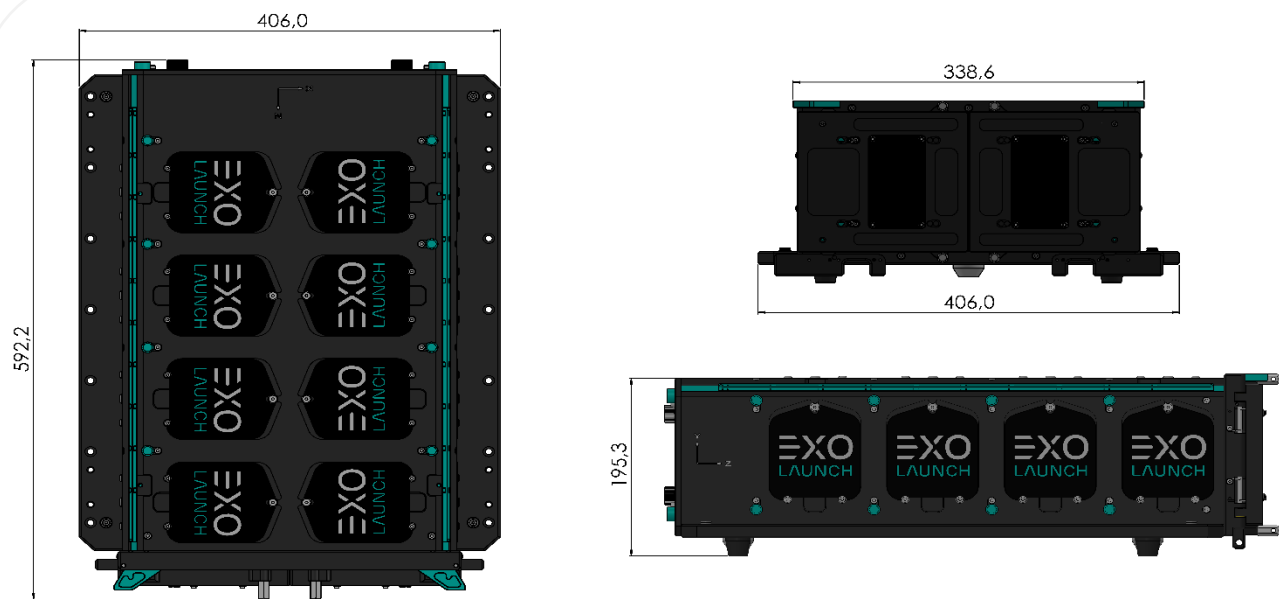


Figure 17:
Outer envelope of the 8U TestPod without the bottom plate.

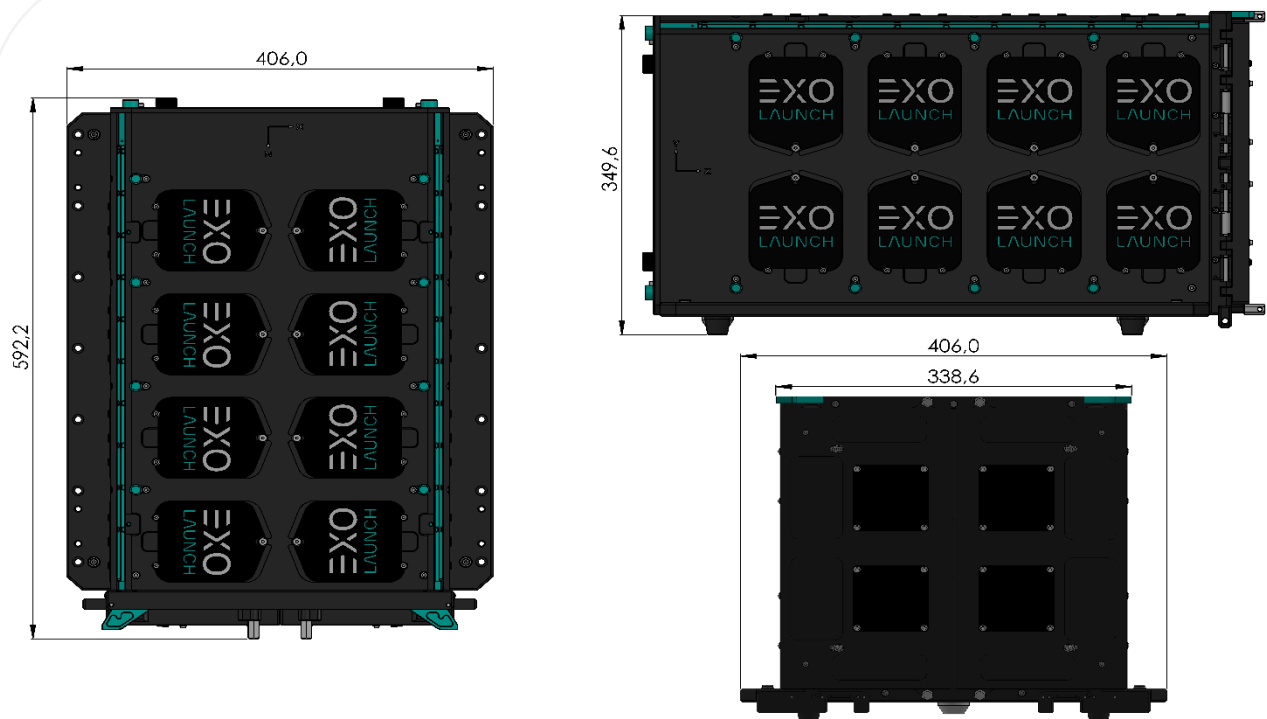


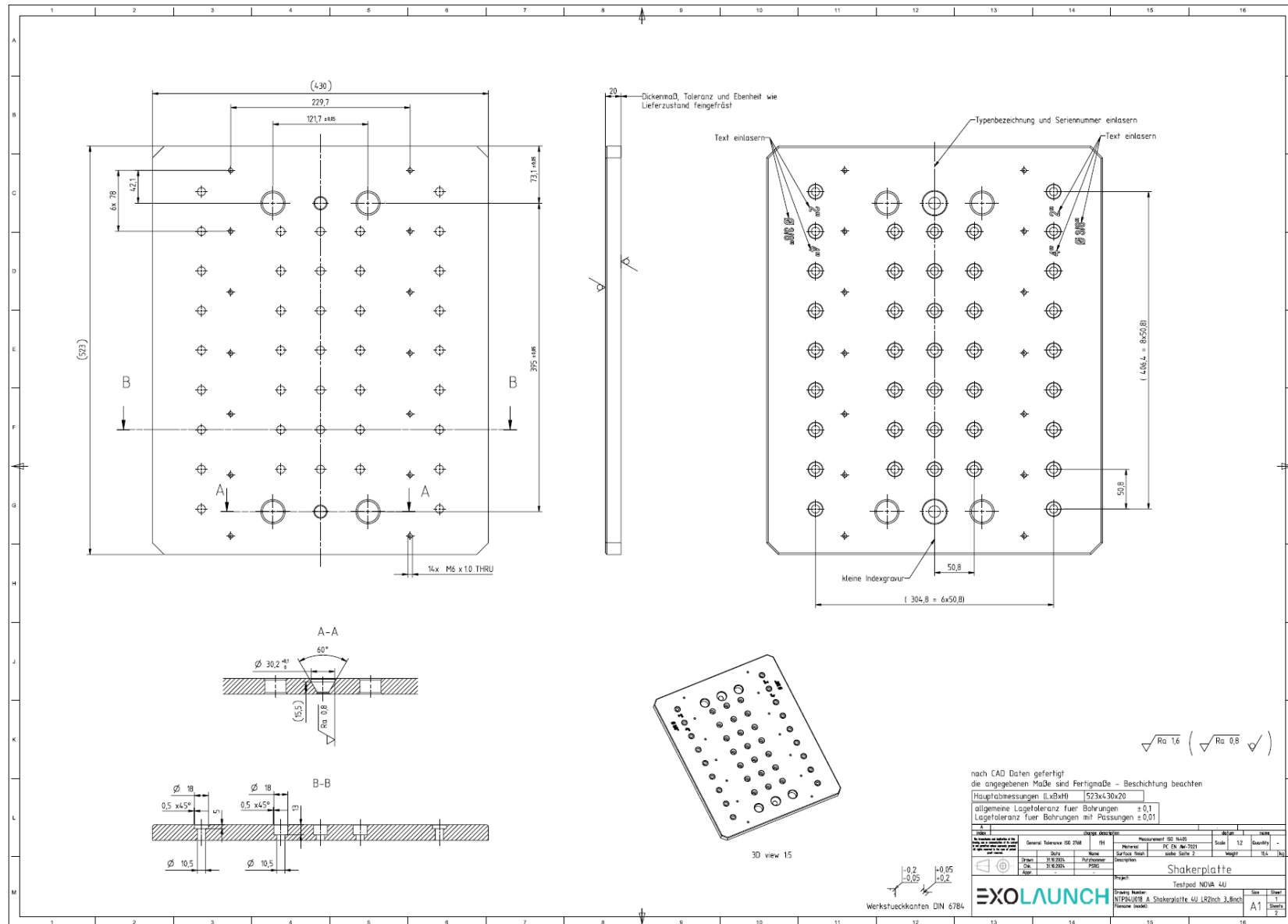
Figure 18:
Outer envelope of the 16U TestPod without the bottom plate.

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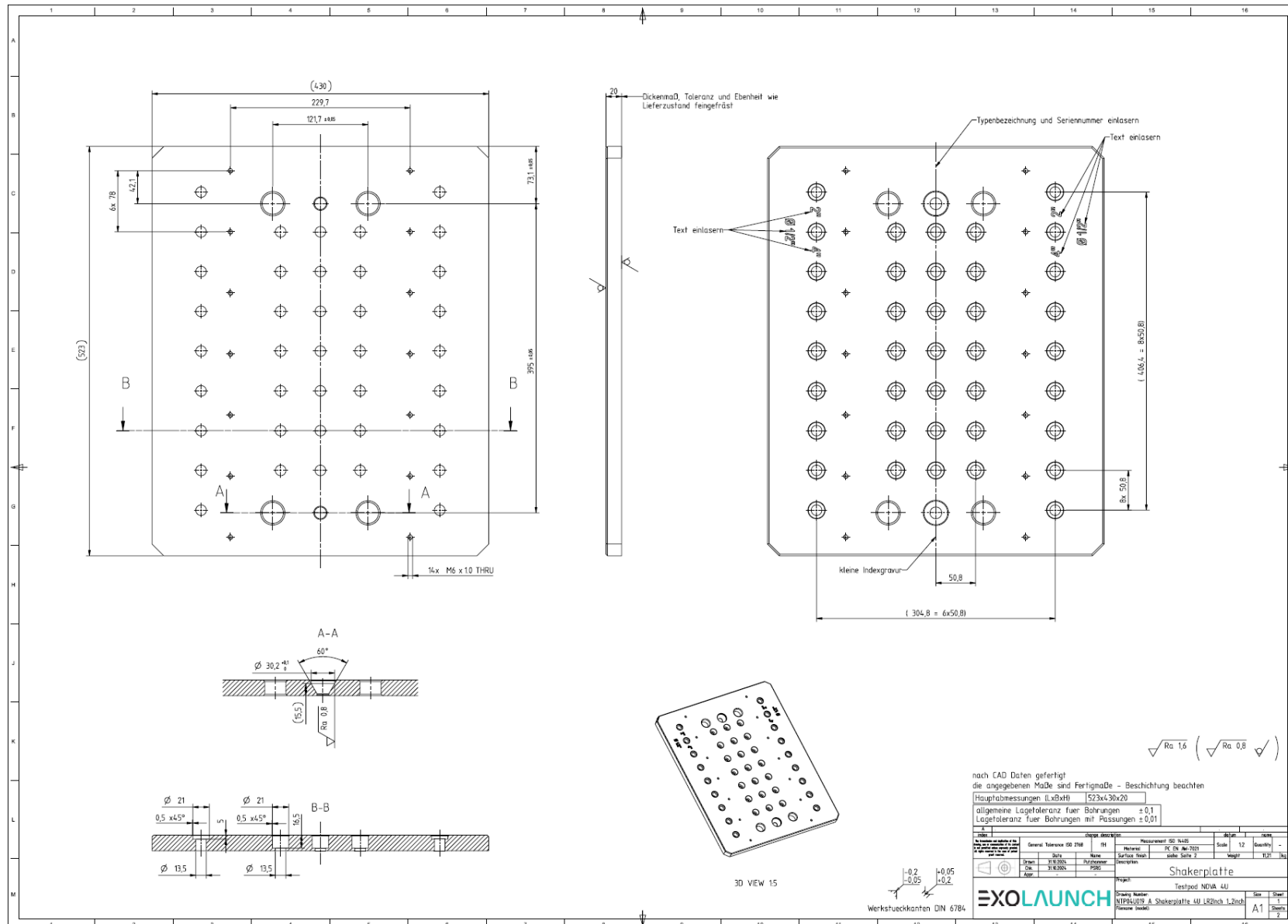
Appendix

TestPod Shaker Interfaces

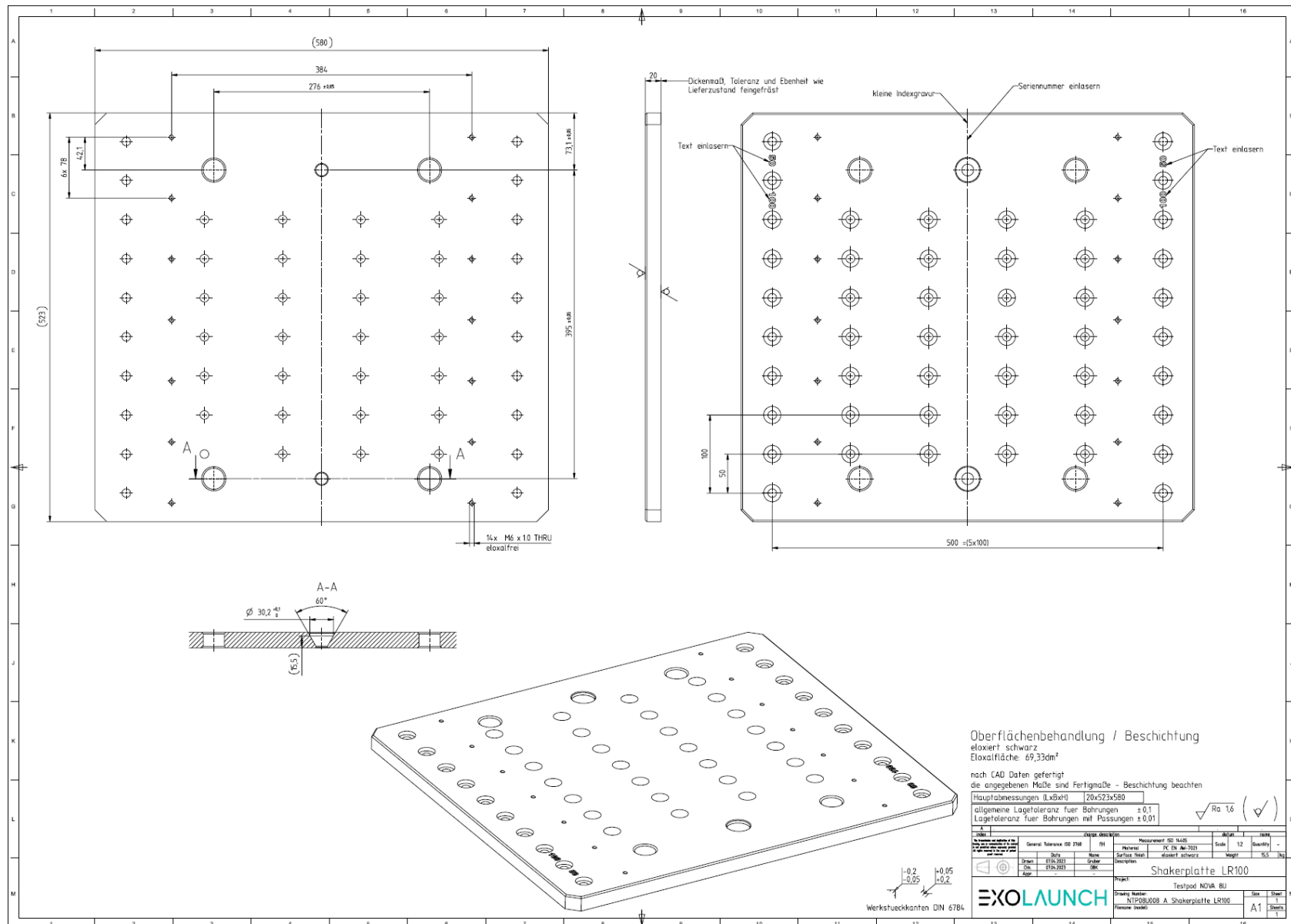
4.3 4U TestPod - 2 Inch Grid Interface Plate (3/8 Inch Fasteners)



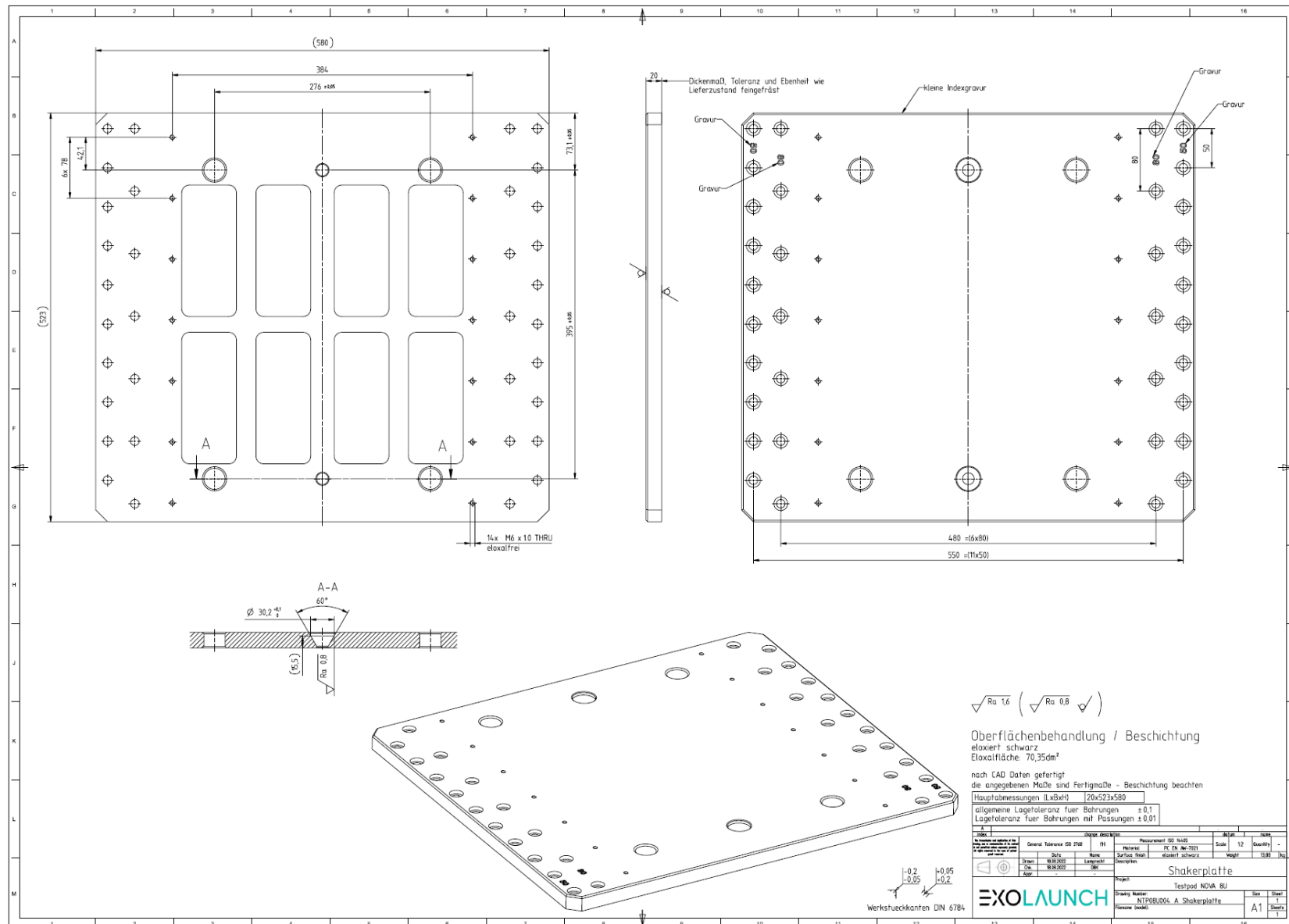
4.4 4U TestPod - 2 Inch Grid Interface Plate (1/2 Inch Fasteners)



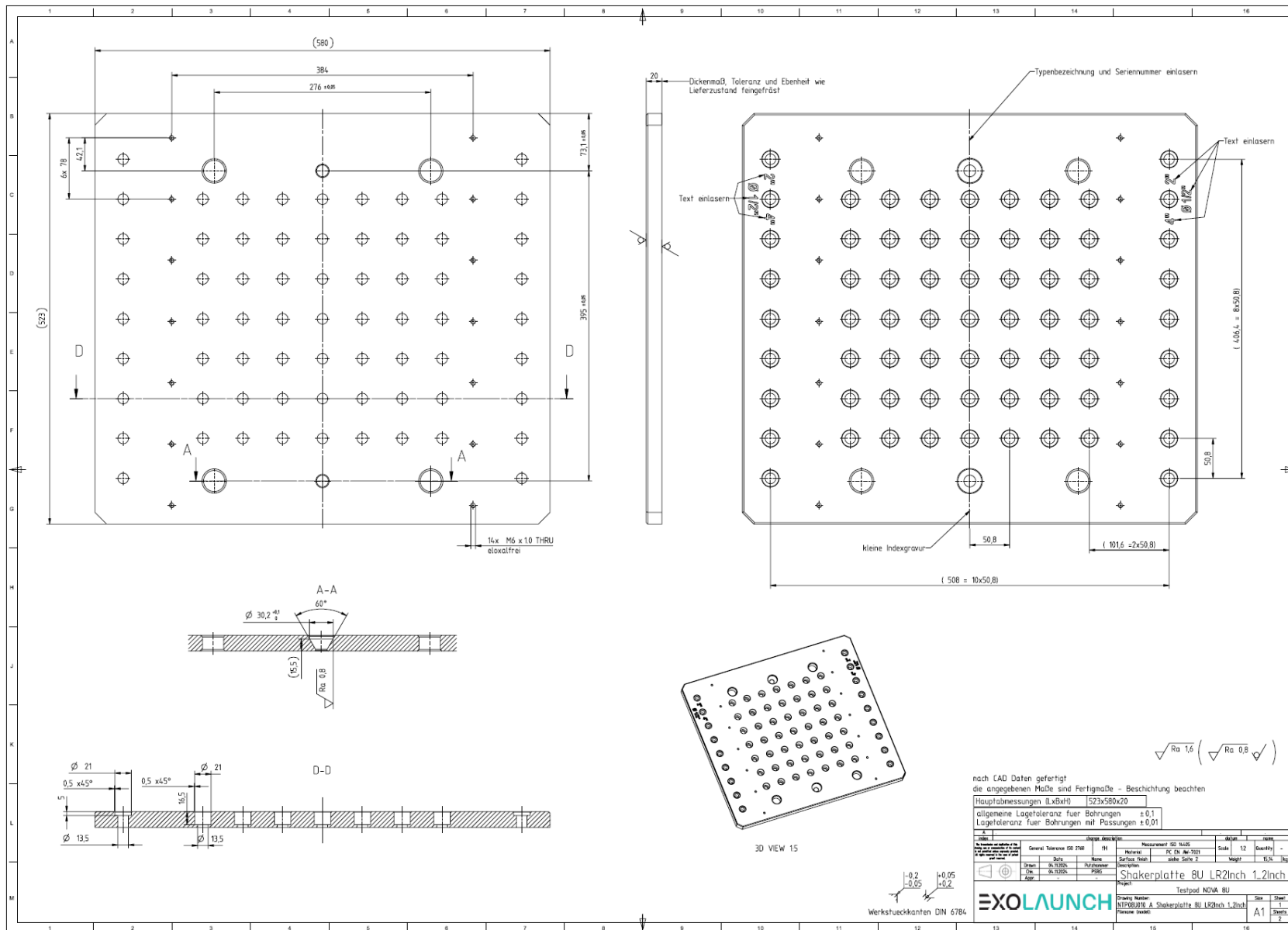
4.5 8U/16U TestPod – 100 mm Grid Interface Plate



4.6 8U/16U TestPod – 80 mm Grid Interface Plate



4.8 8U/16U TestPod – 2 Inch Grid Interface Plate (1/2 Inch Fasteners)



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