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EXOpod NOVA User Manual

Advanced Cubesat deployment system

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Authors

Name	Contact	Initials
Michael Tolstoj	michael@exolaunch.com	MT
Till Siebert	till@exolaunch.com	TS

Change Log

Version	Author	Date	Changes
0.1	MT	18.10.2021	Pre-release version.
0.2	MT	07.02.2022	Pre-release version. Updated pinout table description, thermal qualification description
1.0	MT	06.09.2022	- Layout updated. - Extended description in chapter 1. - Updated Cubesat volume requirements in section 2.3. - Updated allowable tolerance of Cubesat Z-axis length in Table 1. - Moved mass properties to Appendix A and B. - 12U S1 and S2 and 16U configurations added. - Added deployment energy values and deployment time calculation in section 2.4. - Updated mounting torque of main interface in section 4.1. - Updated description of lifting interface in section 4.1.4. - Added Telemetry Toggler RBF description in section 5.2. - Updated thermal interface description in chapter 6. - Added information on transportation and satellite integration in chapter 7.
1.1	TS, MT	06.03.2024	- Added 8U NOVA deployer in section 2.2 - Added 4U/8U NOVA Cubesat information in section 2.3 - Added new slot adapters in section 3.4 with mass properties in appendix 7.4D - Rework of the FEM modeling section in section 3.5 - Added different mounting configurations in section 4.1 - Updated Nova 16U Bottom Plate Mounting interface in section 4.1.2 - Added different lifting configurations in section 4.1.3 - Added access window location for 16U Nova in section 4.2.5 - Added information about the Nova product ecosystem in section 7
1.2	MT	17.06.2024	- Added more detailed breakout of allowable Cubesat masses in Table 1 - Updated information on cubesat slot adapters in section 3.4 - Added information on vibration and shock loads experienced in Nova in section 3.5 - Updated lifting interface information in section 4.1.3 - Updated no-fire current and fixed typo (swapped Actuator 1 and 2) in Figure 36 in section 5.1

Applicable Documentation

#	Changes
AD-1	Cubesat Design Specification Rev. 14
AD-2	6U Cubesat Design Specification Rev. 1
AD-3	EXO_NOVA_TestPod_Manual_October_2023

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Introduction

1.1 What is the EXOpod Nova?

Cubesats have been extremely successful in facilitating access to space. Since California Polytechnic State University (Cal Poly) and Stanford University introduced the Cubesat Design Specification in 1999, more than 1,500 Cubesats have been launched into Low Earth Orbit. Their small size and low mass, combined with standardized separation systems that are universally compatible with any launch vehicle, have allowed Cubesats to become an increasingly valuable asset to the New Space industry. Their design provides affordable access to space, while enabling the development and use of fascinating new technologies which would not be otherwise feasible.

Since 2017, Exolaunch has supported the conquest of space by Cubesats by successfully launching and deploying 270+ **Cubesats** between 0.25U and 16U using its market leading EXOpod Cubesat deployer family. However, Cubesat technology has come a long way since its initial inception, and the growing demands of the market are pushing the design of traditional deployer systems to their limits. Satellite developers are continuously pushing the boundaries of the Cubesat Design Specification by increasing mass, volume, and overall complexity in order to achieve performance improvements. At the same time, constellations comprising of hundreds of Cubesats are demonstrating new technologies and enabling new applications – consequently, the number of Cubesats launched each year is steadily growing.

Exolaunch has developed its **EXOpod Nova Advanced Cubesat Deployer** within this context. Nova is a state-of-the-art separation system, built on years of experience working with leading Cubesat developers and launch providers, and is set to redefine the term "Cubesat". Nova offers up to **four times more space** for lateral protrusions, while also increasing the possible mass capacity by up to **33%** compared to other deployers on the market. Building on the significant flight heritage and inheriting the best features of EXOpod, Nova adds new capabilities, boosts performance, and further increases reliability.

Figure 1: Two EXOpod Nova deployers during launch vehicle integration on a SpaceX Falcon 9.

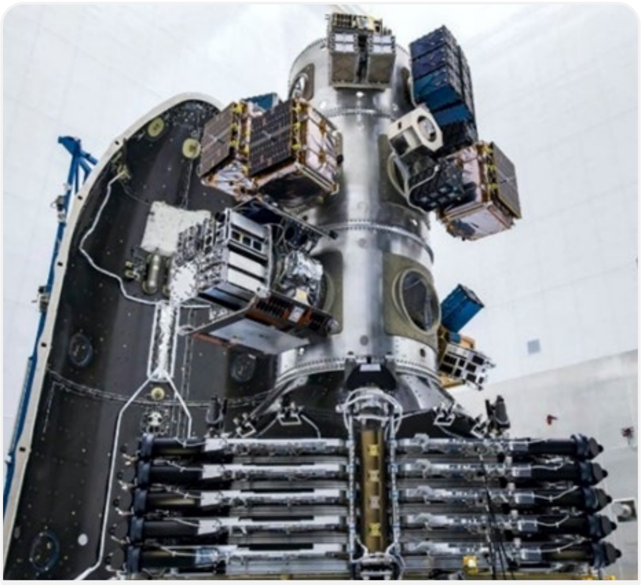


Figure 2: EXOpods as part of the SpaceX Transporter-1 dedicated rideshare mission.

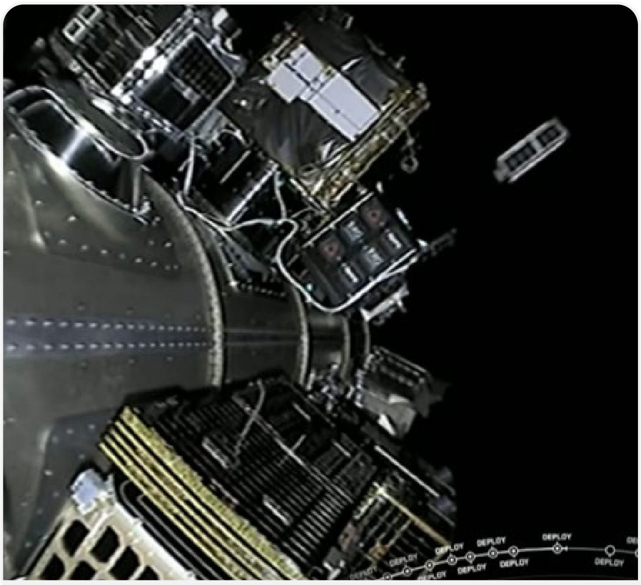


Figure 3: EXOpod Nova deploying a Cubesat on the SpaceX Transporter-5 mission in May 2022.

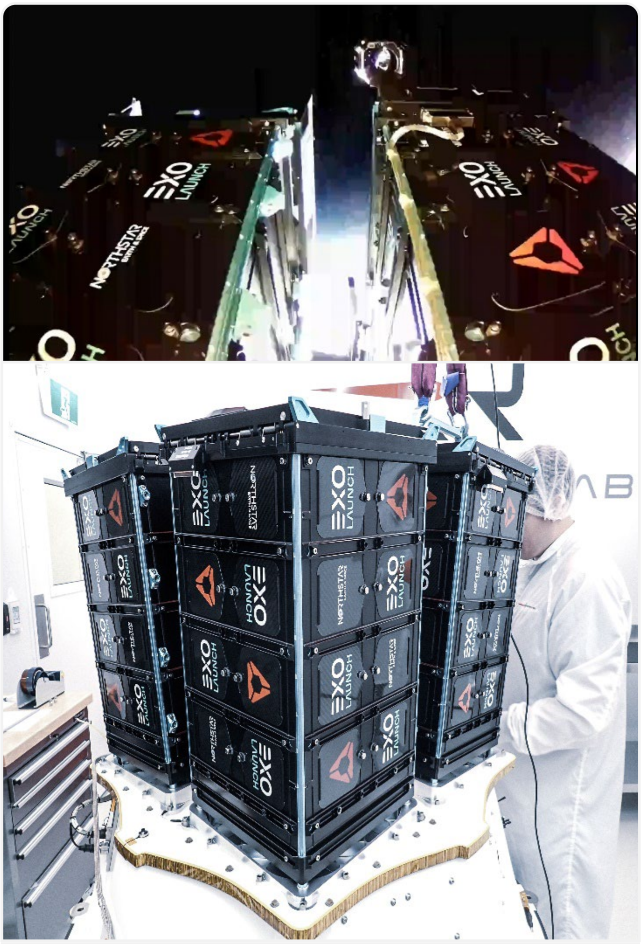


Figure 5: Four EXOpod Nova flying on Rocket Lab's "Four Of A Kind" mission in January 2024.

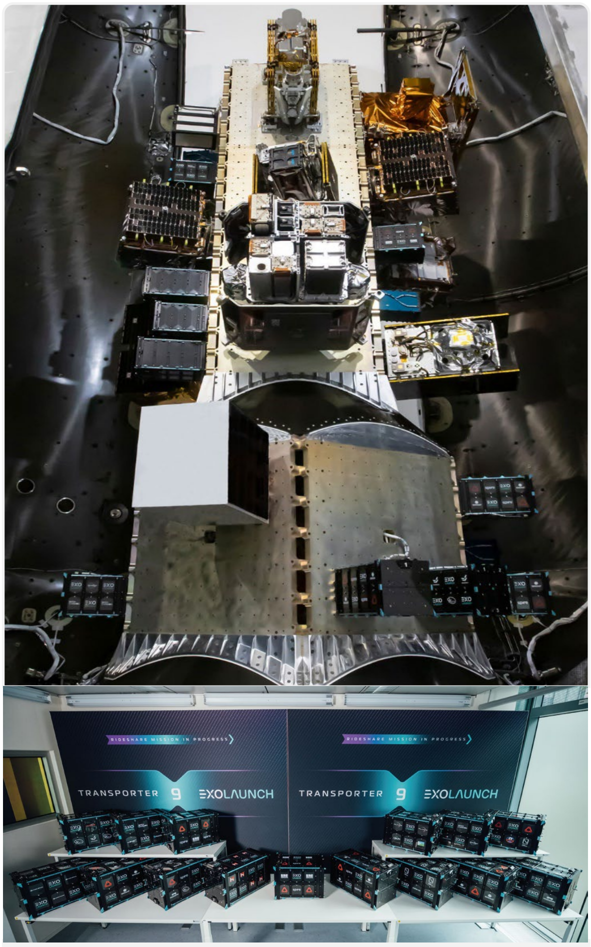


Figure 4: Fifteen Novas launched on SpaceX's Transporter-9 mission in November 2023.

1.2 Purpose and Applicability

This User Manual defines the interface requirements between EXOpod Nova and Cubesats for developers using Exolaunch launch services and products, as well as for launch providers. EXOpod Nova is designed as a standardized deployment system to launch and deploy any satellite that complies with the **Cubesat Design Specification Rev. 14**. Note that if there is any conflicting information between the CDS and the Nova User Manual, the Nova User Manual takes priority.

EXOpod Nova also allows for the deployment of Cubesats that exceed the limits of the Cubesat Design Specification in several key domains, which this User Manual in turn defines. The document also specifies the minimum requirements for compatibility with EXOpod Nova and the Launch Vehicle flight safety program when using Exolaunch services. This includes a description of all mechanical, thermal, and electrical interfaces, as well as their performance specifications.

This document is valid until it is rescinded by Exolaunch or is superseded by a subsequent document version.

1.3 Quality Assurance

Quality assurance for the EXOpod Nova separation system is ensured at every step of the production chain. The entire production line fulfils or exceeds the highest quality assurance requirements. The facilities that manufacture Exolaunch products are certified to ISO 9001:2015 standard, which requires regular inspection of the manufacturing and assembly facilities and ensures a consistently high quality of the final product. These exceptional quality standards are also applied to the extensive qualification and acceptance testing processes.

1.4 Qualification and Flight Heritage

EXOpod Nova has flight heritage from the SpaceX Transporter Rideshare Program as well as from Rocket Lab's Electron and ISRO's PSLV and is manifested for launch on various other launch vehicles. Nova has been qualified to the launch environments, including vibration, shock and thermal vacuum, of all of Exolaunch's launch partners, including Falcon 9 and Falcon Heavy, PSLV, Ariane 6, Vega-C, Electron, Spectrum and others. Regular delta qualifications ensure that the system is compatible with new emerging launch vehicles on the market, as well as with evolving customer requirements.

In addition, the deployer has inherited most of its features and mechanisms from the EXOpod deployer family which has established flight heritage since 2017. To date, the EXOpod and EXOpod Nova family of deployers has launched on 19 missions and has successfully deployed over 270 Cubesats between 0.25U to 16U into orbit without failure.

In 2023, EXOpod was flight qualified for higher radiation environments as it successfully delivered a commercial 16U satellite to GEO. The flight trajectory featured a coast through the Van Allen belts.

Figure 6:
EXOpod Nova during environmental qualification testing.

2

EXOpod NOVA Advanced Cubesat Deployer

2.1 Components and Features

The main components of the EXOpod Nova are shown in Figure 7. Each component is described in detail later in the document.

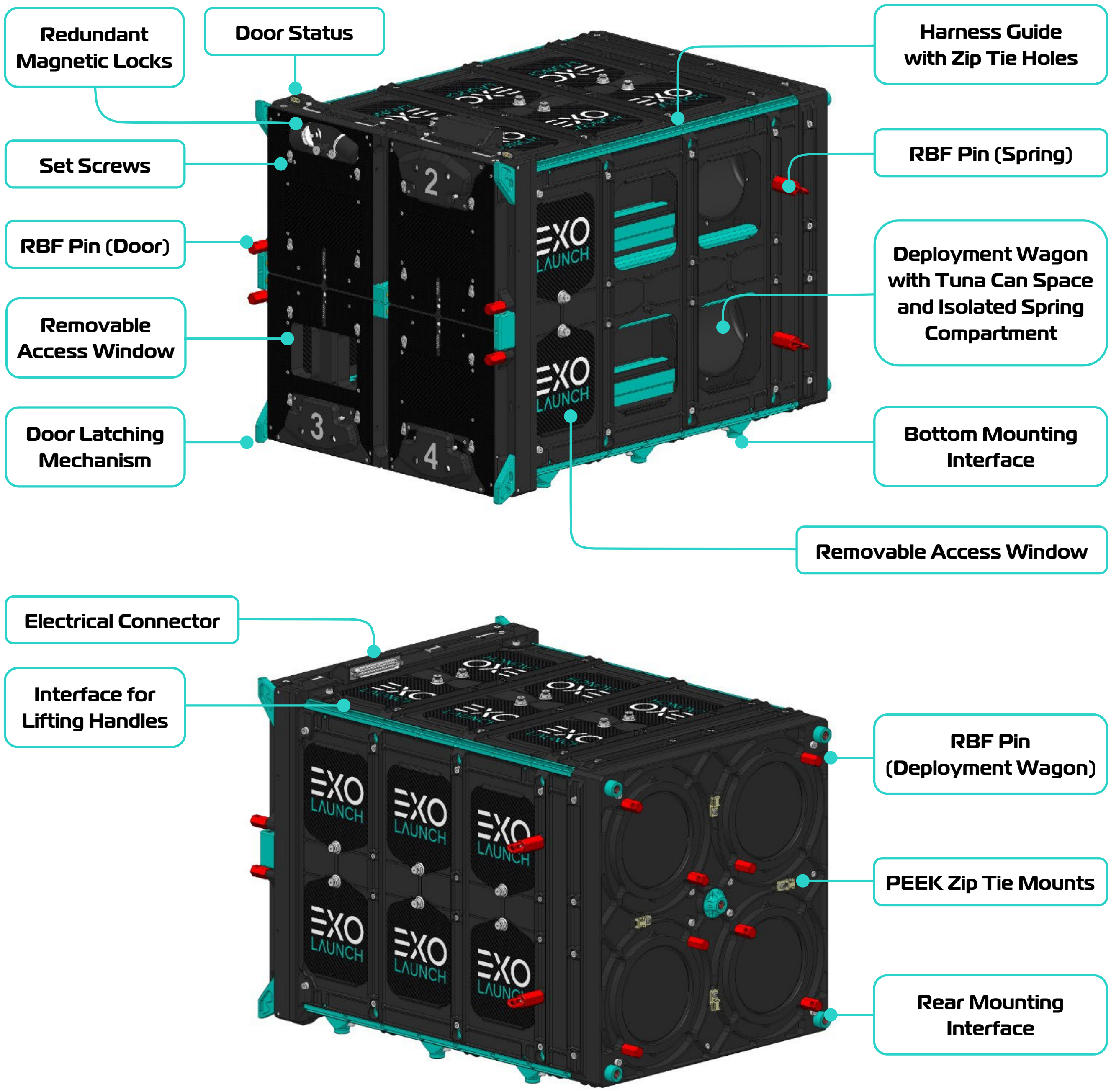


Figure 7: Main components of EXOpod Nova.

2.2 EXOpod NOVA Configurations

The various configurations for EXOpod Nova are each identified with a corresponding "S-code", S1 – S4, which specifies the number of slots available. All EXOpod Nova configurations are shown in Figure 8 to Figure 12, along with the associated S-code of each deployer configuration.

In deployer configurations with multiple slots, each slot is entirely independent and is fully isolated from each other. Each slot also can be modified to accommodate Cubesats that are of a smaller form factor than the size of the slot by using non-deployable adapters. For example, a 3U slot can be downsized to host 1U or 2U Cubesats, see section 3.4.

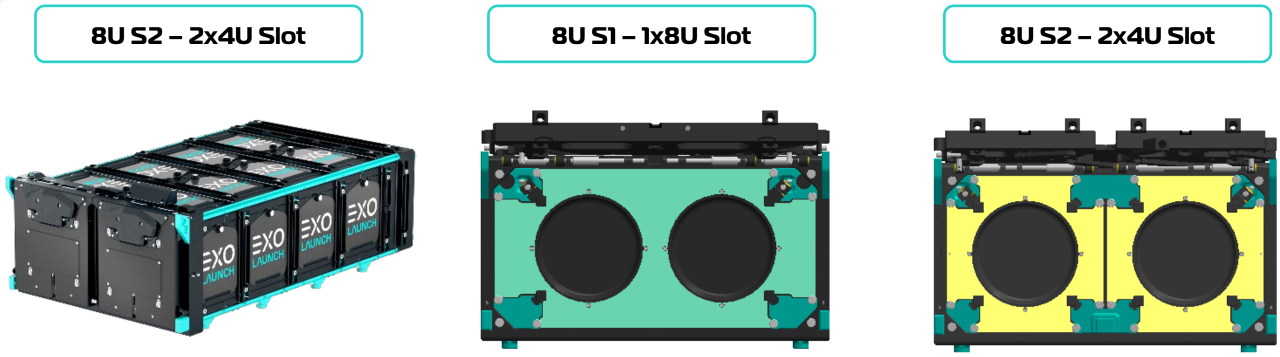


Figure 8: Representation (Left) and 1x8U Slot and 2x4U Slot internal configuration (Right) of the 8U EXOpod Nova.

Figure 9: Representations (Left) and internal configuration (Right) of the 12U/16U EXOpod Nova S1.

Figure 10: Representations (Left) and internal configuration (Right) of the 12U/16U EXOpod Nova S2.

Figure 11: Representations (Left) and internal configuration (Right) of the 12U/16U EXOpod Nova S3.

Figure 12: Representations (Left) and internal configuration (Right) of the 12U/16U EXOpod Nova S4.

2.3 Cubesat Allowable Volume

The general requirements of Cubesats are provided in the Cubesat Design Specification (CDS) Standard Rev. 14. In the past, Cubesat deployers have been developed to follow the CDS. However, EXOpod Nova has been designed to allow Cubesats to exceed certain limitations of the Cubesat Design Specification in terms of allowable mass and volume. Importantly, EXOpod Nova is also backwards-compatible, and therefore is still able to accommodate any fully CDS-compliant Cubesat even if it does not take advantage of Nova's enhanced performance envelope.

Notably, in the CubeSat Design Specification Rev 14, the specified Cubesat rail length (Z) for both 6U and 12U configurations is indicated as 366mm, a new definition compared to previous releases. Exolaunch introduces additional distinctions between 6U/12Us and 6UXL/12UXLs. Specifically, Exolaunch designates the Cubesat rail length (Z) for **a standard 3U/6U/12U as 340.5mm**, while a 3UXL/6UXL/12UXL is defined as having a length of 365.9mm. Comprehensive details on allowable CubeSat dimensions are provided in Table 1.

The maximum dimensions for 1U to 16U Cubesats that may be used with EXOpod Nova are provided in Table 1, and are further illustrated in Figure 13 and Figure 14. Here, the mint green areas mark the rails – the primary interfaces with EXOpod Nova. The **GREY** and BLUE (the so-called "Tuna Can") volumes may be used by the customer. The rails comply with the CDS and have a tolerance of ±0.1 mm, which must be adhered to if the Cubesat is to fit within the deployer. There is no defined tolerance for all other dimensions. Protruding features may be of any size within the usable volume envelope, but no part may extend beyond it. Custom Cubesat form factor may also be accommodated. Please contact Exolaunch.

The CDS states that Aluminum 7075, 6061, 5005, and/or 5052 may be used for both the main Cubesat structure and the rails.

Caution: The rails must additionally be **hard anodized (Type III hard anodization).** Any deviation from the CDS, such as, but not limited to, the use of a different material or surface finishes (e.g. other forms of anodizing or a chromate conversion dual finish) **must be approved by Exolaunch in written form. Additional compatibility testing may be required.** Furthermore, any holes or edges on the Cubesat rail must be adequately chamfered. The rails must have a surface roughness of Ra ≤ 1.6. **These requirements also apply to satellite engineering models using EXOpod Nova or Nova TestPods!**

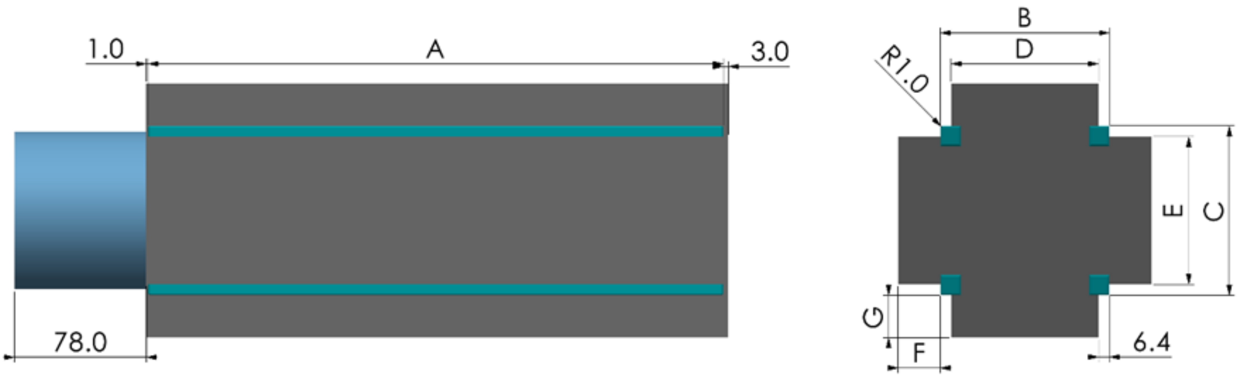


Figure 13: Maximum allowable dimensions for Cubesats launched in an EXOpod Nova. Contact areas with the deployer are marked in mint green.

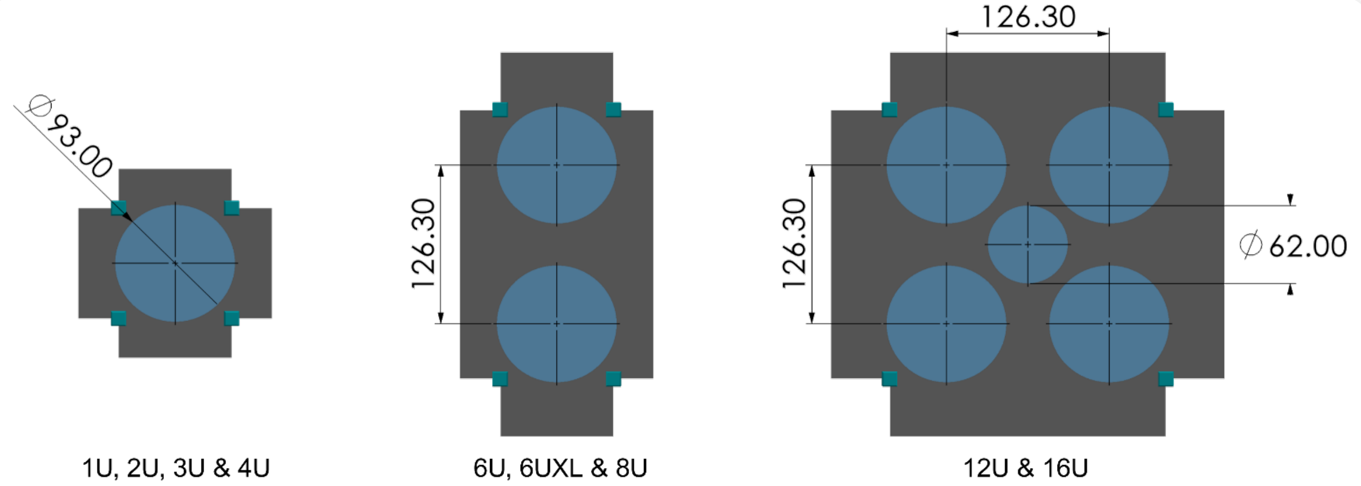


Figure 14: Maximum allowable tuna can dimensions for Cubesats launched in an EXOpod Nova.

Table 1: Maximum Cubesat dimensions

Description		Units	Letter	1U, 2U, 3U, 4U	6U, 6UXL, 8U	12U, 12UXL	16U
Cubesat Rail Length (Z)	[±0.5 mm]	mm	A	1U: 113.5 2U: 227.0 3U: 340.5 3U XL: 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		
Number of Tuna Cans		-	-	1	2	4*	4*
Distance Between Tuna Cans		mm	-	-	126.3		
Maximum Mass***		kg	-	1U: 2.5 2U: 4.5 3U: 7.0 4U: 9.0	6U: 14.0 6UXL: 16.0 8U: 18.0	12U: 26.0	36
Maximum Distance Between COG and Geometric Center		mm	-	See Table 2			

***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.**

****The 12U and 16U S1 Nova has an additional, fifth tuna located in the center between the four larger tuna cans, see Figure 11. The usable height of this tuna can is 67 mm with a 62 mm diameter.**

*****Qualified masses are primarily based on SpaceX Falcon 9 launch environments and differ slightly for other launchers or OTV missions. Please talk to Exolaunch.**

The maximum recommended distance between the COG and the geometrical center is outlined in Table 2. All values are based on the CDS [AD-1] and [AD-2] and should be seen as a guideline rather than a firm limitation. For unique Cubesat designs, the deviations can be higher, however, this can lead to increased local loads on the satellite during testing and launch and can also cause higher tip-off rates. For questions on custom designs and form factors, please contact Exolaunch.

Table 2: Maximum recommended distance of the COG from the geometrical center

Description	X-axis (mm)	Y-axis (mm)	Z-axis (mm)
1U	± 20	± 20	± 20
2U	± 20	± 20	± 45
3U	± 20	± 20	± 70
4U	± 20	± 20	± 90
6U, 6UXL	± 45	± 20	± 70
8U	± 45	± 20	± 90
12U	± 45	± 45	± 70
16U	± 45	± 45	± 90

2.3.1 Cubesat-to-Nova Fitcheck

To guarantee the compatibility of the Cubesat and Nova deployer, Exolaunch requires performing:

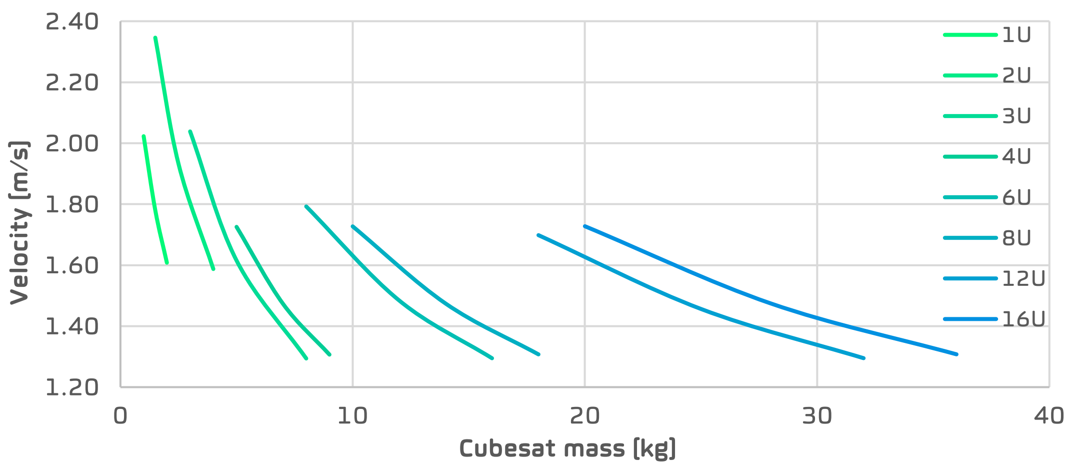
- A virtual fitcheck using a simplified CAD model of Nova and the satellite
- The measurement of the rail dimensions on the assembled satellite
- Preferably, a physical fitcheck with an Exolaunch Nova or Nova TestPod

Exolaunch will provide a rail measurement guide as well as a simplified 3D model of the applicable Nova configuration on request.

2.4 Deployment Energy

Deployment velocities are calculated based on the physical properties of the mechanical springs. Each 8U Nova has two springs and each 12U/16U Nova has 4 springs. The spring configuration is identical across all configurations. This means that in a 1U-4U slot the deployment wagon is pushed by one out four springs. Two springs are combined to push the deployment wagon in a 6U-8U slot and four springs in a 12U-16U slot respectively. Typical Cubesat velocities are illustrated in Figure 15. Satellite specific deployment velocities are coordinated in the mission specific ICD. For more information reach out to Exolaunch.

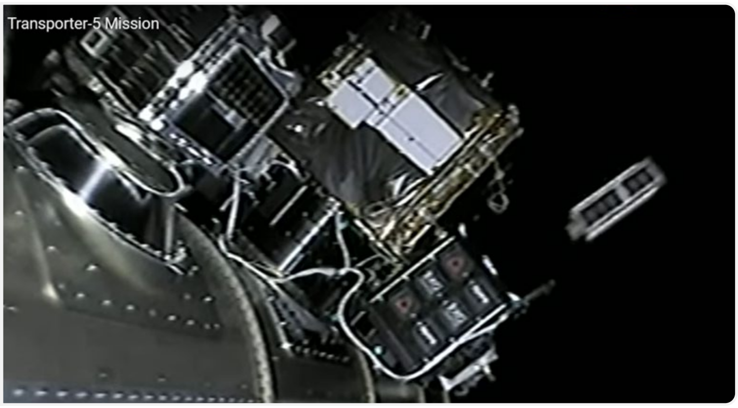
Figure 15: Deployment velocities for different Cubesat sizes and masses



2.5 Tip-Off Rates

Tip-off rates for all Cubesat types are expected to be below 10 deg/s in all axes and are dependent on Cubesat mass properties. 3U long form factor types tend to be more stable. The separation half cone angle is ±7.5 deg.

Figure 16: Successfully deployed Cubesat on SpaceX Transporter-5 mission



3

Mechanical Properties

3.1 Coordinate System

The coordinate system of EXOpod Nova is shown below. The coordinate system origin is in the center of the rear plate mounting interface plane.

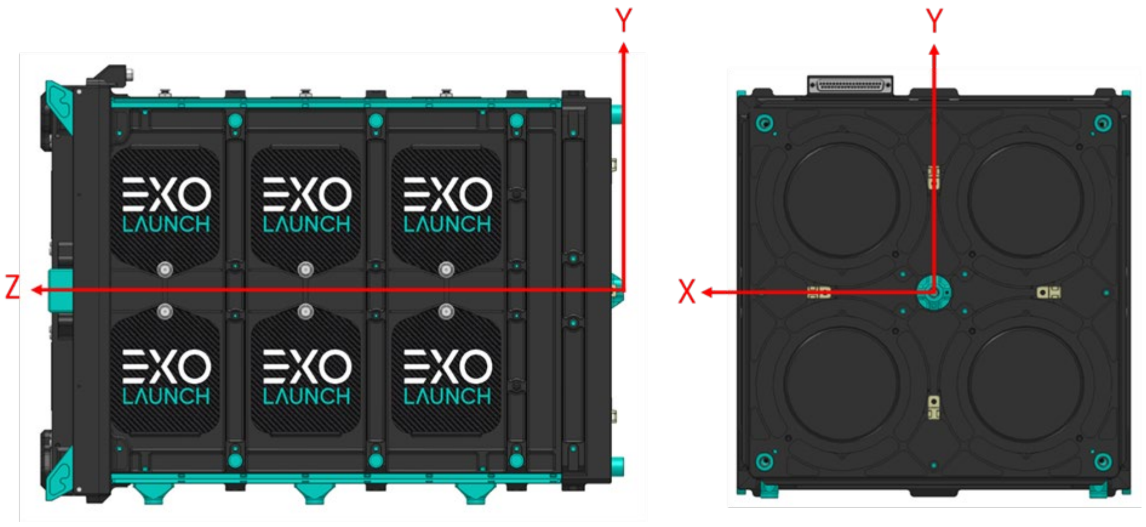


Figure 17: Coordinate System of the EXOpod Nova.

3.2 Mass Properties

Detailed mass properties for different EXOpod Nova configurations can be found within Appendix A for the 8U (Table 10 through Table 11), Appendix B for the 12U (Table 12 through Table 15) and Appendix C (Table 16 through Table 19) for the 16U. Configurations vary based on number of slots, and open/closed state. The masses of each configuration are summarized in Table 4.

- Nova configuration: 8U/12U/16U S1-S4, see Section 2.2
- Open and Closed state: see Table 3
- The masses do not include slot adapters or fasteners.

Table 3: Nova in stowed and deployed configuration.

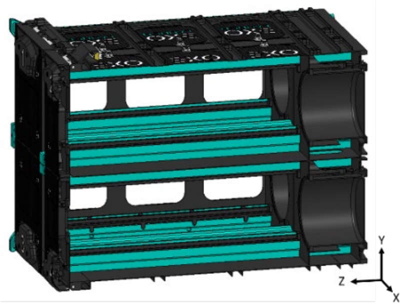
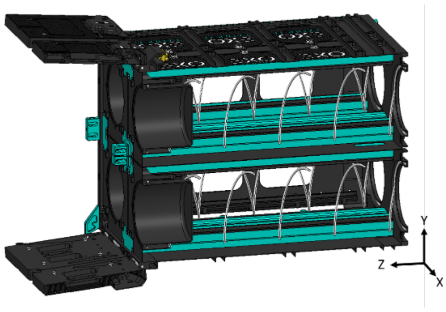
Closed State: Doors locked and spring in the stowed state	**Open State:** Doors open and spring in the relaxed state
	

Table 4: EXOpod Nova masses of different configurations.

Configuration	Mass [kg]	Tolerance
8U S1	7.70	±5%
8U S2	8.83	
12U S1	9.77	
12U S2	11.31	
12U S3	12.32	
12U S4	13.32	
16U S1	10.75	
16U S2	12.85	
16U S3	14.05	
16U S4	15.27	

3.3 Outer Dimensions

The outer dimensions of the 8U, 12U, and 16U EXOpod Nova variants are shown in Figure 18 through Figure 20 respectively.

Figure 18:
8U EXOpod Nova outer dimensions.

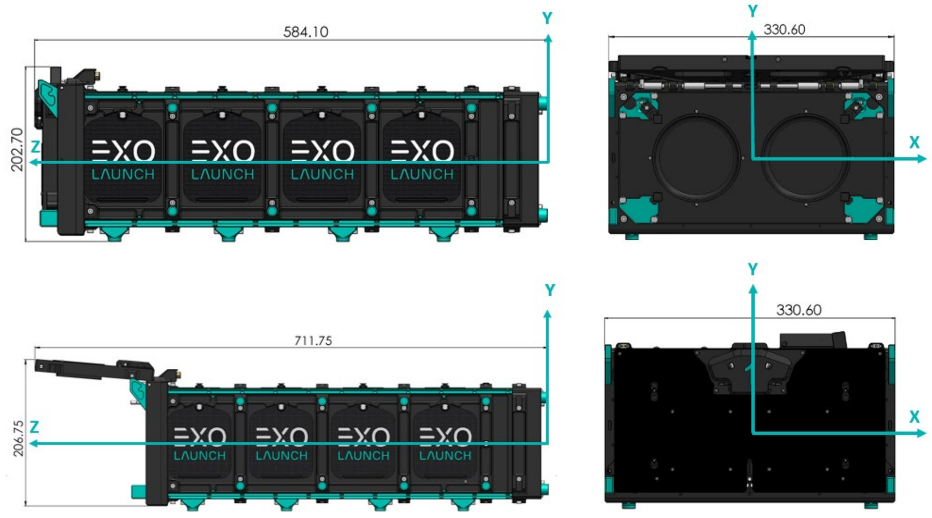


Figure 19:
12U EXOpod Nova outer dimensions.

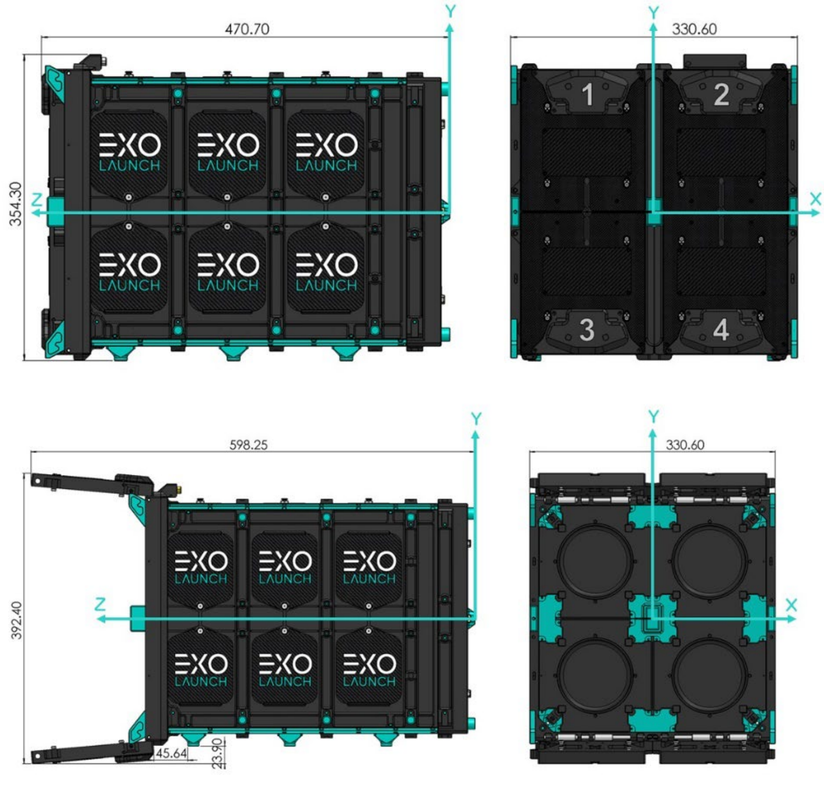
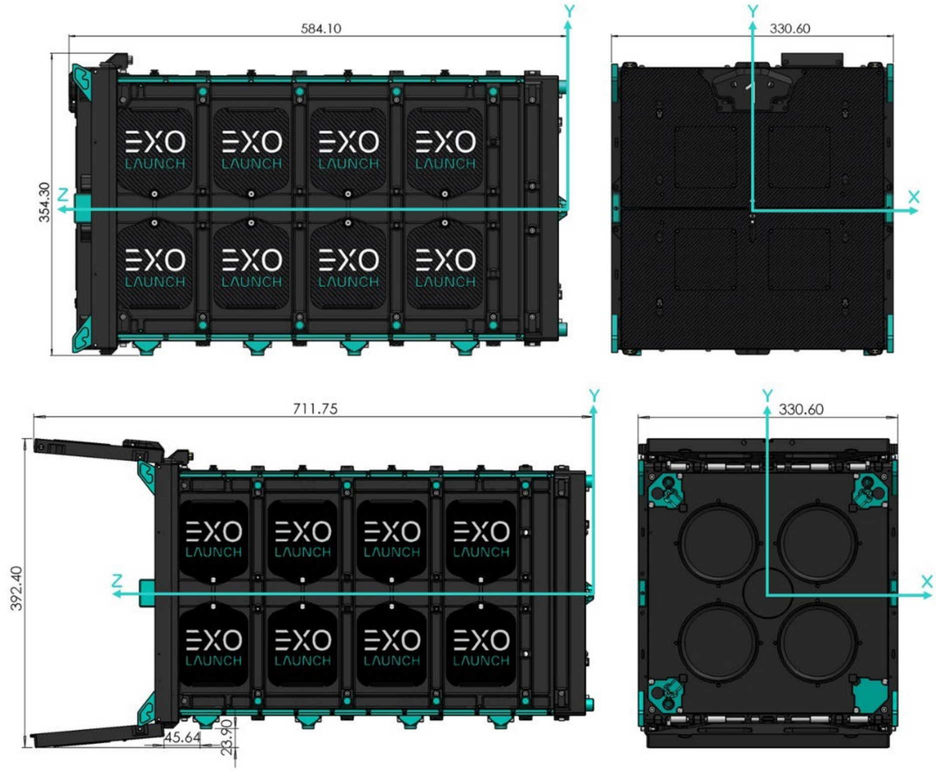


Figure 20:
16U EXOpod Nova outer dimensions.



3.4 Cubesat Adapters

To ensure that EXOpod Nova can accommodate non-standard Cubesat form factors, a variety of adapters have been designed to fit in the slots of the deployer and downsize it to the required form factor. Custom screws at the tip of the guiding rails act as stoppers, preventing the adapters from exiting the EXOpod Nova during deployment. Built-in switches provide a telemetry signal to the launch vehicle indicating the status of the deployment. Figure 21 illustrates some of the adapters offered by Exolaunch. Unique adapter types are available on request. Detailed mass properties of standard Cubesat adapters can be found in Table 20 of Appendix D.

Figure 21: Illustration of some available EXOpod Nova Cubesat adapters.

All adapters are designed with maximum internal volume available for customer use for external features and payloads. In addition to allowing a large variety of Cubesat lengths, this slot adapter design enables the use of custom and over-sized tuna can volumes. As an example, a 6U Cubesat with a large external protrusion can be accommodated in an 8U Nova slot using an 8U-to-6U slot adapter, see Figure 22. Contact Exolaunch for specific CAD file requests.

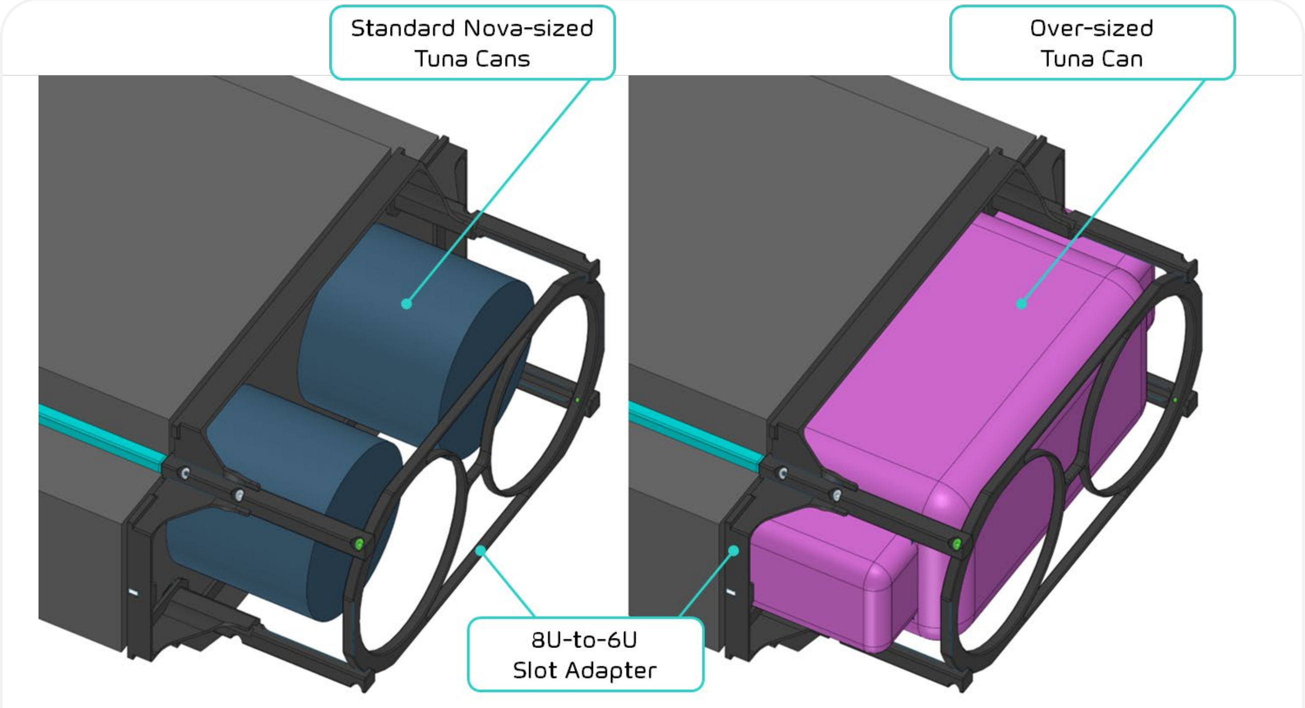


Figure 22: Example of 6U Cubesat with oversized Tuna Can launching in an 8U slot using an 8U-to-6U Slot Adapter.

3.5 Vibration and Shock Loads

Mechanical loads experienced by a Cubesat flying in a Cubesat deployer will always be altered, i.e. amplified, damped or transformed, due dynamic interaction with the deployer's structure compared to loads specified at the launcher interface. This is understood and widely accepted across satellite, deployment system, and launch vehicle manufacturers, meaning that Cubesats are commonly designed and tested directly to loads specified in the launcher User Guide, rather than derived loads. In the same spirit, Cubesats are most often tested using test fixtures (such as the Nova TestPod), which are structurally not representative of the separation system used in flight.

The general effect of the Nova structure on the vibration and shock loads seen by the Cubesat are illustrated in the following Figures. These loads have been measured in tests using monolithic aluminum body test dummies, which are structurally different from an actual Cubesat. See also section 3.6 for additional context.

Vibration loads, see Figure 23, generally see a local amplification at the first natural frequency (FNF) of Nova and are damped quite significantly in the entire frequency range thereafter. The exact location of the Nova's FNF can shift depending on total mass, loads and deployer type, mounting configuration and Cubesat size, but the trend is the same.

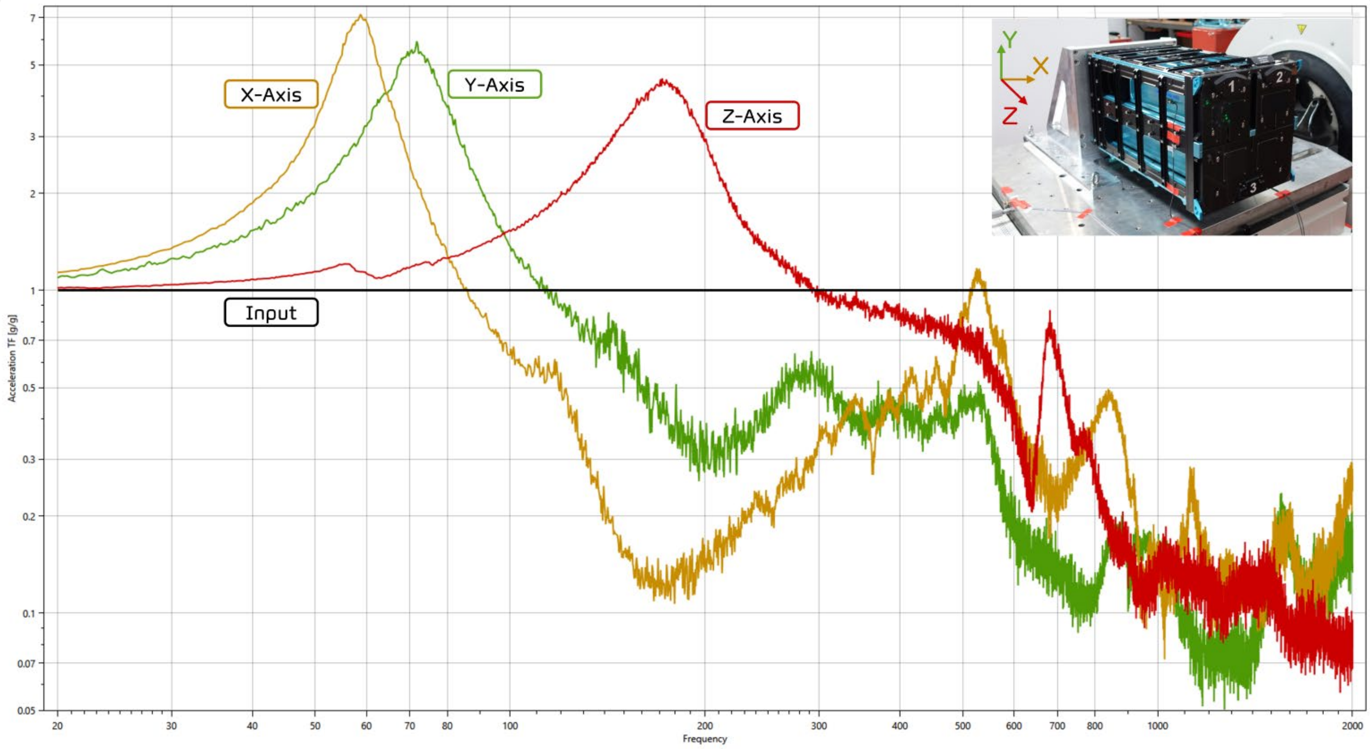


Figure 23: Vibration loads (Random vibe transfer function) as seen by Cubesat flying in EXOpod Nova (Example for particular configuration).

Shock loads, see Figure 24, are damped significantly across a wide portion of the frequency spectrum, particularly in higher frequencies. Exact values depend on input loads, deployer type, mounting configuration and Cubesat size, but trends are consistent.

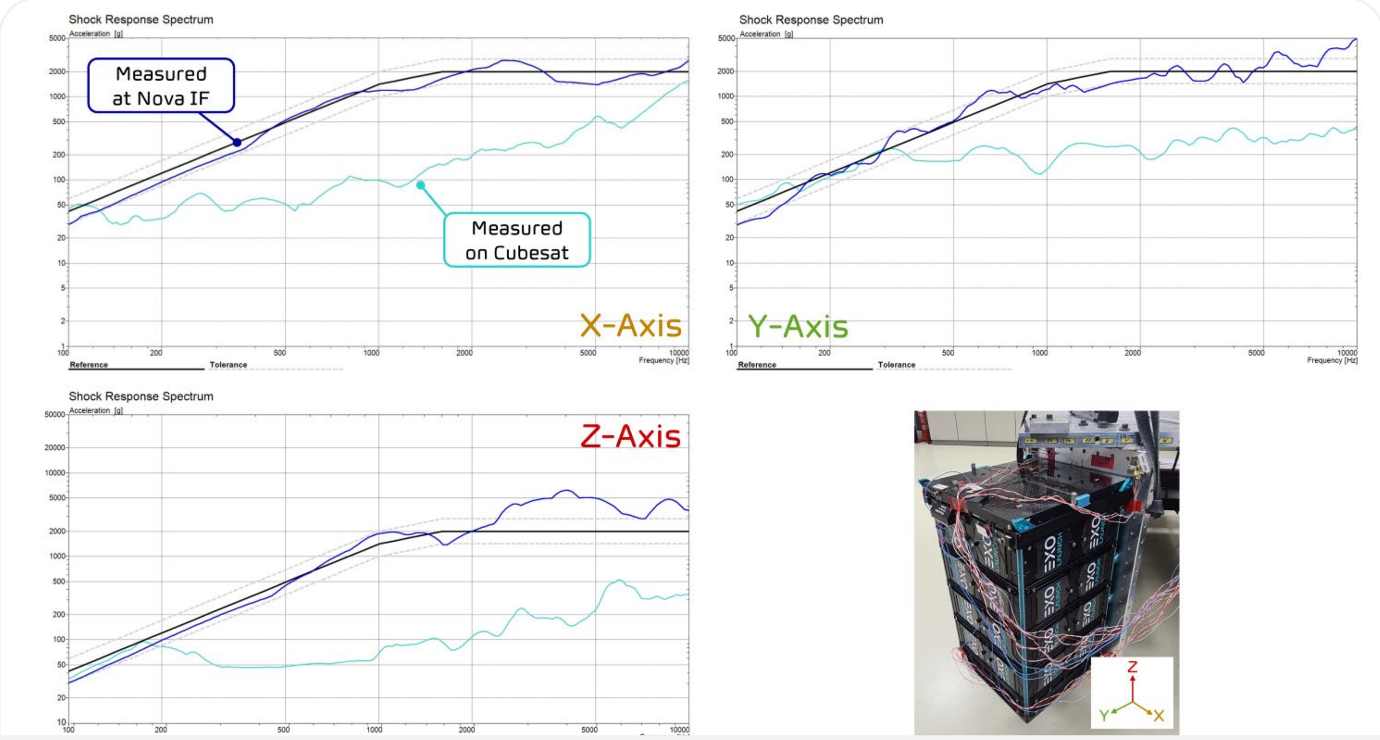


Figure 24: Shock loads (SRS) as experienced by Cubesat flying in EXOpod Nova (Example for particular configuration).

3.6 Loads and Finite Element Modeling

Modelling the dynamic behavior of a Cubesat-Deployer coupled system is challenging and not recommended for most missions. The challenge of the task stems from the fact that manufacturing tolerances – which can't be modelled in FEM - have significant impact on the fit and the dynamic behavior of the coupled system. The damping effect of the clamping mechanism adds to the complexity of the behavior. Even small differences in the size of the Cubesat rails (~0.1mm, within the standard rail tolerances) can have a significant effect on the force applied by the rail clamps. Since the travel on the clamps is so low, even small changes have a large effect; this explains the wide range of forces provided in section 4.2.1. This effect has been verified in test.

Modelling effort can be justified if a particular risk with a sensitive payload or subsystem has been identified. In such cases an FEA can be used as a way to understand how launch environments may affect the satellite, however there is inherent uncertainty which can't be overcome outside of testing. The best approach is to create the model using assumptions about how the satellite is fixed in the deployer, then add margins on top to account for the uncertainty. The only way to get an accurate understanding of the loads is to perform a joint test in the Cubesat deployer, which Exolaunch can offer as a special service in justified cases.

Detailed FE models of the EXOpod Nova for customer use are not available. However, Exolaunch can provide transfer functions for specific Nova configurations. Transfer functions are derived from tests with stiff Aluminum Cubesat dummies.

4

Mechanical Interfaces

4.1 Launch Vehicle Interfaces

EXOpod Nova has mechanical interfaces on the bottom and rear faces for Bottom Plate Mounting (BPM) and Rear Plate Mounting (RPM) respectively, which allows for different mounting orientations on the launch vehicle adapter. These interface properties are summarized in Table 5 and are shown in Figure 23. High-strength stainless steel M8 screws (640 MPa yield strength or higher, e.g. BUMAX 88) in combination with Nord-Lock NL8ss washers are required as fasteners for all EXOpod Nova configurations. For alternative secondary retention methods, please consult with Exolaunch.

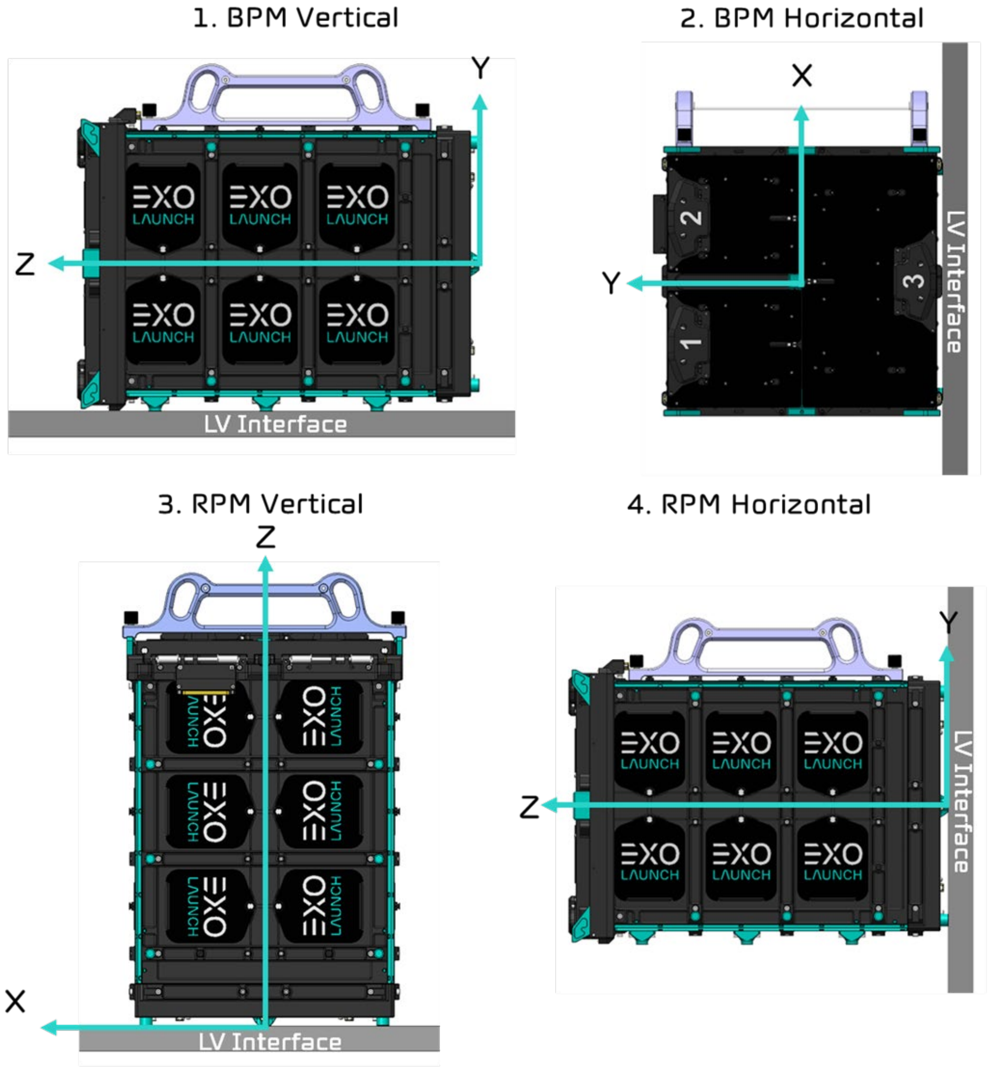


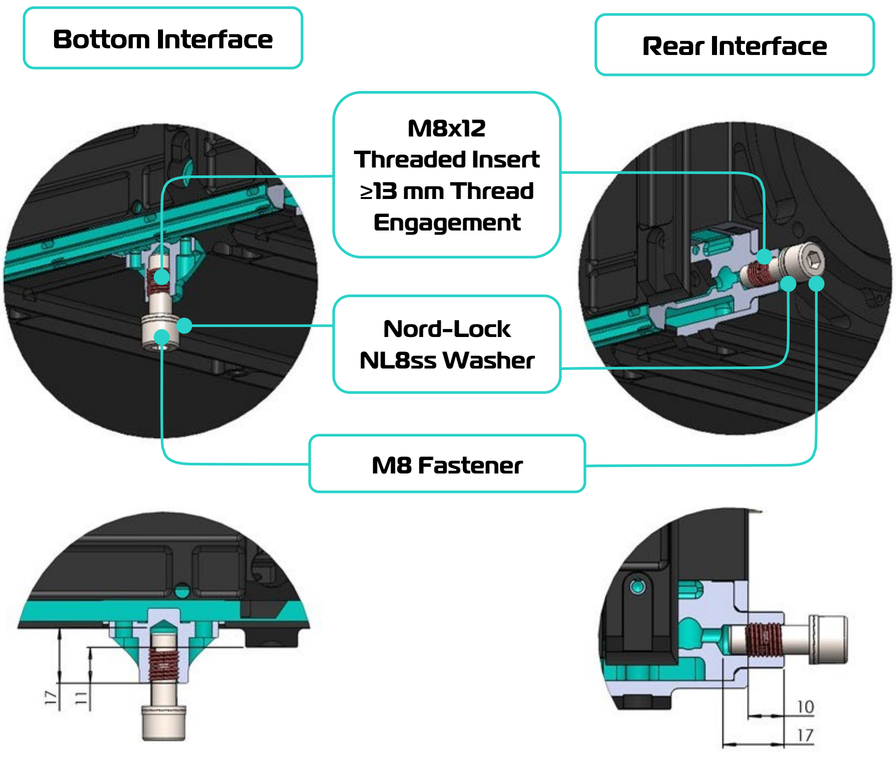
Figure 25: Rear and Bottom Plate Mounting of the EXOpod Nova in horizontal and vertical orientation.

Table 5: Mechanical interface specification.

	Bottom Plate Mounting, BPM			Rear Plate Mounting, RPM	
Deployment	Parallel to mounting plane			Normal to mounting plane	
Attachment points	**8U**: 8	**12U**: 6	**16U**: 8	**8U**: 4	**12U/16U**: 5
Thread	M8x12 Helicoil free- insert				
Required fastener type	M8, BUMAX 88 (800 MPa) or stronger				
Required lock washer	Nord-Lock NL8ss				
Min. screw-in depth for mounting the Nova	13 mm				
Max. screw-in depth for mounting the Nova	16 mm				
Tightening torque – Mounting Nova to launch vehicle interface	22.0 Nm (15kN pre-load)				
Surface finish	Ra 1.6				
Overall Flatness	< 0.1 mm				

The mounting feet of EXOpod Nova feature a free running threaded Helicoil insert for M8 fasteners. The mounting feet on the rear face are directly connected to the internal structure providing increased stiffness. A detailed view is shown in Figure 26.

Figure 26: Detailed view of the mounting feet.



4.1.1 Rear Plate Mounting Interface

The mounting hole pattern of the rear plate mounting (RPM) interface is shown in Figure 25 and Figure 26.

Figure 27:
Mounting hole pattern of the RPM interface on the 8U Nova variants.

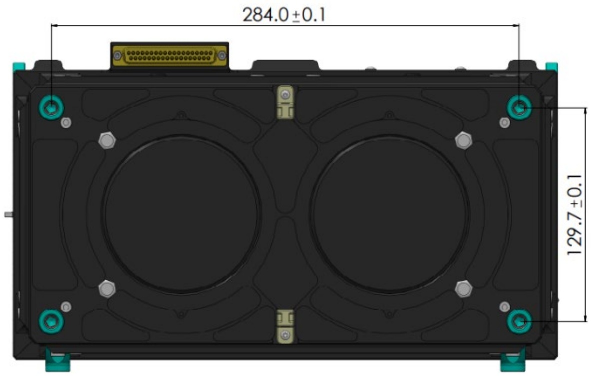
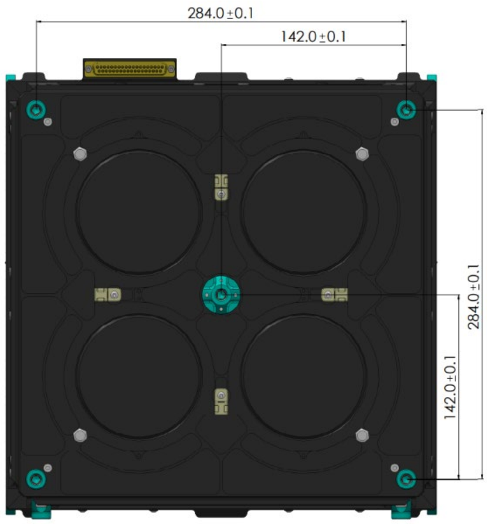


Figure 28:
Mounting hole pattern of the RPM interface on the 12U and 16U Nova variants.



4.1.2 Bottom Plate Mounting Interface

The mounting hole pattern of the bottom plate mounting (BPM) interface is shown in Figure 27 for the 12U Nova and Figure 28 for the 8U and 16U Nova.

Figure 29:
12U Nova mounting hole pattern of the BPM interface.

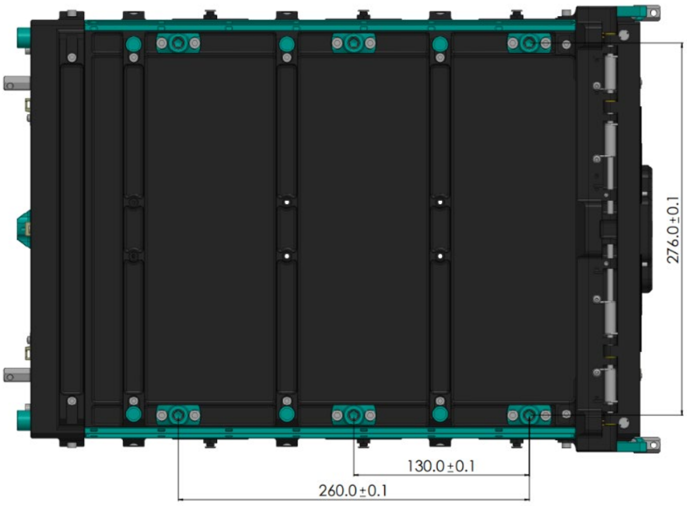
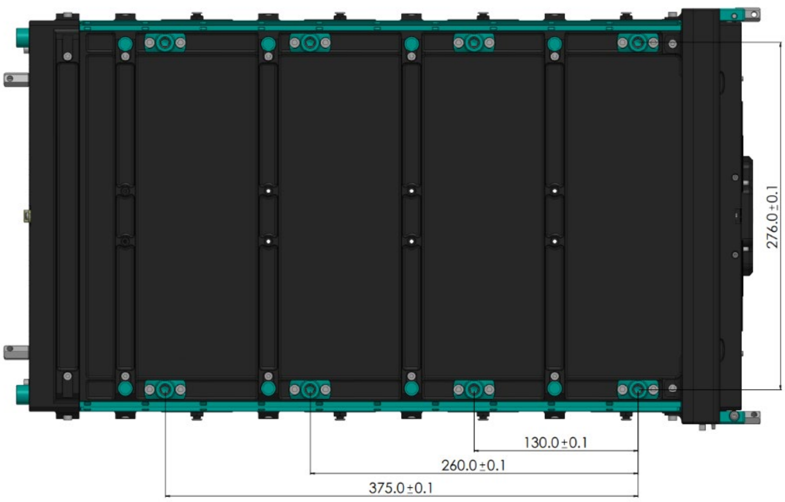


Figure 30:
8U and 16U Nova mounting hole pattern of the BPM interface.



4.1.3 Lifting Interface

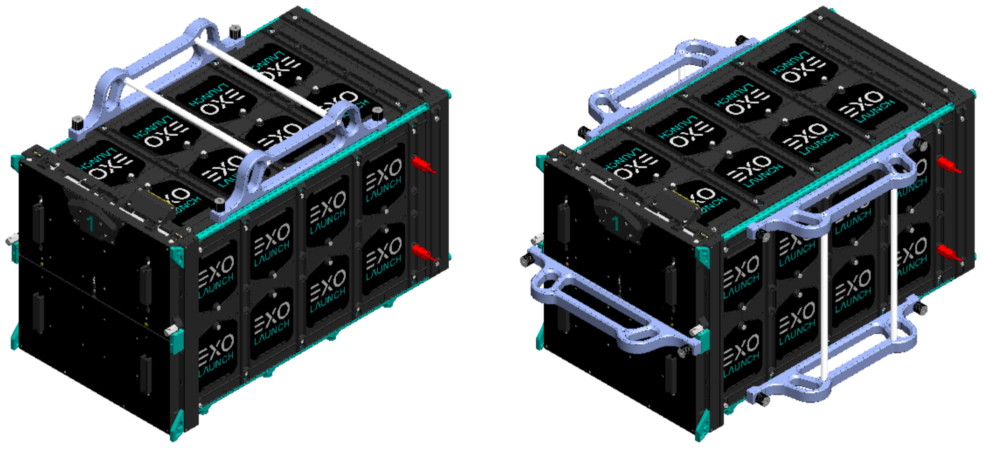
EXOpod Nova provides a dedicated mounting interface for lifting handles on four of the six faces (top, left, right and front), providing maximum flexibility for handling and for different mounting orientations. The lifting handles allow a loaded EXOpod to be lifted by crane or by hand safely and conveniently. Each handle is attached to NOVA using two M4 thumb screws.

While the loaded mass of an EXOpod Nova is limited to 50kg, there is significant safety margin built into the design of the handles, with each handle having a Safe Working Load of 200kg. The use of a crane is strongly advised when moving a loaded deployer. Lifting at an angle is to be avoided. Figure 29 shows EXOpod Nova with lifting handles mounting locations.

Additionally, EXOpod Nova can also be lifted from the bottom interface by installing M8 eye bolts on the mounting interface.

Figure 31: EXOpod Nova with lifting handles installed on the top face (left).

Additional mounting interfaces for the handles are located on the two neighboring +X and -X and +Z faces (right).



4.1.4 Grounding

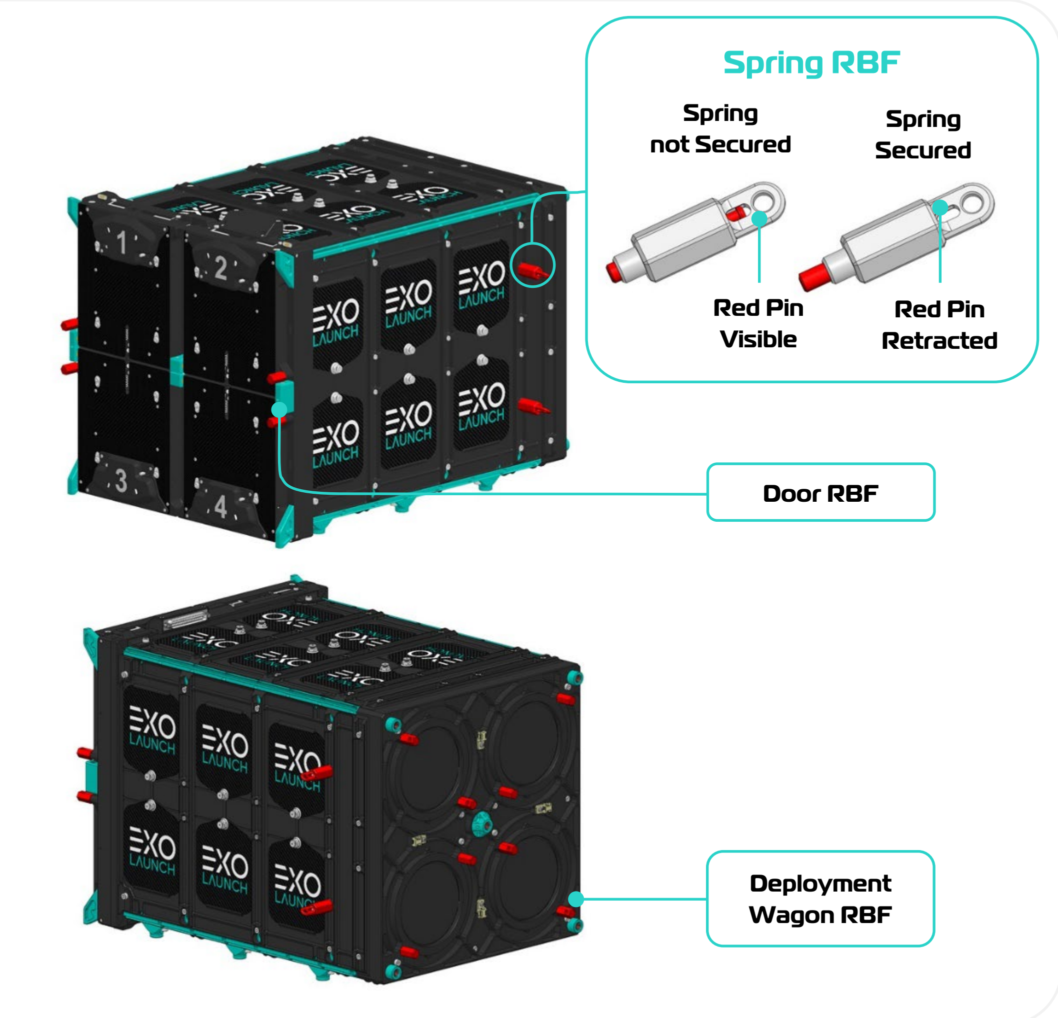
Cubesats are electrically isolated from the deployer when loaded inside. Grounding through the EXOpod Nova is established through a conductive path along the mounting interface screws.

4.1.5 Remove Before Flight Elements

Three sets of Remove Before Flight (RBF) pins provide safety during ground handling, satellite integration, and launch vehicle mating procedures, which are illustrated in Figure 30:

- **Doors:** Each door is secured by a threaded RBF pin. This is the last RBF element to be removed before launch.
- **Spring:** The deployment spring is retained by an innovative spring-loaded RBF pin, which is also used on the CarboNIX microsatellite separation system. The pin is inserted when the deployment wagon is in a deployed state, with the spring-loaded element of the RBF pin snapping into place once the deployment wagon is pushed fully backwards into its stowed position. EXOpod Nova should always be transported in its stowed state.
- **Deployment wagon:** A third set of pins, identical to the ones used on the doors, are used during Cubesat integration to further secure the deployment wagon in a fully stowed position. This ensures the set screws can be optimally set.

Figure 32: EXOpod Nova with RBF pins installed (indicated in red).



4.2 Satellite Interfaces and Accessibility

4.2.1 Rails and Clamping Mechanism

The Cubesat rails are the primary interface between the satellite and 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 guide rails inwards towards the Cubesat. The mechanism engages as the door of the slot 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 31. 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.

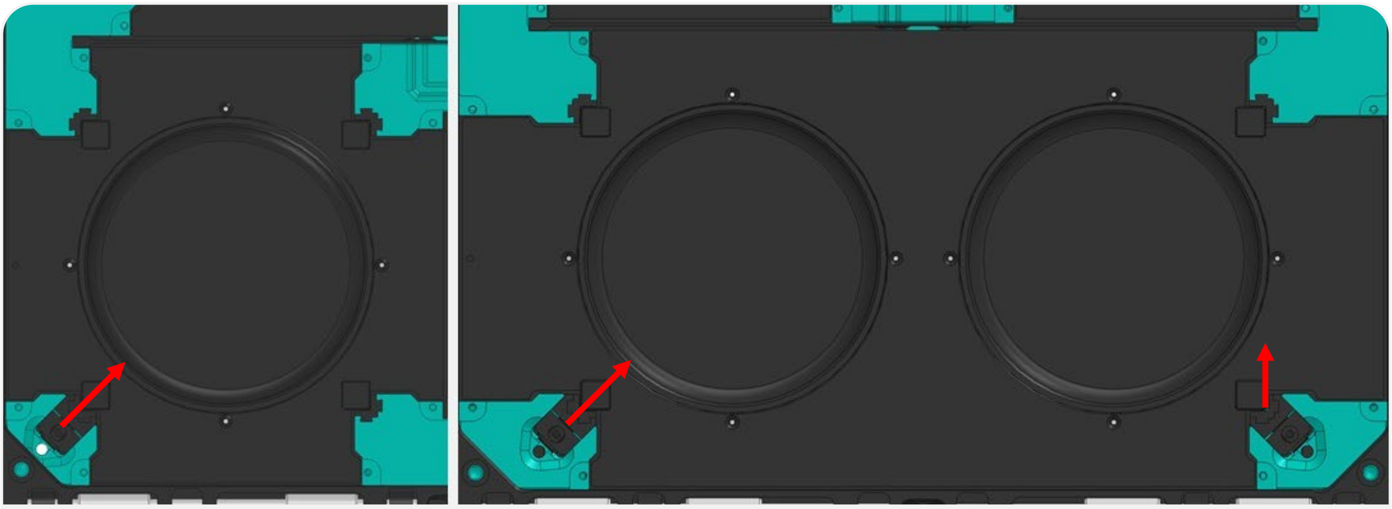
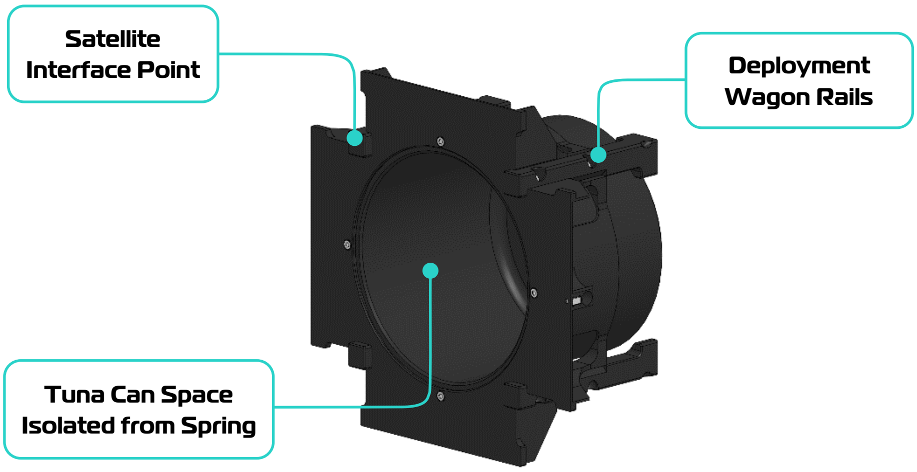


Figure 33: Clamping principle in 3U (left) and 6U (right) Cubesat slots.

4.2.2 Deployment Wagon

The deployment wagon, shown in Figure 32, is situated in between the spring and the Cubesat when the satellite is installed in the slot. It serves to keep the spring in the correct orientation and ensures that the spring force is correctly transmitted to the Cubesat. The deployment wagon is secured in the slot by an independent restraint mechanism. This mechanism will not release the wagon until the door has opened past 90 degrees, which prevents the possibility of the Cubesat impacting the door during deployment. The deployment wagon is stowed and secured with an RBF pin during integration.

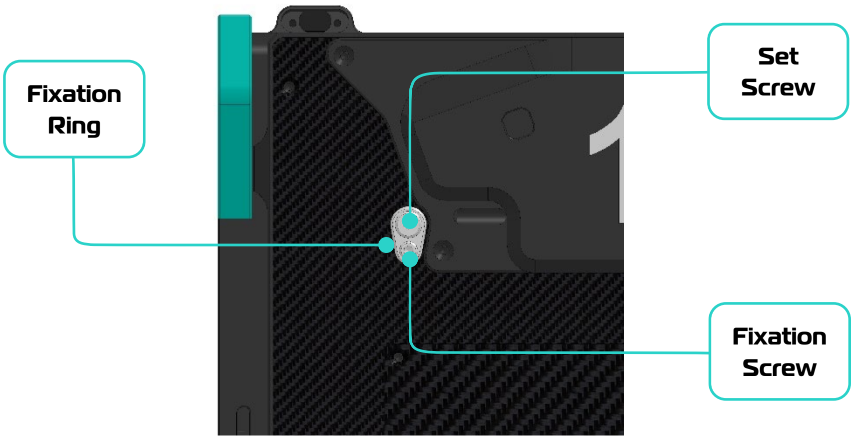
Figure 34:
Deployment wagon of a 3U/4U slot.



4.2.3 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 doors (see Figure 33). Once a satellite is placed inside EXOpod Nova, 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 acts like a wedge, increasing the running torque and preventing the set screw from coming loose.

Figure 35:
Set Screw detailed view



4.2.4 Doors and Locking Mechanism

The doors of EXOpod Nova use a unique electromagnetic locking mechanism which is used across all Exolaunch separation systems. These magnetic locks are highly reliable, with years of impeccable flight heritage, more than 350 successful orbital deployments, and thousands of cycles in test to date. Each door has two locks for redundancy, with each of them capable of triggering deployment independently. The locks require a 28VDC/0.28A/130ms release signal (see section 5.1). The high voltage and duration of the required pulse acts as a safety barrier which cannot be overcome by coupled signals due to RF-emission or static discharge. It also ensures universal compatibility with any launch vehicle by means of the low current compared to motorized systems.

The lock design allows the mechanism to be released and reset within seconds. This fast and simple process also allows functional checks to be easily performed after transportation to the launch site as well as after the final integration with the launch vehicle.

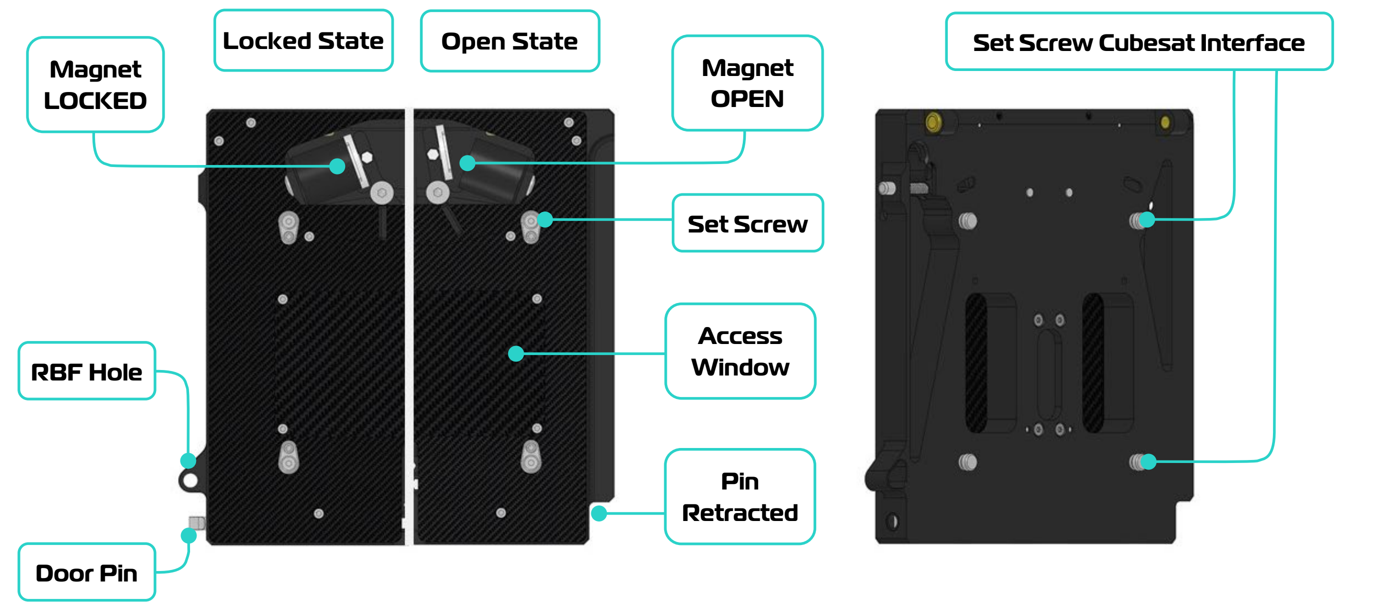


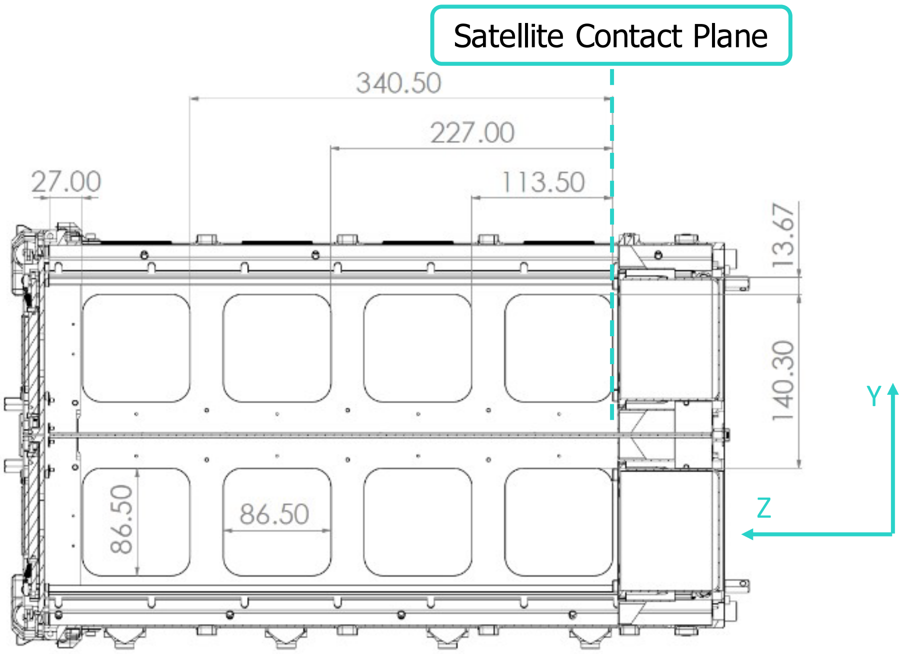
Figure 36: EXOpod Nova door in open and closed state.

The door system is designed with a mechanism that inhibits the release of the deployment spring and wagon until the door has reached an opening angle greater than 90 deg. This system prevents the satellite from impacting the door during deployment. A latching mechanism is built into the hinge of the door, locking the door open and preventing it from rebounding once the door has fully opened.

4.2.5 Access Windows

Large access windows are located on three sides of EXOpod Nova, allowing quick and easy access to the satellite at any point during and after the integration. Convenient access can be useful for a variety of reasons, including the removal of RBF elements, satellite charging, last minute software updates, and functional checks. Small access windows are located on the Z+ face of the EXOpod Nova. The dimensions and locations of the windows are shown in Figure 35.

Measurements in this figure are taken from the deployment wagon interface (satellite contact plane). **Note** that the windows on the top face adjacent to the electrical connector can be blocked by the launch vehicle harness.



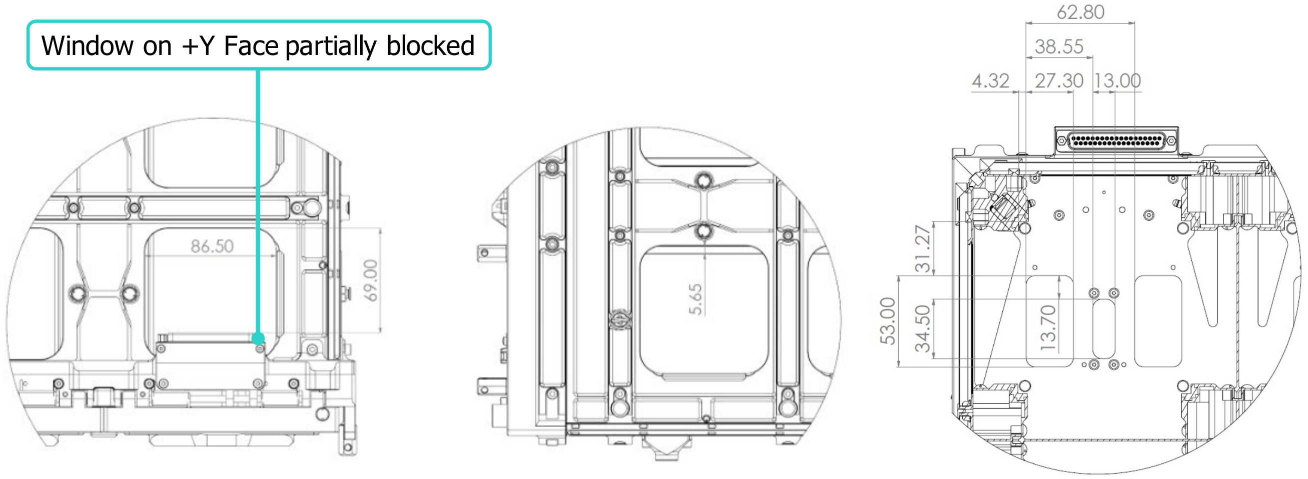


Figure 37: Position and dimensions of the access windows on the EXOpod Nova. The 8U is missing one row of windows whereas the 12U Nova has one fewer columns.

5

Electrical Interfaces

5.1 Electrical Connectors

Each slot of EXOpod Nova has two magnetic locks acting as fully redundant actuators, as well as two reed switches for telemetry, indicating the state of the door and spring. For electrical connectivity, EXOpod Nova is equipped with a D-Sub 37-pin male connector (ITT Cannon DCMA37P), which is identical across all EXOpod Nova variants and serves as the primary electrical interface (see Figure 36). The connector pinout is shown in Table 6, and the corresponding slot numbers are indicated in Figure 37. Exolaunch recommends a D-Sub 37-pin female connector from CONEC (part number 164X11799X) to be used for the electrical harness. For more detailed information contact Exolaunch.

EXOpod Nova features reverse polarity protection diodes on the actuator lines. The telemetry switches are Normally Open (NO), meaning that the first switch circuit closes when the deployer door has fully opened, and the second reed switch closes when the deployment wagon reaches the front of the deployer slot. The electrical signal characteristics for the actuators as well as guidelines for continuity checks are summarized in Table 7.

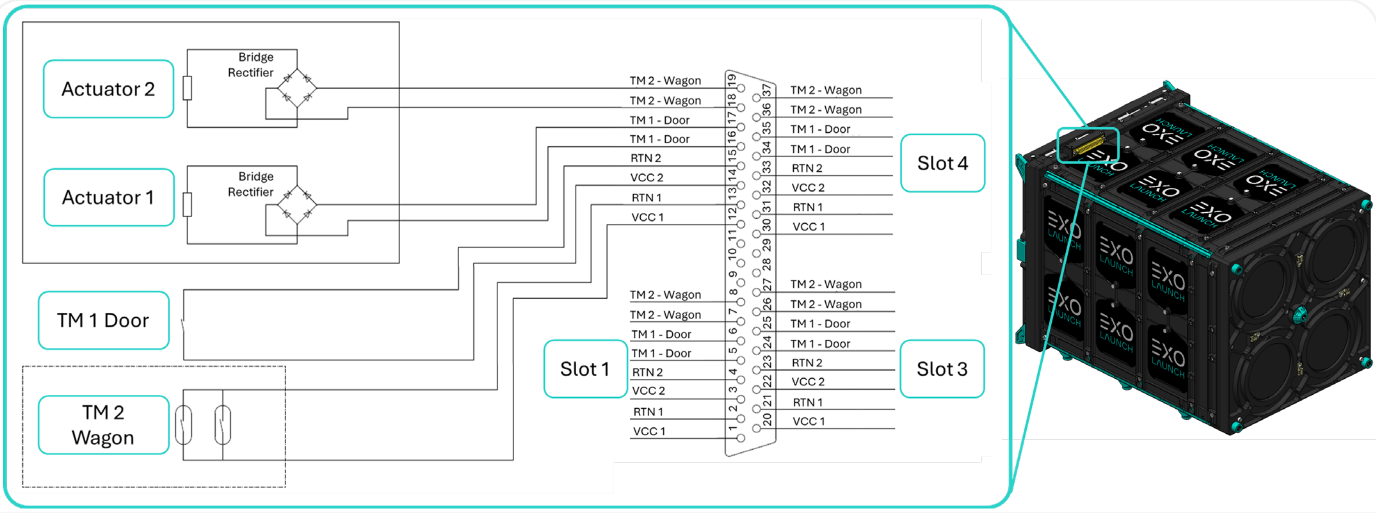


Figure 38: Left: D-Sub 37-pin main connector on EXOpod Nova top side (+Y) with pinout and actuator diagram.

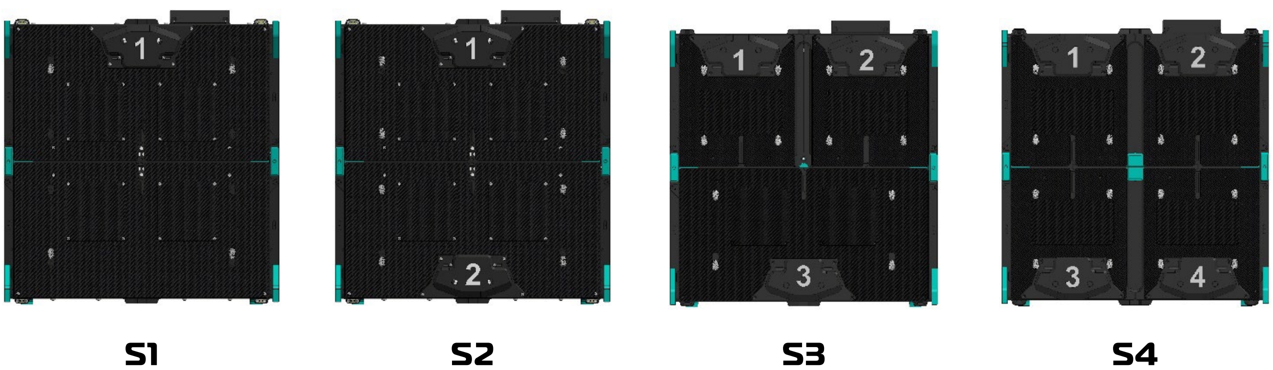
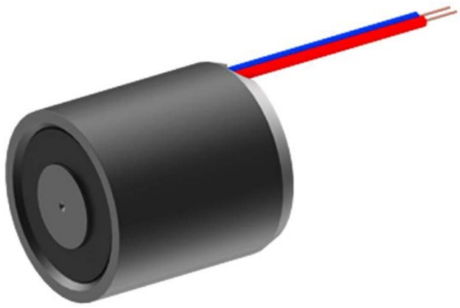


Figure 39: Slot numbers corresponding to the pinout in Table 8. Note that there is only an S1 and S2 option for the Nova 8U.

Table 6: DSub 37 connector pinout. Green cells indicate that the pins for this slot are used in the respective NOVA configuration.

Pin	Slot	Function	EXOpod NOVA Configuration				Remarks
			S1	S2	S3	S4	
1	Slot 1	Actuator 1 VCC	Y	Y	Y	Y	
2		Actuator 1 GND					
3		Actuator 2 VCC					
4		Actuator 2 GND					
5		Door Status TM					Closed when door is fully opened.
6		Door Status TM					
7		Wagon Status TM					Closed when spring is fully extended.
8		Wagon Status TM					
9		x					not connected
10		x					not connected
11		x					not connected
12	Slot 2	Actuator 1 VCC	N	Y	Y	Y	
13		Actuator 1 GND					
14		Actuator 2 VCC					
15		Actuator 2 GND					
16		Door Status TM					Closed when door is fully opened.
17		Door Status TM					
18		Wagon Status TM					Closed when spring is fully extended.
19		Wagon Status TM					
20	Slot 3	Actuator 1 VCC	N	N	Y	Y	
21		Actuator 1 GND					
22		Actuator 2 VCC					
23		Actuator 2 GND					
24		Door Status TM					Closed when door is fully opened.
25		Door Status TM					
26		Wagon Status TM					Closed when spring is fully extended.
27		Wagon Status TM					
28		x					not connected
29		x					not connected
30	Slot 4	Actuator 1 VCC	N	N	N	Y	
31		Actuator 1 GND					
32		Actuator 2 VCC					
33		Actuator 2 GND					
34		Door Status TM					Closed when door is fully opened.
35		Door Status TM					
36		Wagon Status TM					Closed when spring is fully extended.
37		Wagon Status TM					

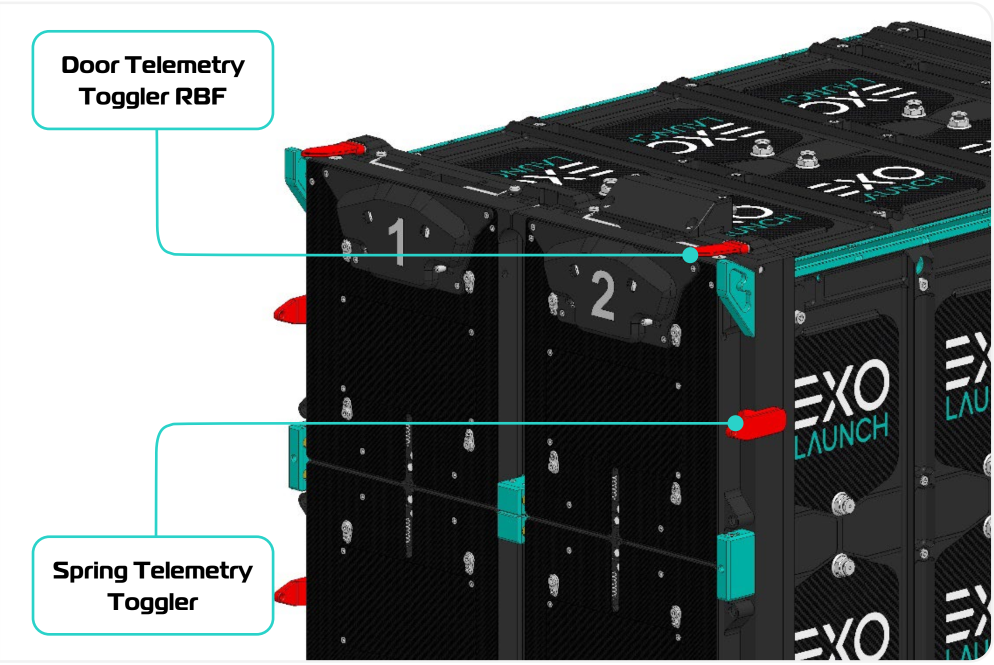
Table 7: Characteristics of the electrical signal to actuate the permanent magnets.

Parameter	Value	Permanent Magnet
Actuating voltage	Nominal: 28±4 VDC	
	Max: 50 VDC	
Pulse duration	Min: 0.130 s	
	Nominal: 0.5 sec	
	Max: 3 sec every 30 sec	
Current	No-fire: 25 mA	
	Nominal: 280 mA	
	Max: 500 mA	
Voltage Drop	1.2V± 10%	
Continuity checks	Actuator lines: 1.2±10% V voltage drop Telemetry lines: Open Loop >1MΩ (in armed mode)	Measured in multimeter diode mode Measured in multimeter resistance mode

5.2 Telemetry Toggler RBF

Nova features special Remove Before Flight elements which can be attached to the deployer from the outside to simulate actuation of the telemetry switches, i.e. simulate an open door or a deployed spring. This allows performing a checkout of the launch vehicle harness after final integration, see Figure 38.

Figure 40:
Nova telemetry toggler RBFs.



5.3 Harness Routing

To facilitate harness routing along the chassis, harness routing points are located on the top and rear faces of EXOpod Nova (see Figure 39). The cable guides on the rear face are made from PEEK, a robust engineering plastic with low outgassing properties.

Figure 41: Left: Harness routing canal and fixation points. Right: Example of harness route.

5.4 Umbilical Connection

An umbilical connection for satellite charging or remote access after integration with the launch vehicle is not available as a standard option. Access to the satellite after integration into Nova is only possible through the access windows which requires direct access by personnel. Custom solutions for umbilical access can be evaluated on a case-by-case basis, talk to Exolaunch.

6

Thermal Interfaces

6.1 Thermal Qualification

To guarantee flawless performance in space, the EXOpod Nova has been qualified to the environments listed in Table 8.

Table 8: Nova thermal qualification environnent.

System level	Parameter		Conditions
Magnetic lock	Thermal Cycling		27 cycles alternating between -34°C and +71°C
EXOpod Nova	Operational	T_{MAX}	+71°C
		T_{MIN}	-34°C
EXOpod Nova	Survival	T_{MAX}	+120°C
		T_{MIN}	-54°C

6.2 Satellite Interfaces

Heat transfer between Cubesat and EXOpod Nova primarily takes place by means of heat conduction through the guide rails, deployment wagon, and set screws.

6.3 Launcher Interfaces

EXOpod Nova is not actively thermally controlled. A conductive thermal path is achieved through the mounting interface. The passive thermal properties are summarized in Table 9. A thermal model of the EXOpod Nova for customer use is not available.

Table 9: Thermal interface.

Description	Bottom Plate Mounting Interface			Rear Plate Mounting Interface	
Contact Area	**8U**: 637.9 mm²	**12U**: 478.4 mm²	**16U**: 637.9 mm²	**8U**: 239.1 mm²	**12U/16U**: 478.2 mm²
Radiating Area	Rough estimate (Aluminum/Carbon): 8U: 0.25m²/0.2m², 12U: 0.5m²/0.25m²m 16U: 0.6m²/0.3m²				
Surface Material	Al 5083 Black Anodized (Type II): Emissivity (ε) ≈ 0.93, Absorption (α) ≈ 0.70 Al 5083 Green Anodized (Type II): (ε) ≈ 0.85, Absorption (α) ≈ 0.58				

7

Integration and Nova Ecosystem

Exolaunch has designed various support equipment to improve user experience, facilitate integration and testing of Cubesats into Nova and ship a loaded EXOpod Nova safely.

7.1 Cubesat Integration

The integration procedure for EXOpod Nova is described in detail in the Nova Cubesat integration Guide. Please contact Exolaunch for further details.

7.2 Nova TestPod

The Nova TestPods are a family of containers which were designed for Cubesat testing and transportation. The TestPods come in multiple sizes to support any Cubesat for factor. They have a strong and robust structure with a removable interface plate for shaker tables. TestPods don't have springs or electrical actuators, making them easy and safe to use for unfamiliar operators. The mechanical interface for the Cubesat is identical to that of a Nova deployer, including the clamping mechanism, meaning that a test in a TestPod serves a fully reliable fitcheck for the satellite. More information is available in the Nova TestPod User Manual in [AD-3}.

Figure 42: Overview of the 4U, 8U and 16U EXOpod Nova TestPods.

7.3 Transportation

To ensure safe storage and transportation, EXOpod Nova is stored and transported inside a Pelican Case with a laser-cut foam shell. For the shipment to the launch site, Nova is placed in an ESD bag with desiccant. Shock sensors are attached to the case, and the case is then strapped onto a pallet. For transportation without a satellite inside, the springs must be in their stowed state and secured using the provided RBF elements. For storage, the spring must be in its deployed state whenever possible. Before satellite integration, Nova is cleaned inside a cleanroom to standard ISO class 8 cleanliness requirements.

Figure 43: EXOpod Nova placed in its custom Pelican case and secured for shipment (Shock sensors not shown)

7.4 Integration MGSE

For easy, fast and safe integration of customer satellites into Nova or into a Nova TestPod, Exolaunch has developed a set of integration MGSE. The Integration Table, which is shown below, is configurable to support any Nova or TestPod configuration and can be set up in minutes. This streamlines the integration procedure for any Cubesat and reduces risk, especially for larger satellites which cannot be lifted manually.

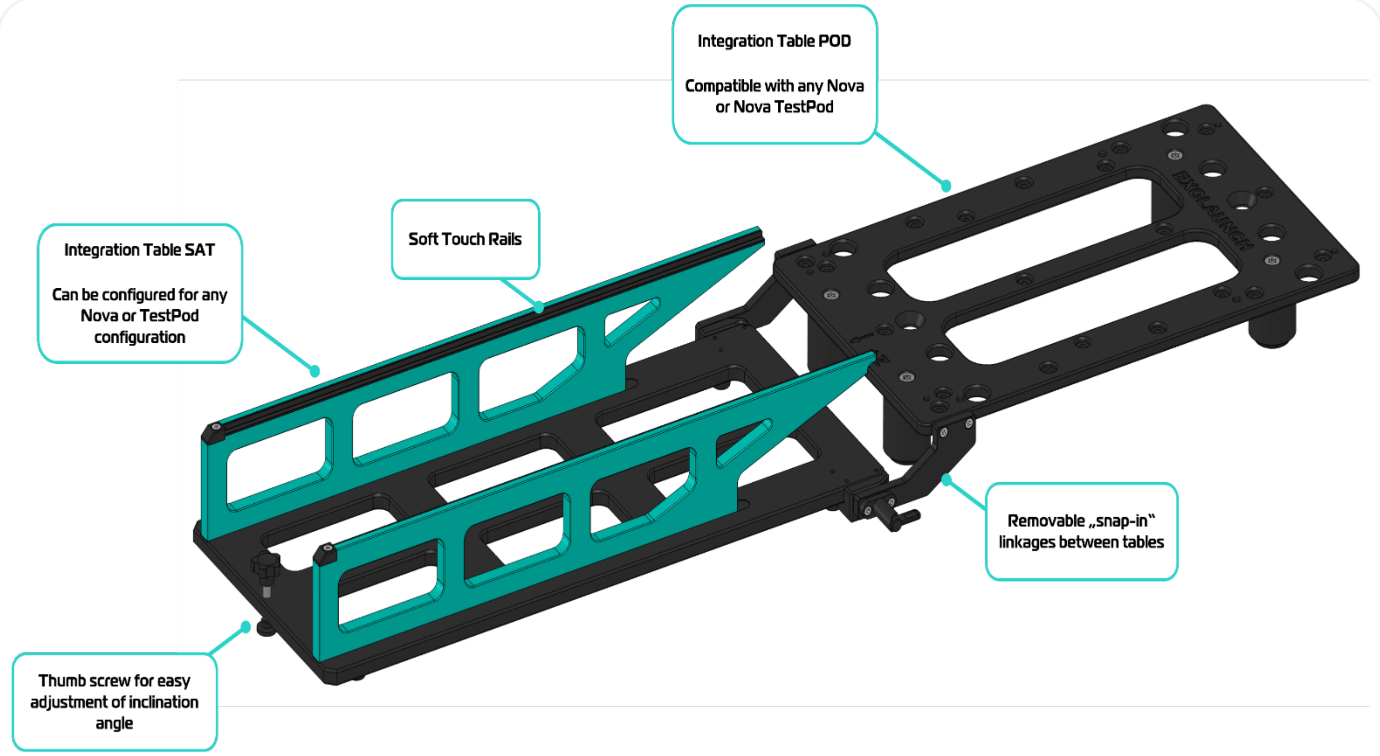


Figure 41: Nova Integration Table Overview

Figure 42: Cubesats manufactured by Kongsberg NanoAvionics being integrated into Nova and Nova TestPod using the Integration Table.

A

Appendix

Nova 8U Mass Properties

The following tables give an overview of the mass properties of the 8U EXOpod Nova system. All tables use the EXOpod Nova coordinate system from section 3.1.

Table 10: Mass Properties 8U S1 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	7.7				kg
Center of Gravity	X	0.47	X	0.48	mm
	Y	5.55	Y	13.65	
	Z	287.01	Z	335.7	
Moments of Inertia rel. to COG	I_{XX}	334805.33	I_{XX}	337661.06	kgmm²
	I_{YY}	411119.71	I_{YY}	409696.94	
	I_{ZZ}	134069.20	I_{ZZ}	138400.24	
Product of Inertia rel. to COG	I_{XY}	4621.50	I_{XY}	20921.85	kgmm²
	I_{XZ}	714.53	I_{XZ}	637.16	
	I_{YZ}	272.57	I_{YZ}	241.46	

Table 11: Mass Properties 8U S2 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	8.93				kg
Center of Gravity	X	0.35	X	0.36	mm
	Y	4.06	Y	13.75	
	Z	296.20	Z	341.25	
Moments of Inertia rel. to COG	I_{XX}	388654.81	I_{XX}	392992.26	kgmm²
	I_{YY}	464487.99	I_{YY}	462483.20	
	I_{ZZ}	140390.24	I_{ZZ}	146808.47	
Product of Inertia rel. to COG	I_{XY}	7050.94	I_{XY}	30213.90	kgmm²
	I_{XZ}	660.50	I_{XZ}	606.13	
	I_{YZ}	274.41	I_{YZ}	245.87	

B

Appendix

Nova 12U Mass Properties

The following tables give an overview of the mass properties of the 12U EXOpod Nova system. All tables use the EXOpod Nova coordinate system from section 3.1.

Table 12: Mass Properties 12U S1 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	9.77				kg
Center of Gravity	X	-3.79	X	-3.79	mm
	Y	4.91	Y	6.94	
	Z	226.81	Z	284.25	
Moments of Inertia rel. to COG	I_{XX}	398624.98	I_{XX}	423267.35	kgmm²
	I_{YY}	392411.67	I_{YY}	392803.03	
	I_{ZZ}	263382.90	I_{ZZ}	287764.62	
Product of Inertia rel. to COG	I_{XY}	7173.66	I_{XY}	9774.23	kgmm²
	I_{XZ}	20.78	I_{XZ}	1842.17	
	I_{YZ}	5223.35	I_{YZ}	5290.84	

Table 13: Mass Properties 12U S2 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	11.31				kg
Center of Gravity	X	0.25	X	0.25	mm
	Y	-1.49	Y	-1.49	
	Z	229.22	Z	280.04	
Moments of Inertia rel. to COG	I_{XX}	447231.16	I_{XX}	484487.51	kgmm²
	I_{YY}	447881.78	I_{YY}	454969.80	
	I_{ZZ}	293501.67	I_{ZZ}	323777.45	
Product of Inertia rel. to COG	I_{XY}	549.94	I_{XY}	1411.23	kgmm²
	I_{XZ}	520.08	I_{XZ}	375.46	
	I_{YZ}	478.38	I_{YZ}	438.04	

Table 14: Mass Properties 12U S3 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	12.32				kg
Center of Gravity	X	0.24	X	0.25	mm
	Y	4.47	Y	6.44	
	Z	234.42	Z	283.53	
Moments of Inertia rel. to COG	I_{XX}	482412.06	I_{XX}	524767.17	kgmm²
	I_{YY}	477425.09	I_{YY}	483689.96	
	I_{ZZ}	302000.92	I_{ZZ}	338236.94	
Product of Inertia rel. to COG	I_{XY}	6552.48	I_{XY}	11492.628	kgmm²
	I_{XZ}	412.52	I_{XZ}	317.582	
	I_{YZ}	519.79	I_{YZ}	480.702	

Table 15: Mass Properties 12U S4 BPM and PRM

Description	Closed		Open		Unit
Mass (±5%)	13.32				kg
Center of Gravity	X	0.25	X	0.26	mm
	Y	-1.28	Y	-1.26	
	Z	238.77	Z	286.27	
Moments of Inertia rel. to COG	I_{XX}	518587.00	I_{XX}	567016.05	kgmm²
	I_{YY}	507300.00	I_{YY}	513264.79	
	I_{ZZ}	311585.37	I_{ZZ}	354233.56	
Product of Inertia rel. to COG	I_{XY}	708.86	I_{XY}	1587.10	kgmm²
	I_{XZ}	389.61	I_{XZ}	300.89	
	I_{YZ}	500.40	I_{YZ}	467.59	

C

Appendix

Nova 16U Mass Properties

The following tables give an overview of the mass properties of the 16U EXOpod Nova system. All tables use the EXOpod Nova coordinate system from section 3.1.

Table 16: Mass Properties 16U S1 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	10.75				kg
Center of Gravity	X	-3.07	X	-3.08	mm
	Y	3.51	Y	5.34	
	Z	279.46	Z	347.28	
Moments of Inertia rel. to COG	I_{XX}	610058.36	I_{XX}	621710.98	kgmm²
	I_{YY}	603219.57	I_{YY}	590535.92	
	I_{ZZ}	298320.11	I_{ZZ}	322778.37	
Product of Inertia rel. to COG	I_{XY}	8949.13	I_{XY}	12794.12	kgmm²
	I_{XZ}	495.63	I_{XZ}	2389.06	
	I_{YZ}	5042.54	I_{YZ}	5158.28	

Table 17: Mass Properties 16U S2 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	12.85				kg
Center of Gravity	X	0.22	X	0.22	mm
	Y	-2.01	Y	-2.01	
	Z	281.68	Z	340.14	
Moments of Inertia rel. to COG	I_{XX}	694132.85	I_{XX}	722132.23	kgmm²
	I_{YY}	697246.55	I_{YY}	695044.16	
	I_{ZZ}	336341.31	I_{ZZ}	366652.94	
Product of Inertia rel. to COG	I_{XY}	768.96	I_{XY}	2277.80	kgmm²
	I_{XZ}	693.79	I_{XZ}	527.45	
	I_{YZ}	564.26	I_{YZ}	585.33	

Table 18: Mass Properties 16U S3 BPM and RPM

Description	Closed		Open		Unit
Mass (±5%)	14.05				kg
Center of Gravity	X	0.17	X	0.16	mm
	Y	4.37	Y	6.08	
	Z	288.53	Z	343.84	
Moments of Inertia rel. to COG	I_{XX}	754393.93	I_{XX}	785453.16	kgmm²
	I_{YY}	750472.01	I_{YY}	745477.39	
	I_{ZZ}	347910.56	I_{ZZ}	384109.73	
Product of Inertia rel. to COG	I_{XY}	10301.23	I_{XY}	15774.01	kgmm²
	I_{XZ}	816.81	I_{XZ}	539.24	
	I_{YZ}	555.14	I_{YZ}	558.11	

Table 19: Mass Properties 16U S4 BPM and RPM

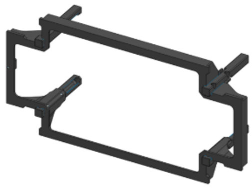
Description	Closed		Open		Unit
Mass (±5%)	15.27				kg
Center of Gravity	X	0.16	X	0.15	mm
	Y	-1.84	Y	-1.73	
	Z	294.28	Z	347.00	
Moments of Inertia rel. to COG	I_{XX}	814482.37	I_{XX}	849216.33	kgmm²
	I_{YY}	802792.82	I_{YY}	795190.95	
	I_{ZZ}	360202.81	I_{ZZ}	402304.72	
Product of Inertia rel. to COG	I_{XY}	1290.68	I_{XY}	2770.94	kgmm²
	I_{XZ}	760.07	I_{XZ}	463.22	
	I_{YZ}	548.60	I_{YZ}	553.32	

D

Appendix

Cubesat Adapter Mass Properties

Table 20: Mechanical Properties of Cubesat slot adapters with minimum volume

Adapter	1U max		2U max		6U XL max		Units
							
Mass	0.218		0.324		0.196		kg
Center of Gravity	X	0.7	X	0.47	X	-1.61	mm
	Y	0.00	Y	0.00	Y	0.00	
	Z	64.09	Z	125.02	Z	66.95	
Moments of Inertia rel. to COG	I_{XX}	853	I_{XX}	2792.78	I_{XX}	613.76	kgmm²
	I_{YY}	869.40	I_{YY}	2803.64	I_{YY}	2332.96	
	I_{ZZ}	917.93	I_{ZZ}	1333.7	I_{ZZ}	2777.05	
Product of Inertia rel. to COG	I_{XY}	0.00	I_{XY}	0.00	I_{XY}	0.00	kgmm²
	I_{XZ}	5.88	I_{XZ}	13.90	I_{XZ}	-3.25	
	I_{YZ}	0.00	I_{YZ}	0.00	I_{YZ}	0.00	

E

Appendix

Acronyms

Acronym	Description
BPM	Bottom Plate Mounting
CAD	Computer Aided Design
CDS	Cubesat Design Specification Standard Rev. 14
COG	Center of Gravity
FEA	Finite Element Analysis
FEM	Finite Element Modeling
LV	Launch Vehicle
MOI	Moment of Inertia
MGSE	Mechanical Ground Support Equipment
RBF	Remove Before Flight
RPM	Rear Plate Mounting
VDC	Volt Direct Current

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