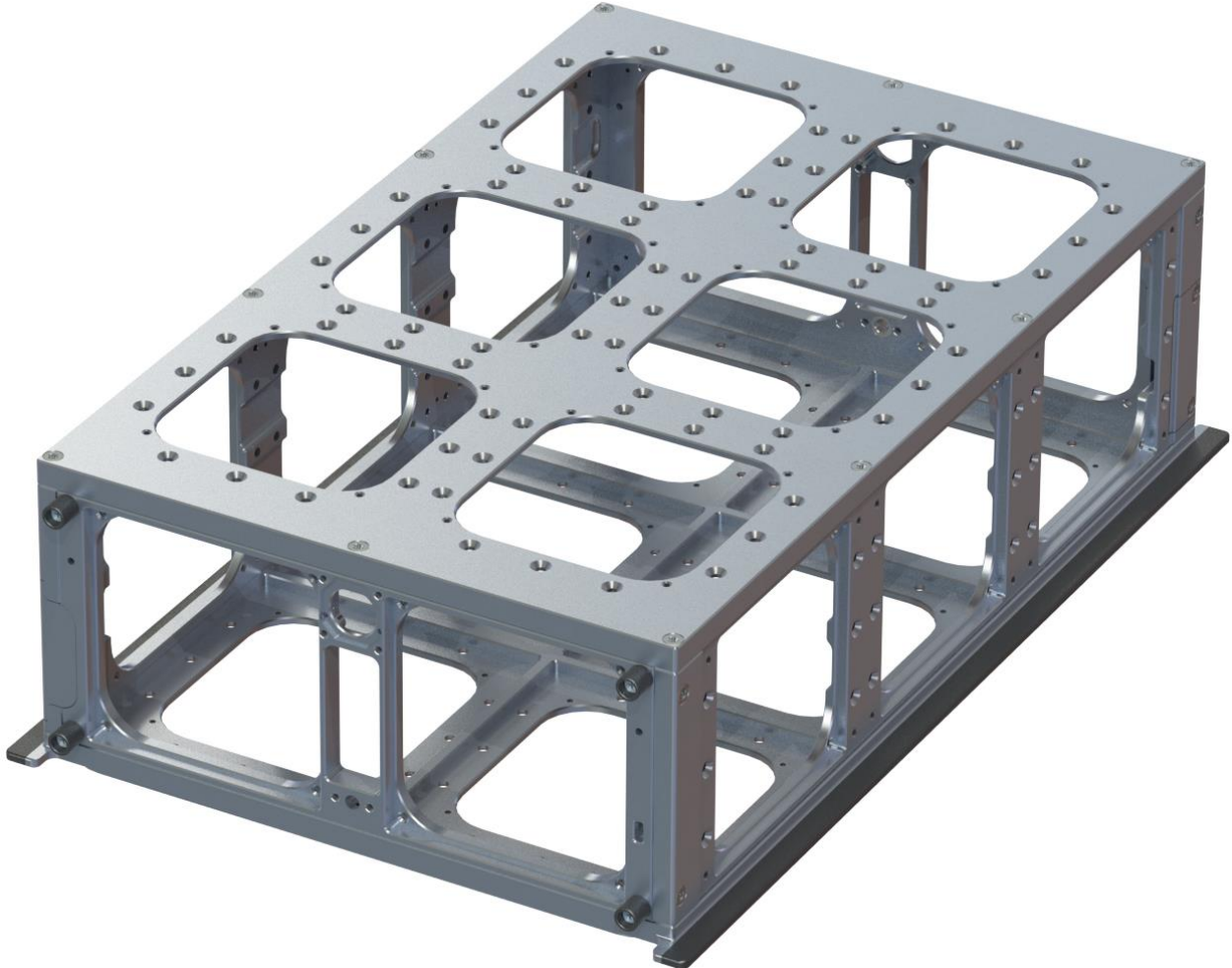




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UM-22 User Manual

711-01113 SUPERNOVA™ 6U Structure Kit User Manual



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Revisions

REV	DATE	AUTH	NOTES
A0	10/2/14	SJH	Initial release
A1	12/16/14	SJH	Features pg3, table pg4, photo pg8, text clarifications
A2	03/18/15	SJH	Corrections to PSC document numbers
B	06/20/18	JMM	Update for Block V

APPLICATIONS

- Highly configurable 6U nanosatellite structure for rapid integration of enhanced CubeSat missions

FEATURES

- 6U-size nanosat Structure
- Over 9000cc combined internal and external payload volume
- Compatible with Planetary Systems Corporation (PSC) Canisterized Satellite Dispenser™
- Hard Anodized 7075-T73 base plate tabs provides a predictable load path within launcher
- Alodyned¹ 6061-T6 side and top plates
- Nitronic-60 locking Helicoils throughout structure
- Modular architecture allows a wide range of bus configurations and flight orientations
- Structure can accommodate six 10x10x10cm (CubeSat-sized) modules with additional room available for cable routing, external instruments, solar panels, etc.
- 22 Space Access Ports (SAPs) for ease of use during integration and external instrument mounting
- Accommodates 15-pin PSC Separation Connector for passing power & data to SUPERNOVA™ bus while inside dispenser
- Over 10kg allowable mass in addition to structure
- Included covers allow for easy RF/EMI shielding
- All threaded holes are vented

¹ Alodyne is the default plating for the SUPERNOVA™ 6U Structure Kit. Please contact Pumpkin, Inc. for additional plating options.

1 SUPERNOVA™ 6U SYSTEM OVERVIEW

1.1 Introduction

Pumpkin’s SUPERNOVA™ series 6U structure kit provides a platform for rapid integration of mission hardware into a flight ready spacecraft. The precision machined structure allows a high level of configurability while maximizing the available mass and volume for payload. The SUPERNOVA™ structure has been thoroughly tested for shock and vibration durability and each structure fully conforms to the specifications required for use with Planetary Systems Corporation’s 6U *Canisterized Satellite Dispenser™* (hereon referred to as *CSD*).

The modular nature of the SUPERNOVA™ enables satellite subsystems to be assembled and tested in units, or stacks, external to the flight structure. This allows for distributed development and ease of re-configuration in response to mission demands.

In addition to the basic structure assembly, a selection of mounting hardware, covers, and adapters are available to accommodate a range of possible layouts.

1.2 Specifications

All references to coordinates with regard to the SUPERNOVA™ structure follow the position and orientation set out by the CSD specification. The XZ plane is coincident with the lower surface of the tabs. The ZY plane is centered between the outer edges of the tabs. The XY plane lies 8.5mm from the outer surface of the rear (-Z) panel.

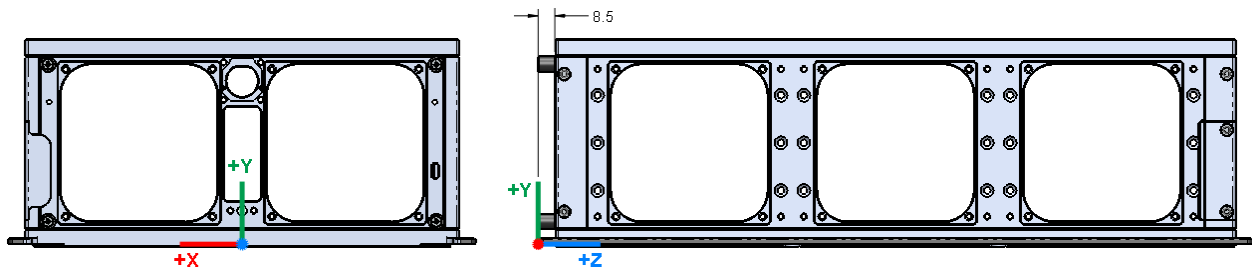


FIGURE 1: REFERENCE COORDINATES

PARAMETER	VALUE	UNITS
Empty structure mass	1.65	kg
Total allowable mass in CSD	14.00	kg
Internal volume	6700	cc
External volume	2685	cc
Overall width (-X, +X)	221.7	mm
Overall height (-Y, +Y)	105.6	mm
Overall length (+Z)	365	mm
Center of mass, X	0	mm
Center of mass, Y	50	mm
Center of mass, Z	181	mm

TABLE 1: STRUCTURE PARAMETERS (W/O COVERS)

1.3 Components List

QTY	COMPONENT	PUMPKIN P/N	MATERIAL
1	SUPERNOVA Base Plate	703-01040	Al-7075
1	SUPERNOVA Top Plate	703-01041	Al-6061
2	SUPERNOVA Side Plate	703-01042	Al-6061
2	SUPERNOVA 6U End plate	703-01043	Al-6061
2	SUPERNOVA Sep Conn Cover	703-01199	Al-6061
4	SUPERNOVA CSD Pusher Plate Standoff	703-01506	Al-7075
4	Screw, M2.5x10mm Flat Phillips	N/A	18-8 SS
30	Screw, M3x12mm Flat Torx (T10)	N/A	18-8 SS

TABLE 2: STRUCTURE KIT ASSEMBLY COMPONENTS

QTY	COMPONENT	PUMPKIN P/N	MATERIAL
4	Stack Adapter A	703-01044	Al-6061
4	Stack Adapter B	703-01045	Al-6061
4	Stack Extender	703-01046	Al-6061
12	SUPERNOVA 1U X-Z Cover	703-01485	Al-5052
14	SUPERNOVA 1U Extended Cover	703-01048	Al-5052
56	Screw, M2.5x3.4mm Undercut Flat Torx (T6)	N/A	18-8 SS
48	Screw, M2.5x5mm Flat Torx (T8)	N/A	18-8 SS

TABLE 3: ADDITIONAL COMPONENTS & SPARES

The following table lists additional Pumpkin products that are compatible with the SUPERNOVA™ 6U Structure Kit and available for purchase. Please contact Pumpkin for more information.

COMPONENT	PUMPKIN P/N	MATERIAL
SUPERNOVA Sep Conn Bracket	703-01051	Al-6061
SUPERNOVA SIDE PLATE, DUPLEX RADIO	703-01876	Al-6061
SAP ADAPTER X, NSL DUPLEX ANTENNA	703-01904	Al-6061
SUPERNOVA SEP SWITCH MODULE	705-01468	N/A
SUPERNOVA GSE MODULE	710-01853	N/A
CUSTOM SUPERNOVA BASE PLATE	703-0XXXX	Al-7075
CUSTOM SUPERNOVA TOP PLATE	703-0XXXX	Al-6061
CUSTOM SUPERNOVA SIDE PLATE	703-0XXXX	Al-6061
CUSTOM SUPERNOVA 6U END PLATE	703-0XXXX	Al-6061
SUPERNOVA SPACECRAFT FIXTURE KIT FLOOR	711-01911	N/A
SUPERNOVA SPACECRAFT FIXTURE KIT DESKTOP	711-01913	N/A

TABLE 4: OPTIONAL COMPONENTS AVAILABLE FOR PURCHASE

1.4 Tools

A T6, T8, and T10 Torx driver are included with the structure kit for preliminary assembly and disassembly. It is recommended that an electronic torque wrench be used for final assembly. Refer to TABLE 6 for torque values.

1.5 Structure External Dimensions

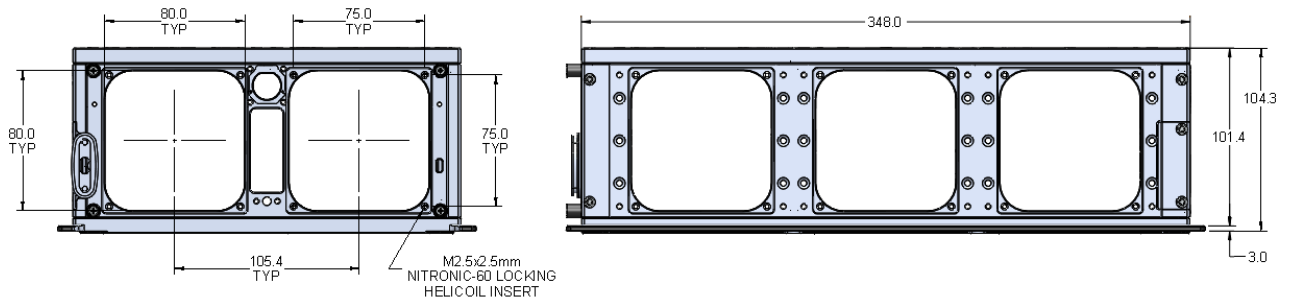


FIGURE 2: EXTERNAL DIMENSIONS - SIDE²

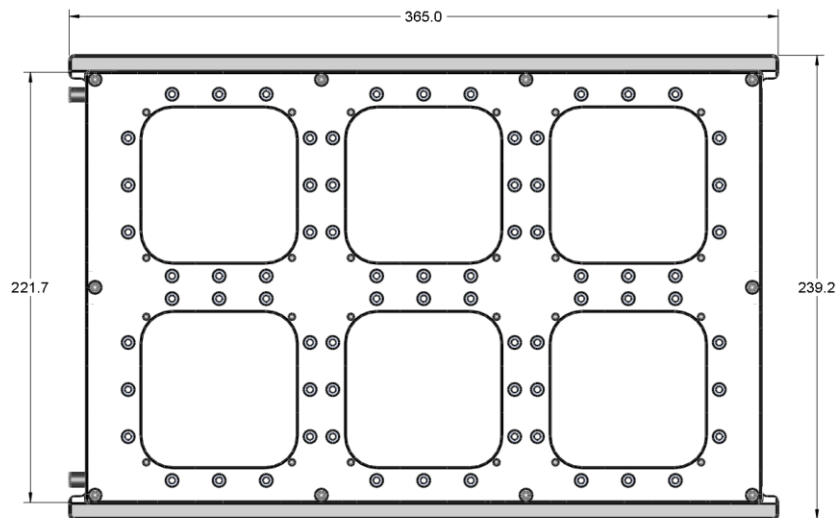


FIGURE 3: EXTERNAL DIMENSIONS - TOP

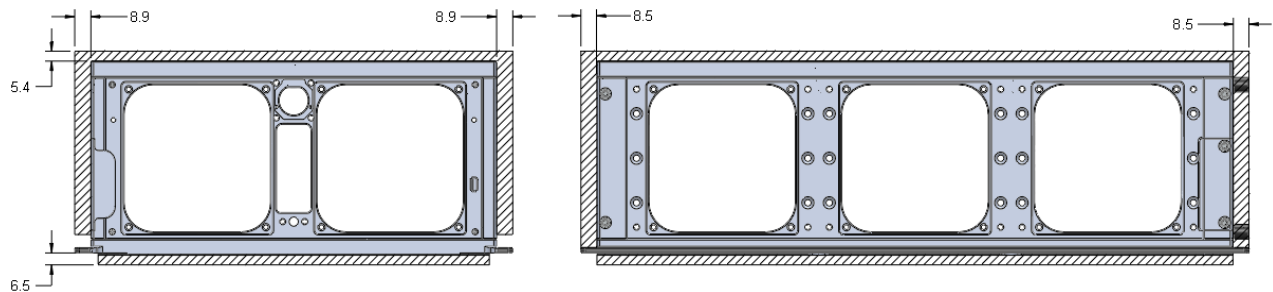


FIGURE 4: ALLOWABLE VOLUME OUTSIDE STRUCTURE

² Further details regarding Space Access Port (SAP) mechanical interfaces can be found in 2017_SUPERNOVA_SAP_Design_Guidelines.pdf

1.6 Structure Internal Dimensions

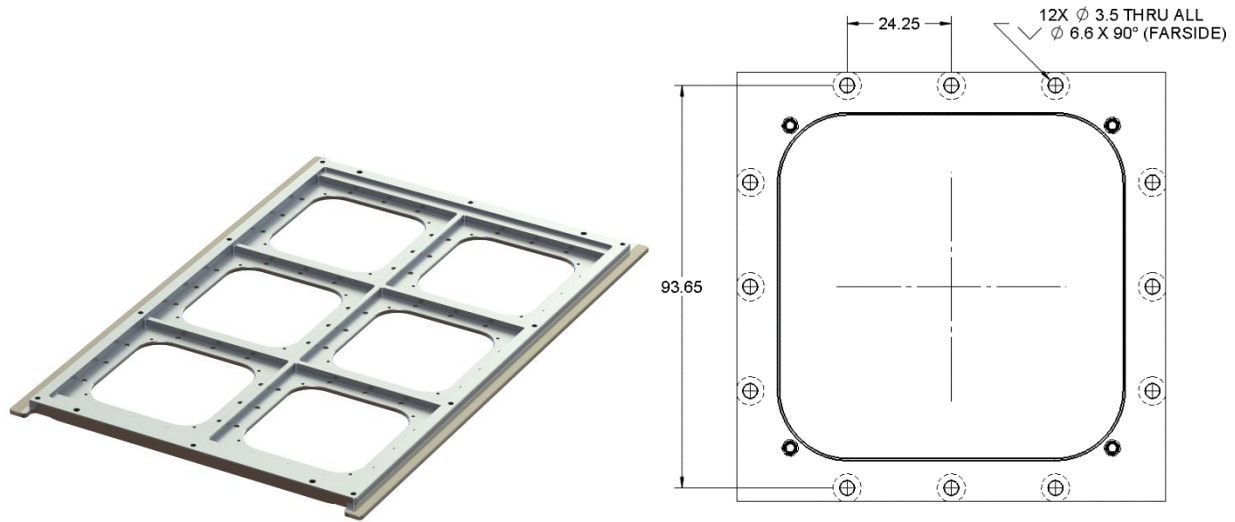


FIGURE 5: CELL LAYOUT & MOUNTING HOLE PATTERN

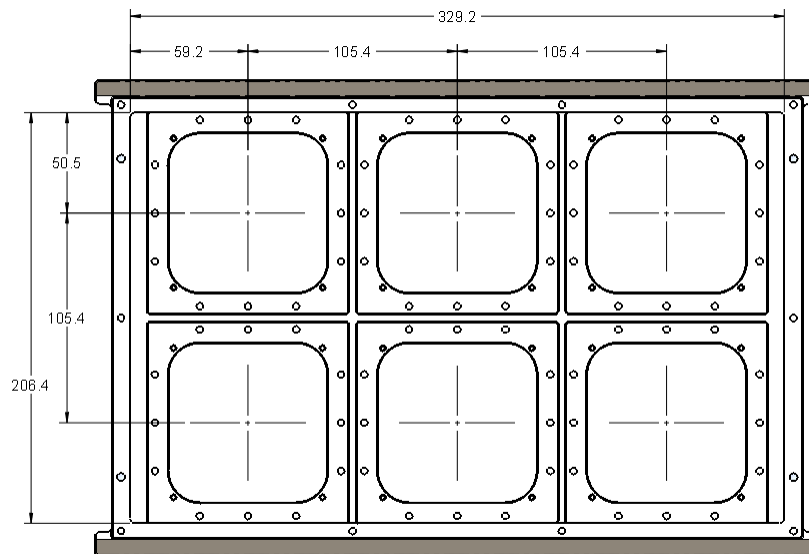


FIGURE 6: INTERNAL DIMENSIONS - TOP VIEW

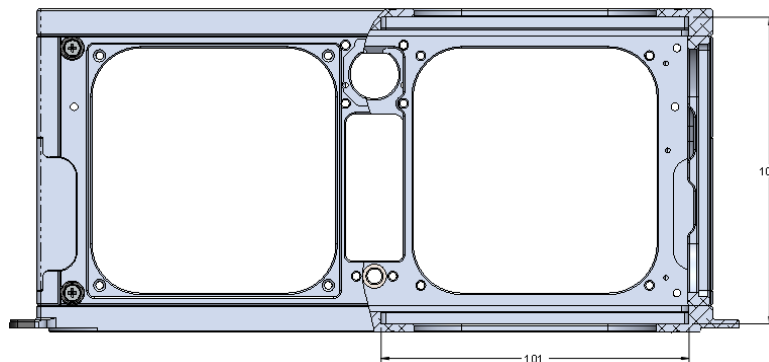


FIGURE 7: CUTAWAY - CELL CROSS SECTION

1.7 The CSD

SUPERNOVA™ is designed specifically for use with Planetary Systems Corporation's Canisterized Satellite Dispenser™ (CSD) & meets all payload dimensional specifications outlined in the CSD payload specification (2002367E). Note that the CSD specification also requires a set of inhibit switches which are not included in the base SUPERNOVA™ structure kit.

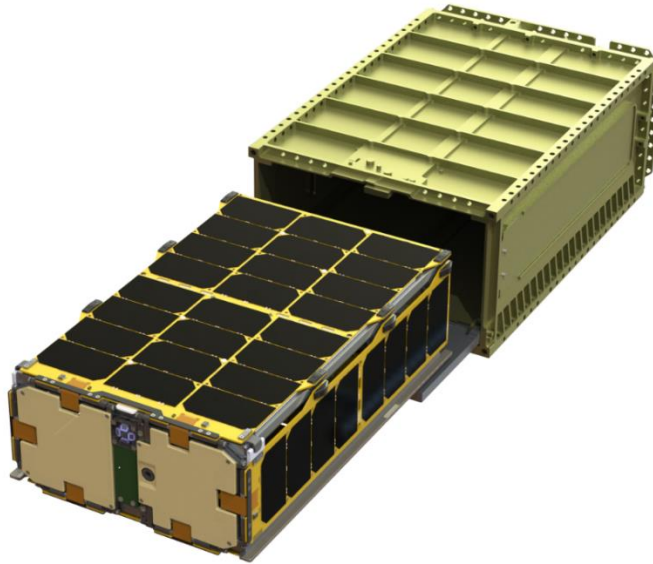


FIGURE 8: SUPERNOVA™ SPACECRAFT DEPLOYING FROM CSD

SUPERNOVA™ supports the use of Planetary Systems Corporation's Separation Connector for signal and power routing while in the dispenser. The PSC Separation Connector is optional and not included with the SUPERNOVA™ Structure Kit. It is available for purchase from Planetary Systems Corporation. Additionally, a SUPERNOVA-specific mounting bracket is available for purchase from Pumpkin, Inc.



FIGURE 9: PSC SEPARATION CONNECTOR AND PUMPKIN MOUNTING BRACKET

1.8 Flight Configurations & Deployables

SUPERNOVA™ enables flexibility in flight orientation and deployable solar panel configuration. Shown below are four possible configurations. Deployable solar panels and bus electronics can be purchased separately from Pumpkin Inc.

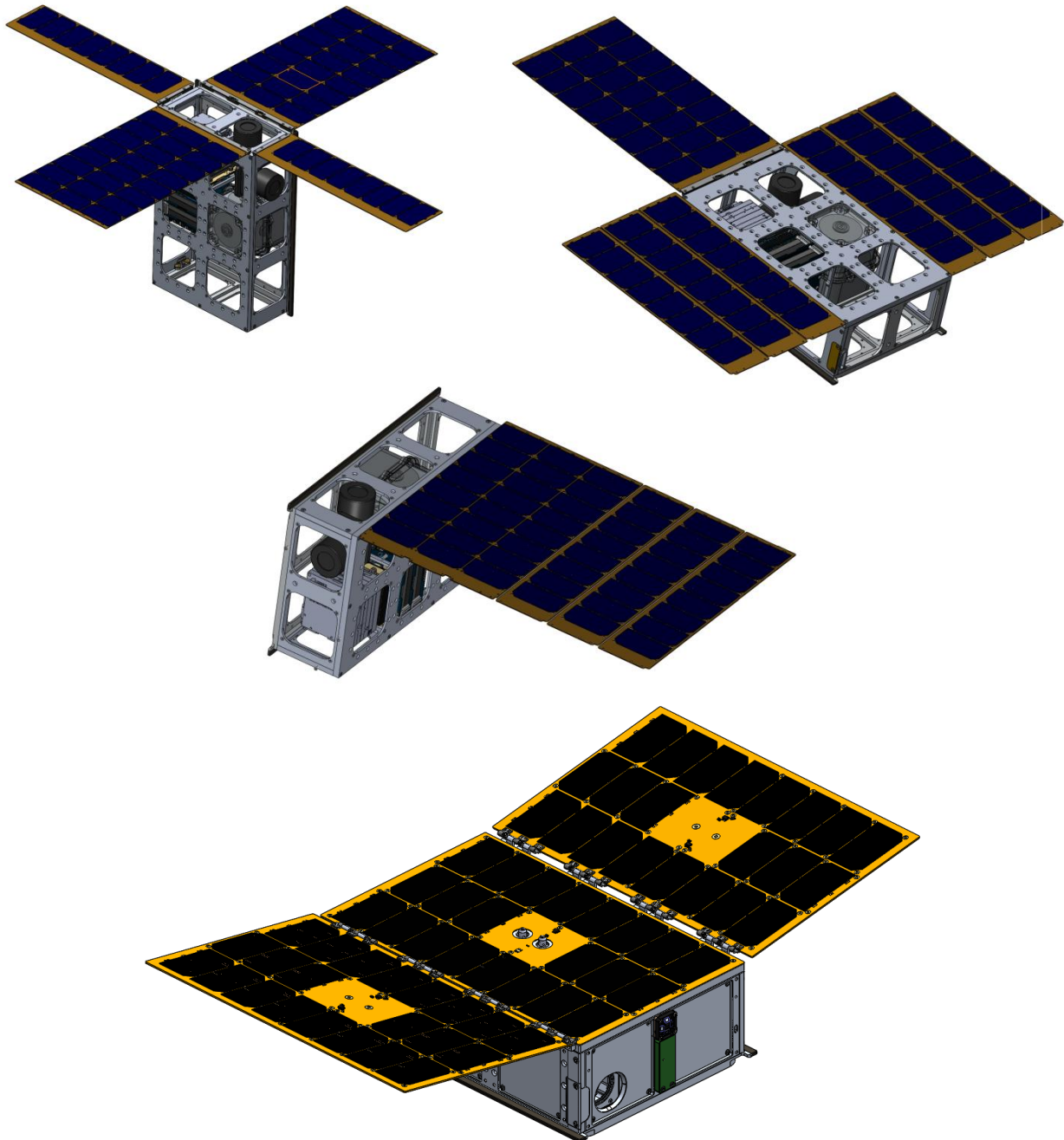


FIGURE 10: EXAMPLE FLIGHT CONFIGURATIONS

2 STRUCTURE ASSEMBLY

2.1 Assembly Overview

A high level of symmetry and minimal number of fastener types ensures that SUPERNOVA™ assembly is quite straightforward. The structure is composed of six main components, which are fastened together by 30 M3-0.5 x 12mm long flat Torx screws, as well as up to 22 cover panels. +/- Y covers are fastened using M2.5-0.45 x 3.4mm undercut flat Torx screws. +/- X and Z covers are fastened using M2.5-0.45 x 5mm flat Torx screws.

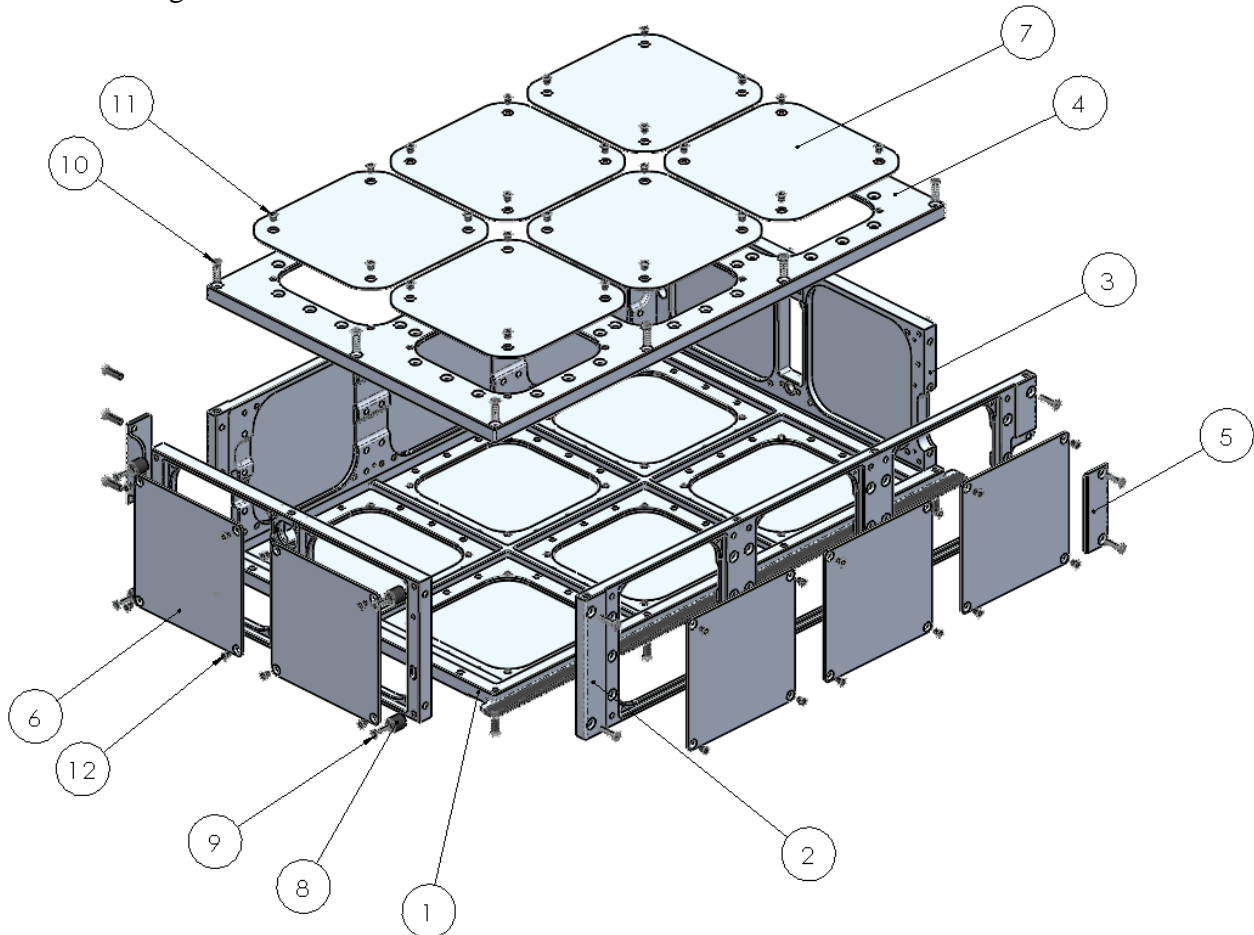


FIGURE 11: SUPERNOVA™ STRUCTURE ASSEMBLY

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	703-01040	SUPERNOVA Base Plate	1
2	703-01042	SUPERNOVA Side Plate	2
3	703-01043	SUPERNOVA 6U End Plate	2
4	703-01041	SUPERNOVA Top Plate	1
5	703-01199	SUPERNOVA Sep Conn Cover	2
6	703-01485	SUPERNOVA 1U X-Z COVER	10
7	703-01048	SUPERNOVA 1U EXTENDED COVER	12
8	703-01506	SUPERNOVA CSD PUSHER PLATE STANDOFF	4
9	N/A	M2.5x10mm FLAT PHIL SCREW	4
10	N/A	M3x12mm FLAT TORX SCREW	30
11	N/A	M2.5x3.4mm UNDERCUT FLAT TORX SCREW	48
12	N/A	M2.5x5mm FLAT TORX SCREW	40

TABLE 5: FIGURE 11 COMPONENT LIST

Parts 703-01040 and 703-01041 are symmetric in 2 planes so their assembly orientation doesn't matter as long as the correct side is facing outward.

Part 703-01043 is handed with the separation connector cutout on the left hand side when the correct side is facing outward.

Part 703-01042 is handed with the separation connector cutout on the right hand side when the correct side is facing outward.

Part 703-01199 mounts to the lower right hand side of the 703-01042 were the separation connector cutout is.

Part 703-01506 mounts to one of the 703-01043 6U End Plates. Whichever side this part is mounted on will be designated the $-Z$ side and will establish the coordinate frame for the structure.

(Optional) Part 703-01051 is a removable bracket for mounting the separation connector. This part would be substituted for one of the 703-01199 parts on the $-Z$ end. It is externally removable to make wiring easier.

In general, the spacecraft should be built up from the tabbed base plate since this is the part that is most critical with regards to dispenser compatibility. The general process for building up a SUPERNOVA™ based 6U satellite is as follows:

1. Build up subsystem stacks externally to structure (see section 3 *Stack Assembly*).
2. Orient and fasten stacks loosely to Base Plate.
3. Route cabling between stacks.
4. Mount Y and Z Walls. By design, the Y and Z walls will not be flush in the Z dimension. The Z wall will be proud by a nominal 0.25mm.
5. Attach wall mounted instruments, etc. and route cabling.
6. Attach Top Plate.
7. Attach external panels, covers, deployable panels, antennas etc.

8. Follow procedure in section 2.4 *Final Assembly* to prep and torque fasteners for flight.

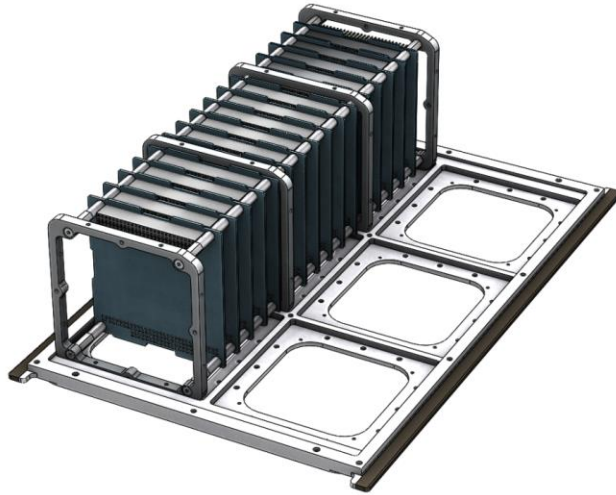


FIGURE 12: '3U' STACK MOUNTED TO BASEPLATE

2.2 Self-Locking Threaded Inserts

The SUPERNOVA™ structure features Nitronic-60 locking threaded inserts that interface with the M3 fasteners that hold the structure together. In addition, the +/- X and Z SAPs feature M2.5 locking threaded inserts, four places per port. All of the SUPERNOVA™ fasteners are made from 316 Stainless Steel, and will gall when used with standard threaded locking inserts. To avoid that galling issue, Nitronic-60 material threaded inserts are used. They provide a significant locking feature, enough so that it's unnecessary to epoxy stake the screws mentioned in this section. Take note that the undercut Torx flathead screws used on +/-Y SAP covers will require epoxy staking prior to flight, as they do *not* feature locking threaded inserts.

It is recommended to avoid cycling fasteners in/out as much as possible as the threaded inserts are rated for only ten cycles. Additional cycles will start to degrade the performance of the locking feature. It should be noted that swapping out fasteners for new fasteners can recover a portion of the locking tension, however, the majority of degradation occurs in the locking threaded insert itself.

2.3 Epoxy Staking

It is recommended that the fasteners on the +/-Y SAP covers be epoxy staked during final assembly. These are the only fasteners on the SUPERNOVA™ structure that require staking.

There are two recommended types of adhesive to use for head staking.

- 3M TC-2810 Thermally Conductive Adhesive
- Scotch Weld Grey

Use mixing nozzles, dispensing guns, or spatulas to mix and place adhesive. A bell jar should be used to degas hand mixed epoxy. A shallow container can be used for mixing and as a painting palette. Tools for mixing and holding adhesive mixtures should be glass or stainless steel to prevent

contamination. It is expected that the integrator will adhere to the adhesive manufacturer’s recommended procedures, to included cure time and temperature.

To remove epoxy, apply heat and carefully chip off.

If using epoxy, use a small amount to apply to the head of the fastener to prevent it from rotating. Keep epoxy out of the driver.

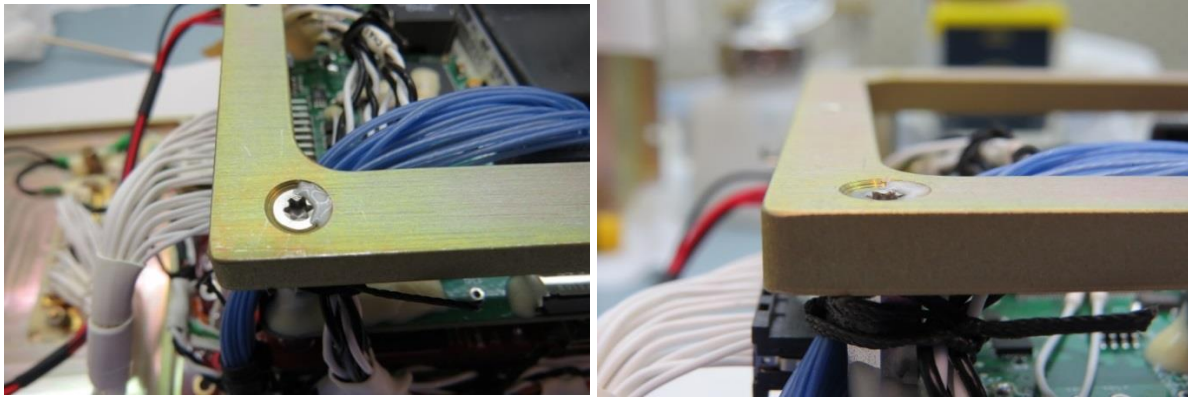


FIGURE 13: EXAMPLE OF EPOXY HEAD STAKING. (PHOTO CREDITS: AFIT)

2.4 Final Assembly

To ensure that fasteners do not vibrate loose during launch, it’s important that during final assembly, the following procedures are followed.

- Check each threaded hole for residue or contamination
- Clean all bolts and threaded holes with isopropyl alcohol
- Clear and dry each threaded hole with compressed air
- Insert screw and use digital torque wrench to tighten according to TABLE 6 below.
- Epoxy stake fasteners on +/-Y SAP covers

TORX-DRIVE SCREW SIZE	TORQUE (NM)	TOOL	WHERE USED
M3-0.5x12mm Flathead <i>Locking Helicoil</i>	1.50	T10	Main Structure - All
M3-0.5x12mm Flathead <i>Locking Helicoil</i>	1.20	T10	Payload +/- X
M3-0.5x8mm Flathead <i>Locking Helicoil</i>	1.20	T10	Payload +/-Y
M2.5-0.45x5mm Flathead <i>Locking Helicoil</i>	0.20	T8	SAP Covers +/- X and +/-Z
M2.5-0.45x3.4 Undercut Flathead <i>Tapped Aluminum (staking req'd)</i>	0.10	T6	+/- Y SAP Covers

TABLE 6: FINAL ASSEMBLY TORQUE SPECIFICATIONS

The torque values listed in TABLE 6 are quite low in the case of the M2.5 tapped holes. Using the right tool is the best way to avoid stripping the threads. The recommended tool is from Check Line³

- Model TSD-50 measures .05 to .50 Nm
- Model TSD-400 measures .40 to 4.0 Nm

Note that these digital torque screwdrivers display in cNm (10cNm = 1Nm)

3 STACK ASSEMBLY

3.1 The Unit Cube

SUPERNOVA™ is based around the idea of a 10x10x10 cm ‘Unit Cube’ similar to the original CubeSat specification. This allows any equipment that is CubeSat compatible to fit within any of the 6 cell locations in the SUPERNOVA™ structure in up to 24 different orientations.

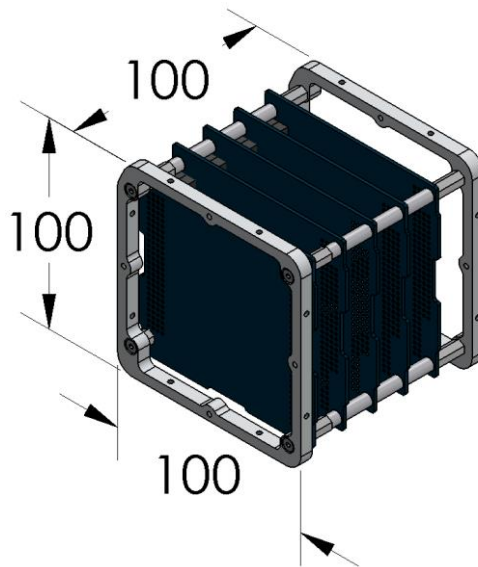


FIGURE 14: '1U' STACK OF PC104 BOARDS

Included with the SUPERNOVA™ structure kit are adapter brackets that allow PC-104 compatible instrument boards to be built up into stacks and mounted to the structure. These stacks can extend from 1 Unit Cube ('1U') up to 310+mm ('3U') in length.

3.2 Assembling Instrument Stacks

Begin with either Stack Adapter A or B (P/N 703-01044 or 703-01045 respectively). These parts are mirror images of one another and are designed to go on either end of a stack. For stacks longer than 1U, one or more Stack Extenders (P/N 703-01046) must be used in place of thru-hole spacers to secure the center of the stack to the structure. Spacers, threaded rods, and additional stack hardware can be purchased separately from Pumpkin Inc.

³ www.checkline.com/products/TSD

For more information on assembling instrument stacks, using the stack adapters and stack extender, please refer to *SUPERNOVA_Stack_Adapter_Assembly_Notes_20180509.pdf*.

3.3 Uniquely Shaped Equipment

Equipment that doesn't fit into PC-104 stacks can also be used with SUPERNOVA™. Some third-party components will require custom mounting brackets to install. It is recommended that payloads that cannot make use of the provided adaptor brackets be attached to both the base plate and top plate. As a rule of thumb, each of the six cell areas of the SUPERNOVA™ structure should have at least one rigid member fastened to both the base plate and top plate with at least two M3 screws per side.

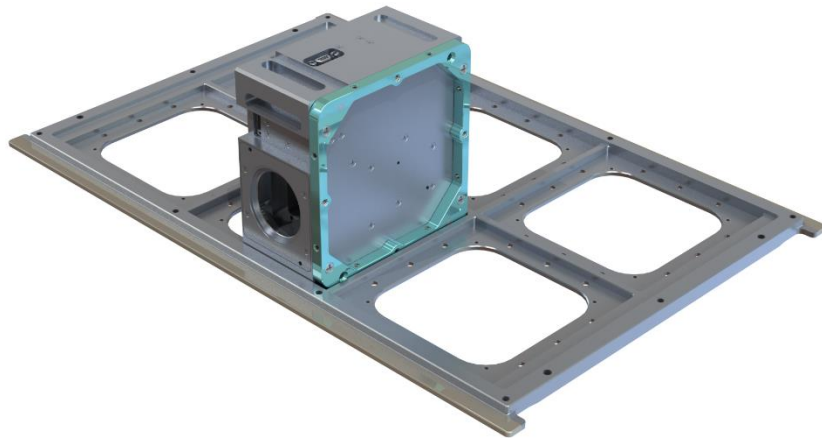


FIGURE 15: 3RD PARTY COMPONENT WITH CUSTOM MOUNTING BRACKET

4 CARE AND CLEANING

- Isopropyl alcohol can be used to clean all parts of the SUPERNOVA™ structure
- Always use cotton/nylon inspection gloves when handling components to avoid marking and leaving skin oils and residues
- SUPERNOVA™ is shipped with orange covers on the CSD tabs. These can be left in place until the spacecraft is ready to be integrated into the CSD to protect the tabs from dirt and damage.
- Extra care should be taken to ensure that no dirt, oils, or other material (such as metal shavings) is present in or around tapped holes prior to inserting fasteners.

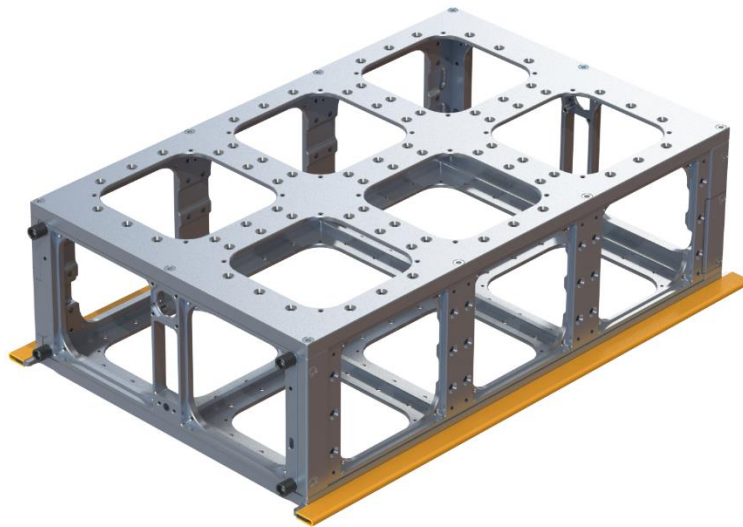


FIGURE 16: SUPERNOVA™ STRUCTURE WITH TAB COVERS

5 ADDITIONAL INFORMATION

5.1 CAD Models

3D CAD Models of the SUPERNOVA™ structure are available for download from Pumpkin's website.

5.2 CSD Specifications

The following specifications were used in the design of the SUPERNOVA™ and are available from Planetary Systems Corporation at www.planetarysystemscorp.com.

- Canisterized Satellite Dispenser (CSD) Data Sheet – 2002337E
- Payload for Canisterized Satellite Dispenser (CSD) Spec. Sheet – 2002367E
- Data Sheet for 4000383 Rev A Separation Switch Assembly – 2002204A
- Data Sheet for Separation Connector Assembly – 2001025C

5.3 References

1. Latta, Robert C., "Structural Analysis of a 6U Cubesat Chassis," M.S. thesis, Dept. Aeronautics & Astronautics, AFIT, Wright-Patterson Air Force Base, OH, 2014.

5.4 Acknowledgements

Dr. Eric Swenson, AFIT
 Phillip Smith, AFIT
 Robert Latta, AFIT
 Walter Holemans, Planetary Systems Corp.
 Ryan Hevner, Planetary Systems Corp.