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6U SUPERNOVA™ Structure Kit

Owner's Manual

REV A0 –10/2/2014 – SJH

Contents

APPLICATIONS

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

FEATURES

- 6U-size CubeSat Structure
- 7000cc payload volume
- Compatible with Planetary Systems Corporation (PSC) Canisterized Satellite Dispenser™
- Anodized 7071 base plate provides a predictable load path within launcher
- Modular architecture allows a wide range of bus configurations and flight orientations
- Structure can accommodate 6 full-sized 10x10x10cm CubeSats with additional room available for cable routing, external instruments, solar panels, etc.
- Accommodates PSC Separation Connector for passing power & data to CubeSat bus while inside dispenser
- Over 10kg allowable mass in addition to structure
- Included covers allow for easy RF shielding

1 SUPERNOVA SYSTEM OVERVIEW

1.1 Introduction

Pumpkin's SUPERNOVA™ series 6U CubeSat structure kit provides a platform for rapid integration of mission hardware into a flight ready CubeSat spacecraft. The precision machined chassis 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 chassis 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 chassis. This allows for distributed development and ease of re-configuration in response to mission demands.

In addition to the basic chassis assembly, the SUPERNOVA™ structure kit comes with a selection of mounting hardware, covers, and adapters 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 with separation connector.

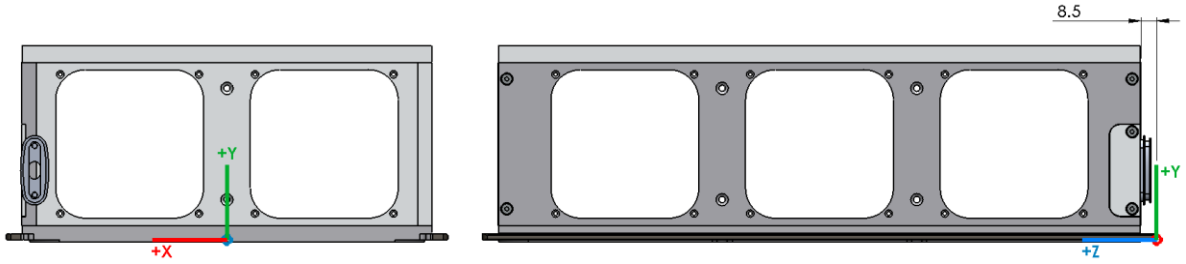

FIGURE 1: REFERENCE COORDINATES

TABLE 1: STRUCTURE PARAMETERS (W/O COVERS)

PARAMETER	VALUE	UNITS
Empty chassis mass	1.64	kg
Total allowable mass in CSD	12.00	kg
Internal volume	7000	cc
Overall width (-X, +X)	239.2	mm
Overall height (-Y, +Y)	105.6	mm
Overall length (+Z)	365	mm
Center of mass, X	0	mm
Center of mass, Y	51	mm
Center of mass, Z	183	mm

1.3 Components List

TABLE 2: CHASSIS ASSEMBLY COMPONENTS

QTY	COMPONENT	PUMPKIN P/N	MATERIAL
1	Base Plate	703-01040	Al-7075
1	Top Plate	703-01041	Al-6061
1	Y Wall	703-01042	Al-6061
1	Z Wall	703-01043	Al-6061
1	Y Wall Sep Conn	703-01049	Al-6061
1	Z Wall Sep Conn	703-01050	Al-6061
1	Separation Connector Bracket	703-01051	Al-6061
29	Screw, M3x12mm Flat Socket Head	N/A	18-8 SS

TABLE 3: ADDITIONAL COMPONENTS & SPARES

QTY	COMPONENT	PUMPKIN P/N	MATERIAL
5	Stack Adapter A	703-01044	Al-6061
5	Stack Adapter B	703-01045	Al-6061
3	Stack Extender	703-01046	Al-6061
10	Side Cover	703-01047	Al-6061
12	Extended Cover	703-01048	Al-6061
16	Threaded Rod, M3 x 75mmL	631-00884	Steel
8	Threaded Rod, M3 x 180mmL	631-00885	Steel
4	Threaded Rod, M3 x 286mmL	631-00977	Steel
40	Threaded F/F Standoff, M3 x 15mmL, 6mm Hex	N/A	Aluminum
72	Spacer, M3-Thru, 15.24 (0.600”) x 6mm OD	N/A	Aluminum
4	Screw, M3x12mm Flat Socket Head	N/A	18-8 SS
96	Screw, M3x8mm Flat Socket Head	N/A	18-8 SS
92	Screw, M2.5x4mm Flat Socket Head	N/A	18-8 SS

1.4 Tools

A 1.5mm and 2mm hex driver are included with the structure kit for preliminary assembly and disassembly. It is recommended that an electronic torque wrench is used for final assembly.

1.5 Chassis External Dimensions

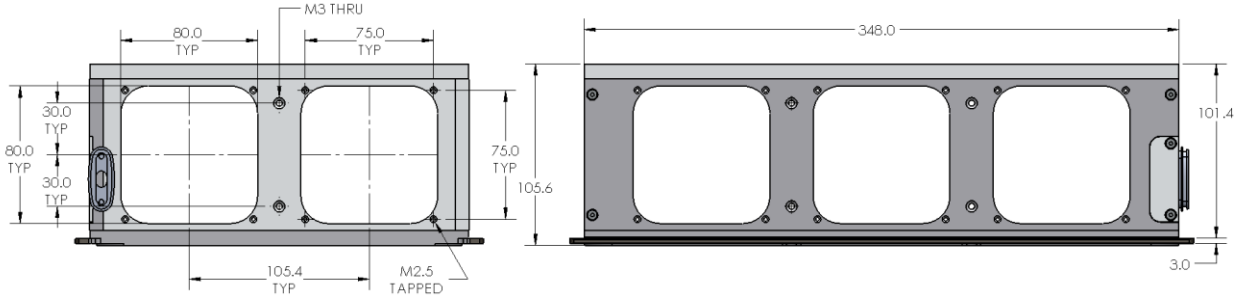

FIGURE 2: EXTERNAL DIMENSIONS - SIDE

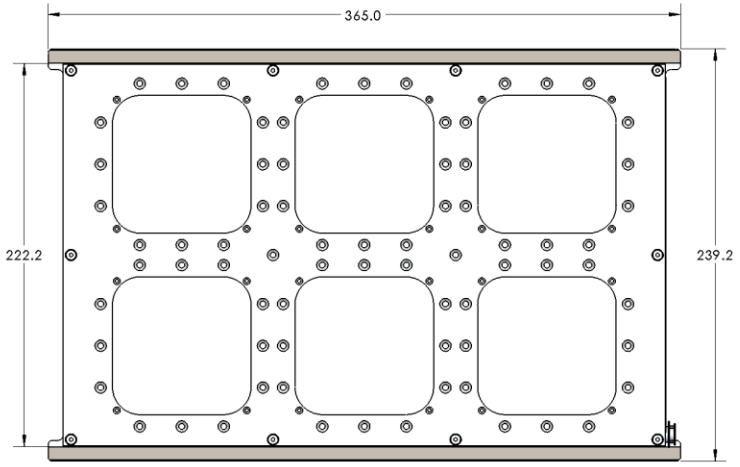

FIGURE 3: EXTERNAL DIMENSIONS – TOP

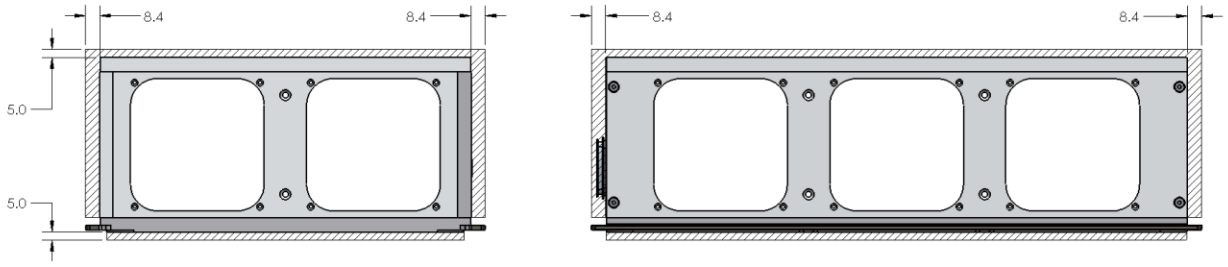

FIGURE 4: ALLOWABLE VOLUME OUTSIDE CHASSIS

1.6 Chassis Internal Dimensions

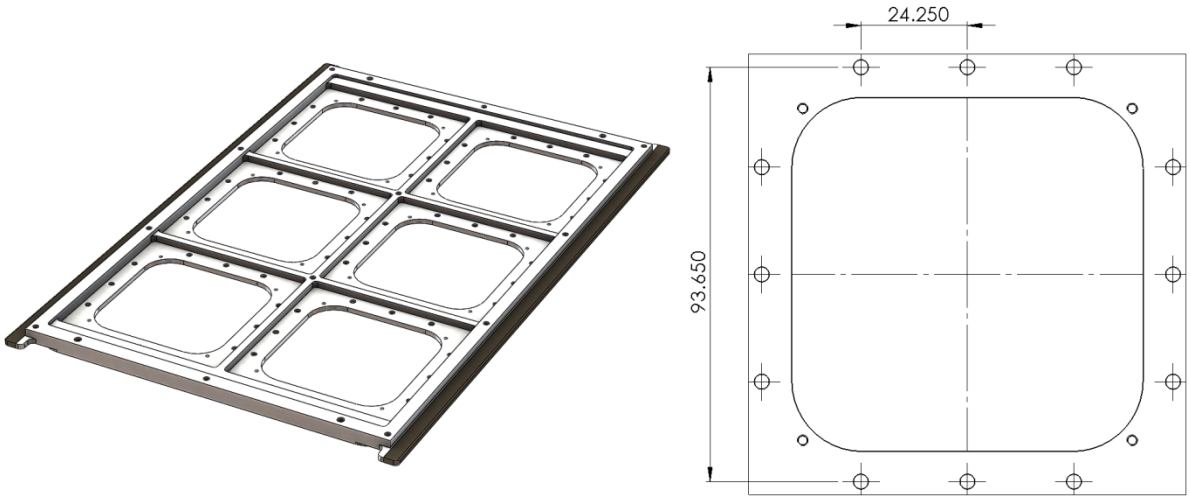

FIGURE 5: CELL LAYOUT & MOUNTING HOLE PATTERN

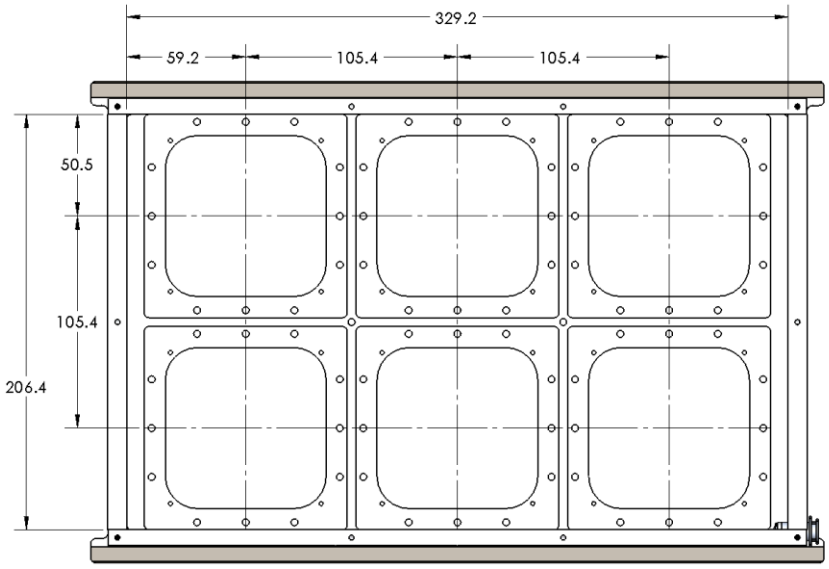

FIGURE 6: INTERNAL DIMENSIONS - TOP VIEW

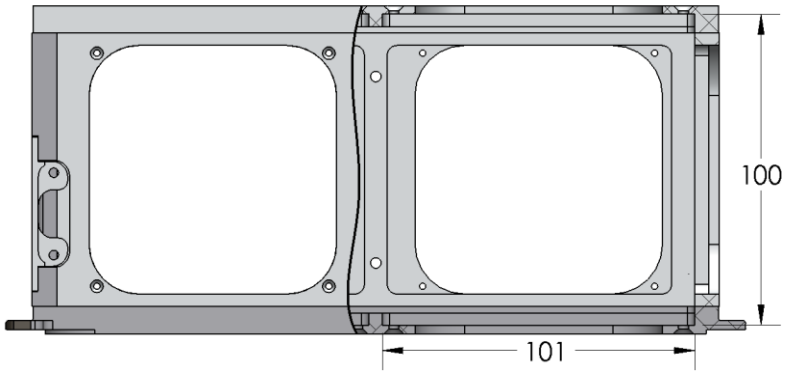

FIGURE 7: CUTAWAY - CELL CROSS SECTION

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 (2002367 Rev A). Note that the CSD specification also requires a set of contact points and inhibit switches which are not included in the base SUPERNOVA™ structure kit. A Pumpkin CSD inhibit switch module is forthcoming.

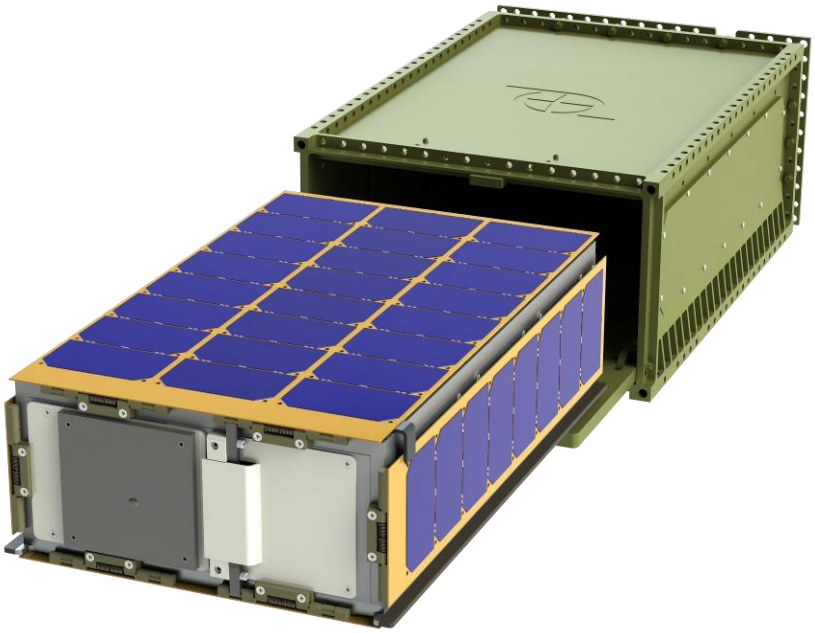

FIGURE 8: SUPERNOVA™ SPACECRAFT DEPLOYING FROM CSD

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.

FIGURE 9: PSC SEPARATION CONNECTOR & MOUNTING BRACKET

1.8 Flight Configurations & Deployables

SUPERNOVA™ enables flexibility in flight orientation and deployable solar panel configuration. Shown below are 3 possible configurations. Deployable solar panels and bus electronics can be purchased separately from Pumpkin Inc.

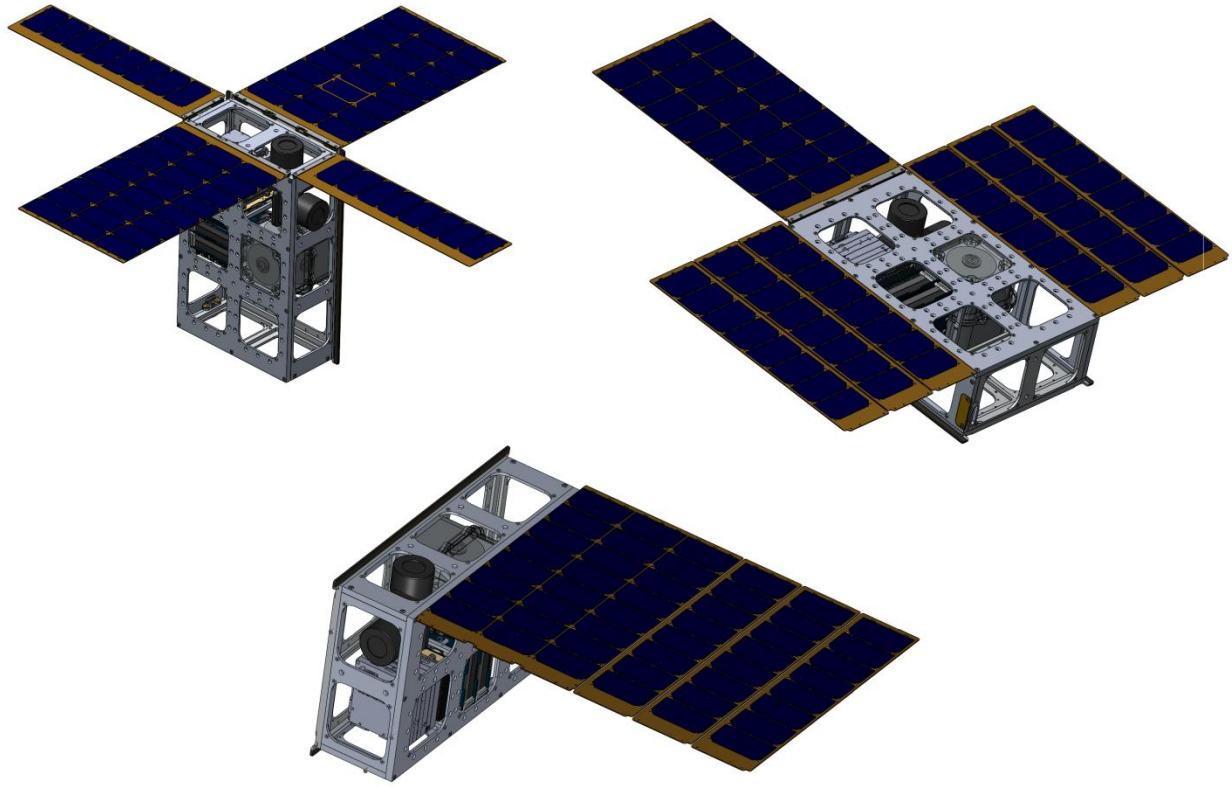

FIGURE 10: EXAMPLE FLIGHT CONFIGURATIONS

2 CHASSIS ASSEMBLY

2.1 Assembly Overview

A high level of symmetry and minimal number of fastener types ensures that SUPERNOVA™ assembly is quite straightforward. The chassis is composed of seven main components, which are fastened together by 29 M3-0.5 x 12mm long flat-head screws, as well as up to 22 cover panels fastened by M2.5-0.4 x 4mm long flat head screws.

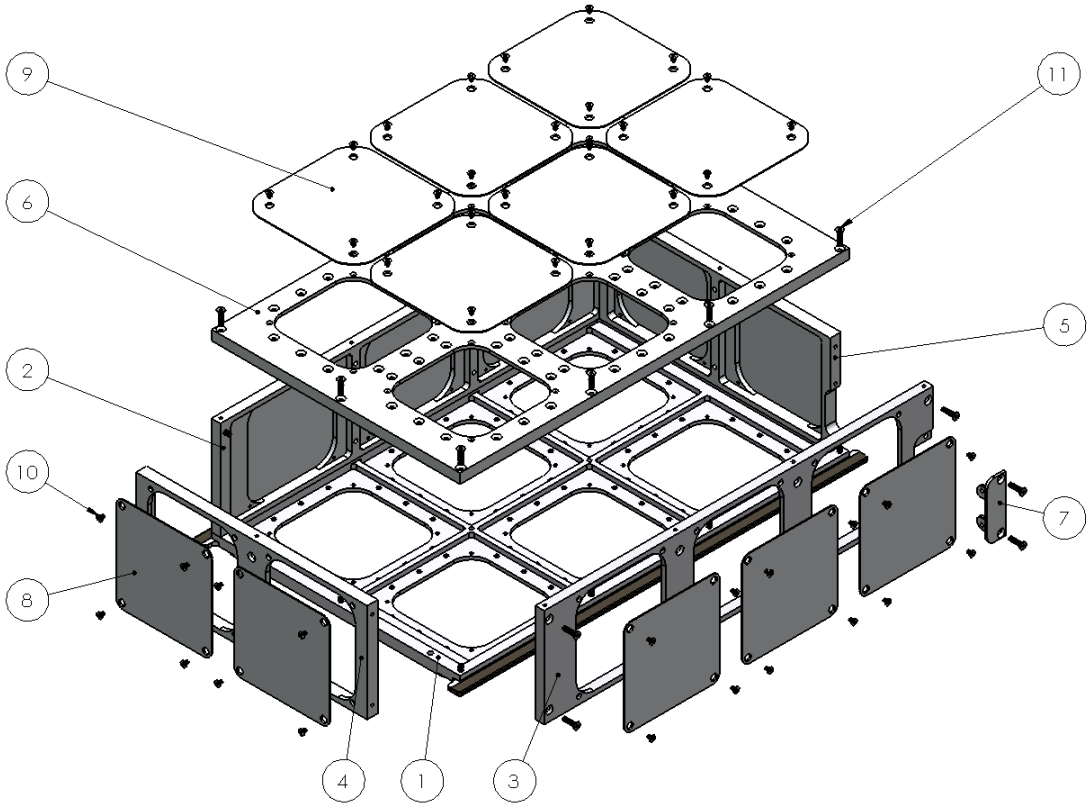

FIGURE 11: SUPERNOVA™ CHASSIS ASSEMBLY

TABLE 4: FIGURE 11 KEY

ITEM #	PART NUMBER	DESCRIPTION	QTY.
1	703-01040	Base Plate	1
2	703-01042	Y Wall	1
3	703-01049	Y Wall Sep Conn	1
4	703-01043	Z Wall	1
5	703-01050	Z Wall Sep Conn	1
6	703-01041	Top Plate	1
7	703-01051	Sep Conn Bracket	1
8	703-01047	Side Cover	10
9	703-01048	Extended Cover	12
10	N/A	Screw, M2.5 FlatPhil	88
11	N/A	Screw, M3 Flat Socket	29

Parts 703-01040, 703-01042, 703-01043, & 703-01041 are symmetric in 2 planes so their assembly orientation doesn't matter as long as the correct side is facing outward.

Parts 703-01049 & 703-01050 have cutout features to allow for a PSC separation connector. The cutouts must be oriented such that they are closer to the base plate than the top plate.

Part 703-01051 is a removable bracket for mounting the separation connector. 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 chassis (see section 3 – *Payload Integration*).
2. Orient and fasten stacks loosely to Base Plate.
3. Route cabling between stacks.
4. Mount Y and Z Walls.
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 2.3 *Final Assembly* to prep and torque fasteners for flight.

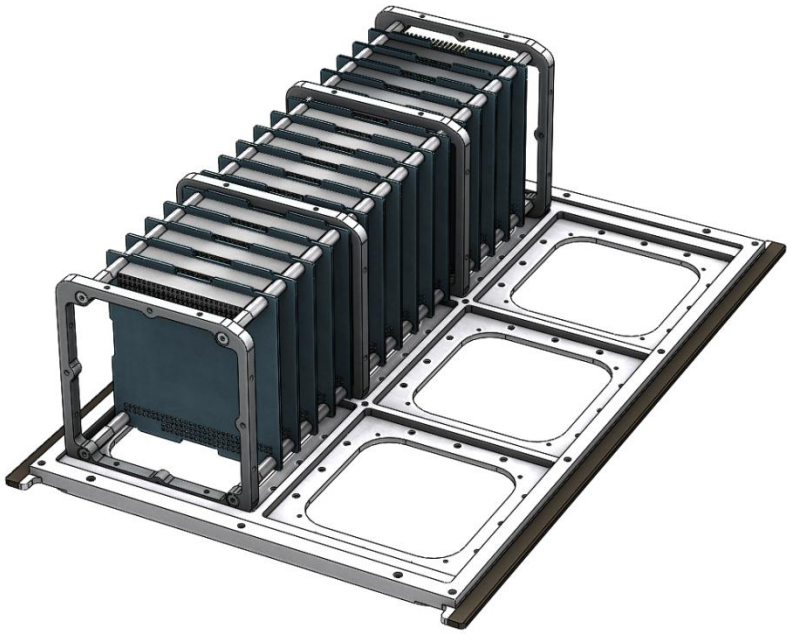

FIGURE 12: '3U' STACK MOUNTED TO BASEPLATE

2.2 Preliminary Assembly

For preliminary assembly, it is recommended that all M3 fasteners to be used are inserted and loosely engaged before tightening any of them, then, *gently* hand-tighten each screw. Every component and screw should come together easily during assembly– avoid using force to engage fasteners or align components.

2.3 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
- Apply Loctite® *222MS* thread locking compound to screw threads*
- Insert screw and use electronic torque wrench to tighten according to table 5 below.

TABLE 5: FINAL ASSEMBLY TORQUE SPECIFICATIONS

SCREW THREAD SIZE	TORQUE (NM)
M3-0.5	0.45(1)

*The use of Loctite® thread-locking compounds in space equipment is not universally accepted. Pumpkin has successfully used this method to lock fasteners on multiple successful nanosatellite missions. SUPERNOVA end-users are ultimately responsible for the proper application of locking compounds and tightening torques to fasteners.

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 the SUPERNOVA™ chassis.

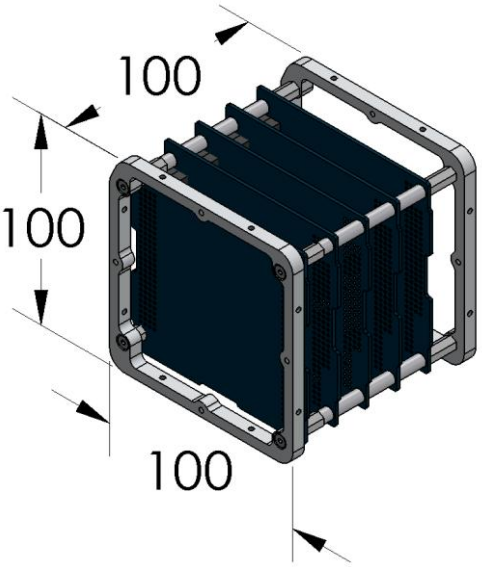

FIGURE 13: '1U' STACK OF PC104 BOARDS

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

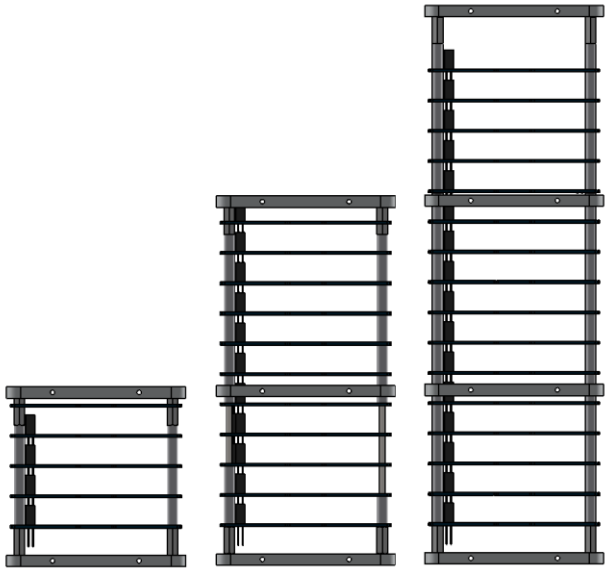

FIGURE 14: '1U', '2U', AND '3U' STACKS

3.2 Assembling Instrument Stacks

Begin with either *Stack Adapter* A or B (# 703-01044 or 703-01045). These are mirror images of one another and are designed to go on either end of a stack. With 4 M3 x 8mm screws and 4 threaded hex standoffs, attach the hex standoffs to the adapter as shown. The appropriately sized threaded rods can then be screwed into the hex standoffs to form a base and rails for sliding on PC-104 boards and standoffs. Next, PC-104 boards can be slid on to the assembly, adding thru-hole spacers between boards as needed. When desired stack height is reached, use 4 more hex standoffs to secure the stack, then fasten the opposite stack adapter onto the remaining end.

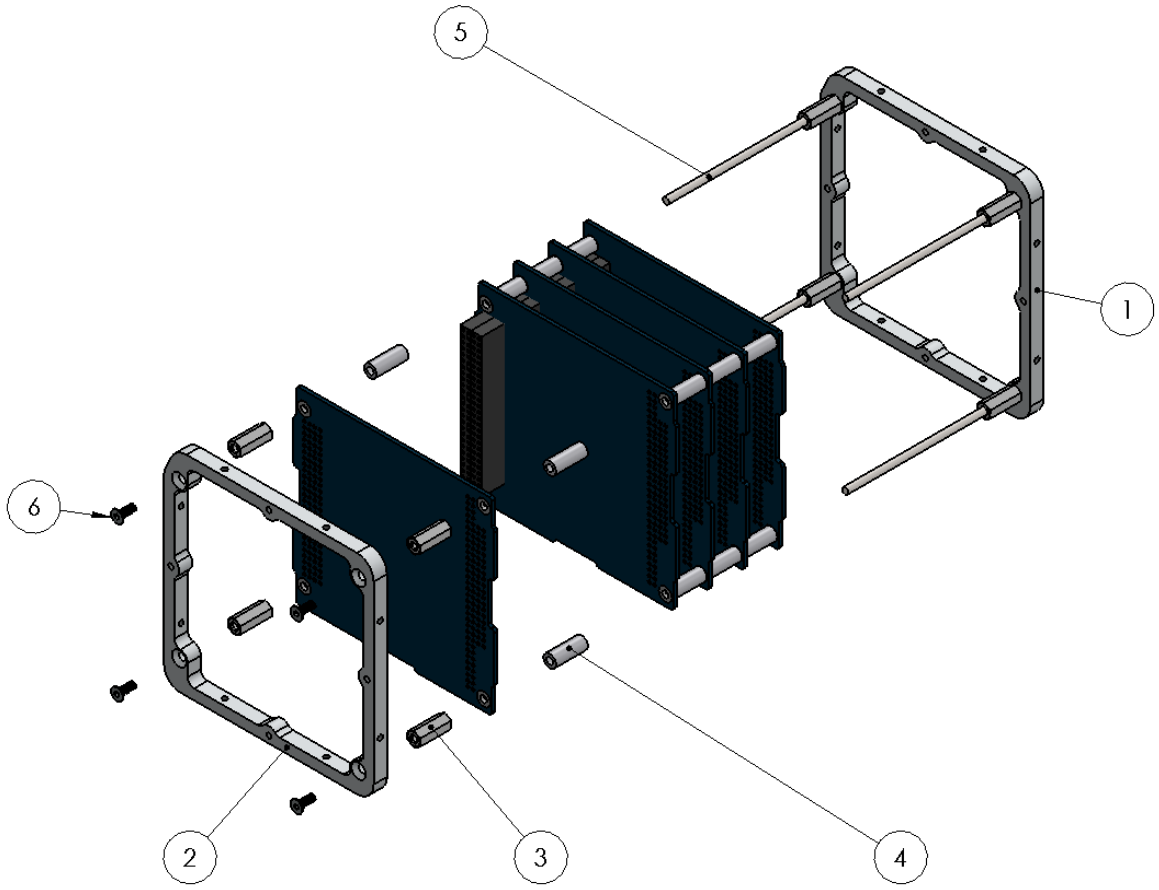

FIGURE 15: STACK ASSEMBLY VIEW

TABLE 6: FIGURE 15 KEY

ITEM NO.	PART NUMBER	DESCRIPTION	1U/QTY.
1	703-01044	Stack Adapter A	1
2	703-01045	Stack Adapter B	1
3	N/A	Standoff, Hex, F-F, M3 x 15	8
4(1)	N/A	Standoff, Round, Thru, M3	Varies
5(2)	631-00258	1U Threaded Rod	4
6	N/A	Screw, M3 Flat Socket	8

Note (1): For stacks longer than 1U, #703-01046 *Stack Extender*, needs to be employed as a spacer, aligned with cell mounting holes.
Note (2): For stacks longer than 1U, use the appropriate 2U or 3U threaded rod.

For stacks longer than 1U, one or more *Stack Extenders* (#703-01046) must be used in place of thru-hole spacers to secure the center of the stack to the chassis. *Note that Stack Adapters and Stack Extenders have a notch in one corner that will always align in a stack.*

Because of varying sizes of PC boards, connector heights, etc. various sizes of thru-hole spacers will likely be needed for building stacks and some spacer machining or grinding will usually be necessary for the adapter spacing to meet the base plate mounting hole pattern. A jig for easily building up stacks of the correct size will be available from Pumpkin in the future. Additional spacer lengths can be purchased directly from Pumpkin.

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 are attached to both the base plate and top plate. As a rule of thumb – each of the 6 cell areas of the SUPERNOVA™ should have at least one rigid member fastened to both the base plate and top plate with at least 2 M3 screws per side.

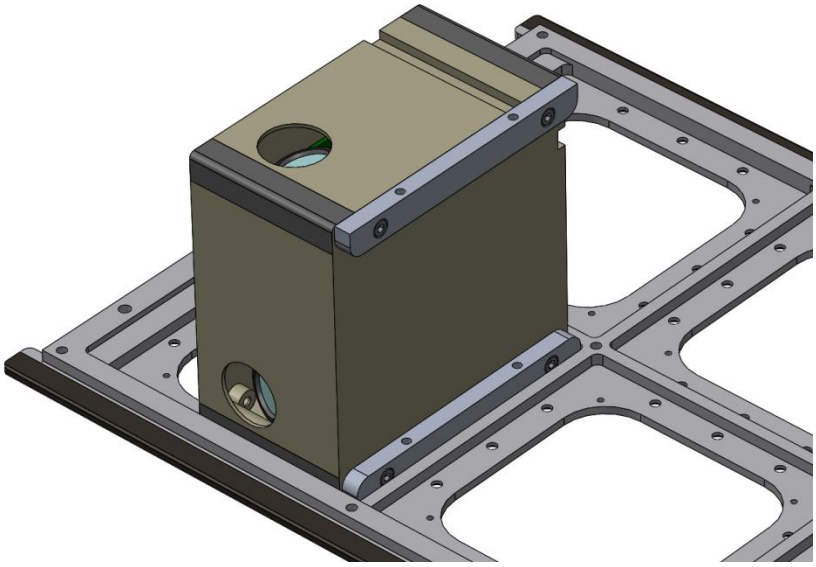

FIGURE 16: 3RD PARTY COMPONENT WITH CUSTOM BRACKET

MAI-400 ADACS SHOWN

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 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.

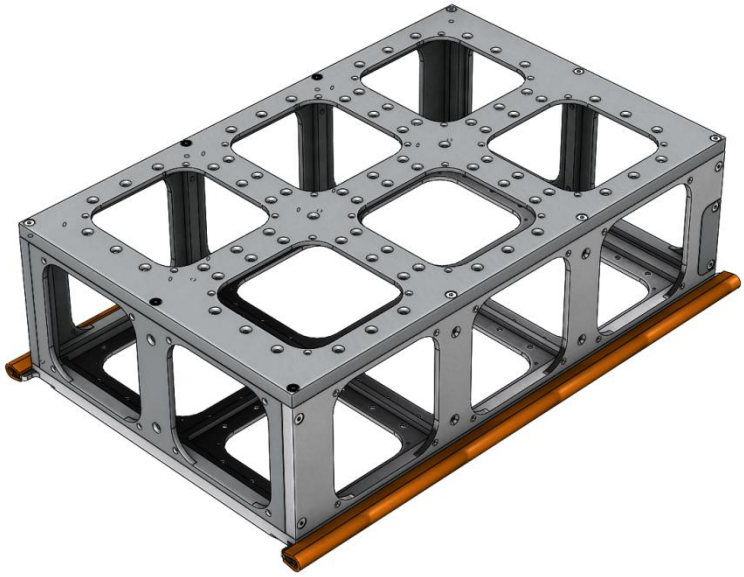

FIGURE 17: SUPERNOVA TM STRUCTURE WITH TAB COVERS

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 – 20022337B
- Payload for Canisterized Satellite Dispenser (CSD) Spec. Sheet – 200236B
- Data Sheet for 4000383 Rev A Separation Switch Assembly – 2002204 Rev –
- 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

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