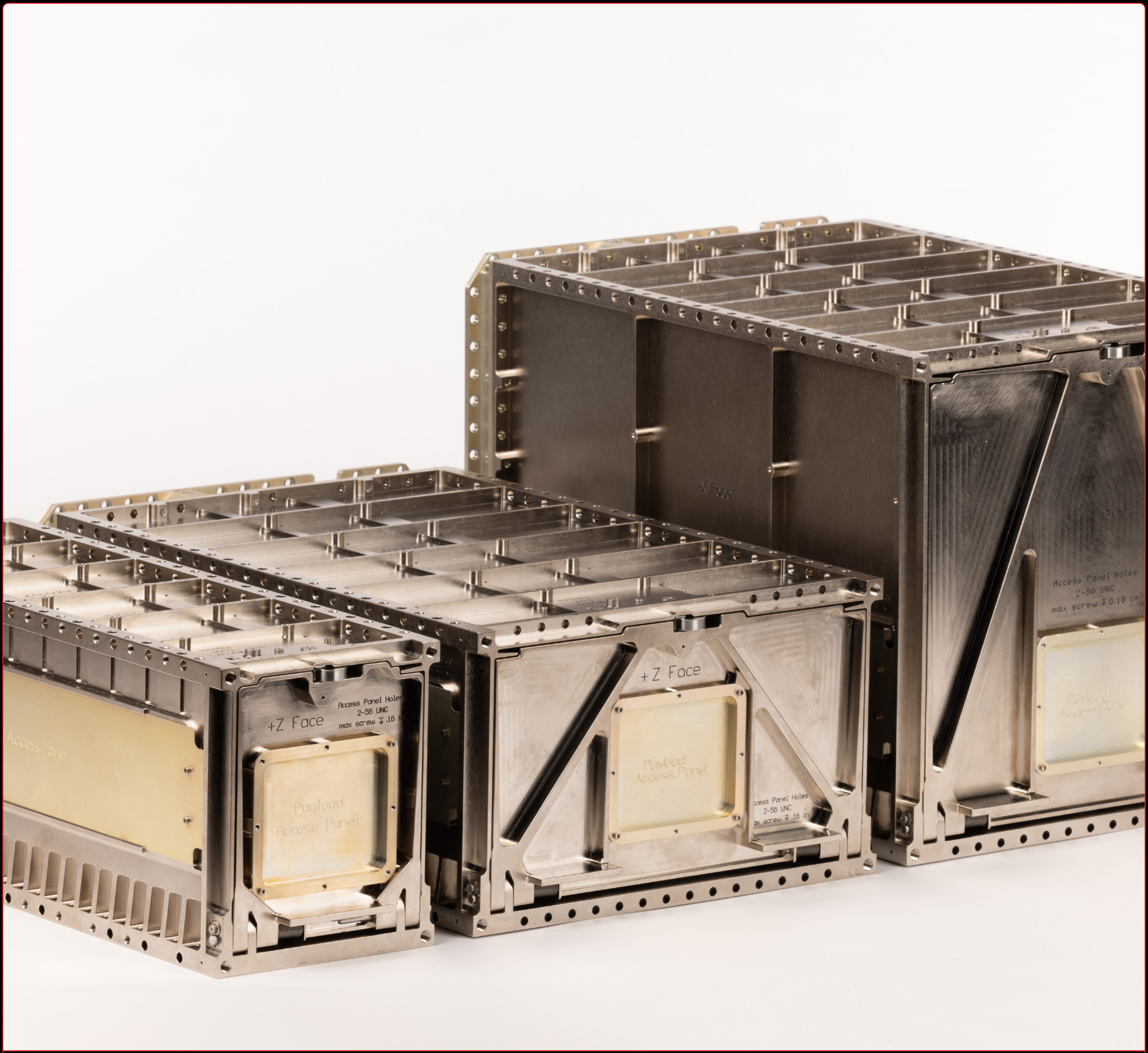

CANISTERIZED SATELLITE DISPENSER

Payload Specification for 3U, 6U & 12U | 2002367F

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This is a standalone specification intended for payload designers. Planetary Systems Corporation does not design or manufacture payloads.

1. FEATURES AND BENEFITS

- **Preloaded Payload Tabs** create a modelable load path to the payload so strength at critical locations like reaction wheel bearings can be accurately calculated. Preload means the payload can't jiggle and damage itself.
- **Separation Electrical Connector** allows communication and charging between payload and launch vehicle prior to and during launch. It also grounds the payload to the CSD
- **Dispenser Constrained Deployables** greatly reduce the costs and complexity of payload deployables like solar panels and antennas.
- **Largest Volume** versus existing designs accommodates larger payloads. Payloads have 15% more volume and can be 1 inch longer than standard CubeSats.
- **Unrestricted External Shape** eliminates need for four corner rails.
- **Safe/Arm Access on Front** ensures payload access at all times via CSD door.
- **Flight Validated** in 2013.
- **Fully Documented** mechanical and electrical interfaces and CAD models available on request allowing rapid and low-cost design.
- **Parametric Design** commonality allows users easy understanding of electro-mechanical interface for 3U, 6U and 12U sizes.
- **Cross Compatible** with existing CubeSat standards via tab attachment.

2. DESCRIPTION

These payloads are fully contained within a Canisterized Satellite Dispenser (CSD, canister or dispenser) during launch. A CSD encapsulates the payload during launch and dispenses it on orbit. CSDs reduce risk to the primary payload and therefore maximize potential launch opportunity. They also ease restrictions on payload materials and components. This specification currently encompasses three payload sizes, 3U, 6U and 12U.

The payloads incorporate two tabs running the length of the ejection axis. The CSD will grip these tabs, providing a secure, modelable, preloaded junction. This is essential to accurately predict loads on critical components and instrumentation and prevent jiggling.

The payload may use the CSD to restrain deployables. The allowable contact zones are defined.

A payload can be built to this specification without knowledge of the specific dispenser within it will fly. Similarly, dispenser manufacturers will be ensured of compatibility with payloads that conform to this specification.

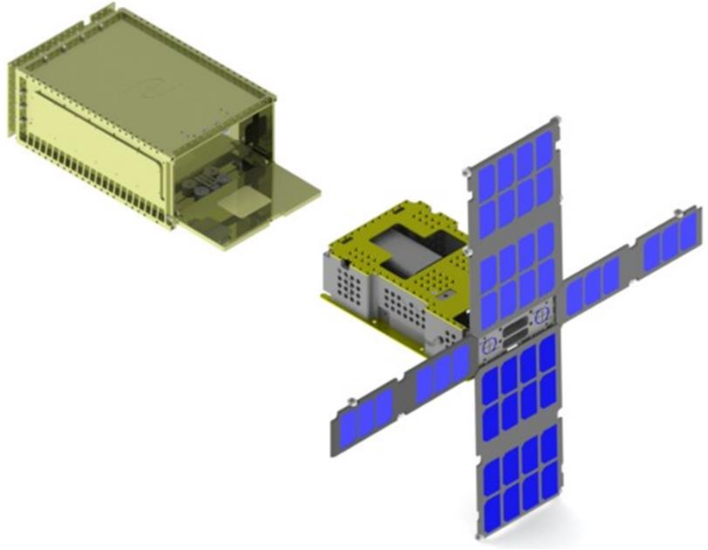


Figure 2-1: Payload deploying from CSD

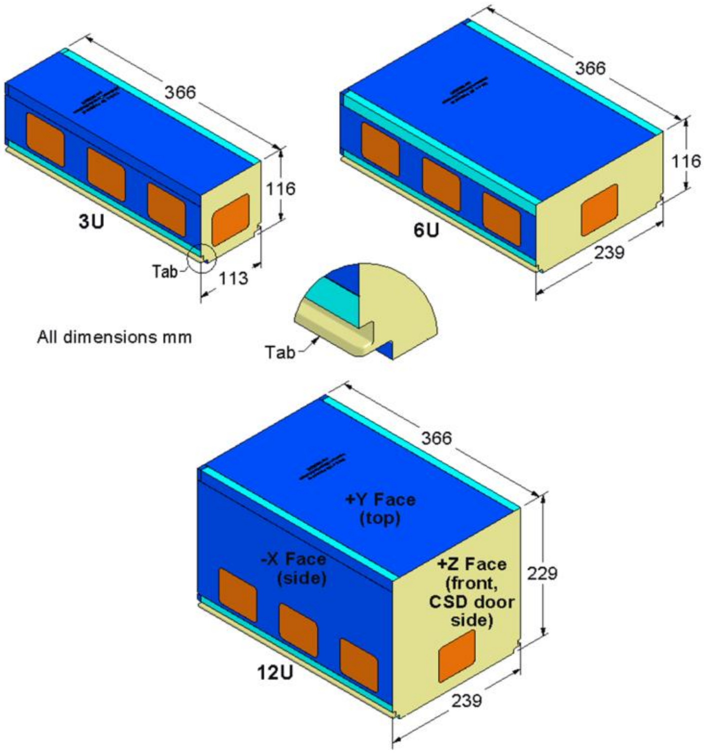


Figure 2-2: Payload sizes (max external dimensions)

CONTENTS

3. PARAMETERS

Table 3-1: Parameters

Symbol	Parameter	Conditions	Unit	3U		6U		12U	
				Min	Max	Min	Max	Min	Max
TL (1)	Tab Load	directional RSS of quasi-static or 3σ random vibration, at payload tabs	N [lb]	-	3559 [800]	-	3559 [800]	-	3559 [800]
CM_X	Center of mass, X	Stowed in CSD	mm [in]	-20 [-.79]	20 [.79]	-40 [-1.57]	40 [1.57]	-40 [-1.57]	40 [1.57]
CM_Y	Center of mass, Y	Stowed in CSD	mm [in]	10 [.39]	70 [2.76]	10 [.39]	70 [2.76]	55 [2.17]	125 [4.92]
CM_Z	Center of mass, Z	Stowed in CSD	mm [in]	133 [5.24]	233 [9.17]	133 [5.24]	233 [9.17]	133 [5.24]	233 [9.17]
Height	Maximum payload depth, +Y dimension		mm [in]	-	109.70 [4.319]	-	109.70 [4.319]	-	222.80 [8.772]
Width	Maximum payload width from origin, ±X dimension		mm [in]	-	56.55 [2.226]	-	119.70 [4.713]	-	119.70 [4.713]
Tab Width	±X dimension		mm [in]	112.7 [4.437]	113.1 [4.453]	239.0 [9.409]	239.4 [9.425]	239.0 [9.409]	239.4 [9.425]
Tab Length	+Z dimension		mm [in]	361 [14.21]	366 [14.41]	361 [14.21]	366 [14.41]	361 [14.21]	366 [14.41]
EP_Y	Ejection plate contact zone, +Y dimension from origin		mm [in]	-	100 [3.94]	-	100 [3.94]	-	213 [8.39]
DC_X1	Deployable contact zone with CSD, ±X face near +Y face		mm [in]	91.4 [3.598]	-	91.4 [3.598]	-	204.5 [8.051]	-
DC_X2	Deployable contact zone with CSD, ±X face near -Y face		mm [in]	-	20.3 [0.799]	-	20.3 [0.799]	-	20.3 [0.799]
DC_+Y	Deployable contact zone with CSD, +Y face (2)		mm [in]	43.85 [1.726]	-	107.0 [4.213]	-	107.0 [4.213]	-
DC_-Y	Deployable contact zone with CSD, -Y face (2)		mm [in]	31.2 [1.228]	-	94.3 [3.713]	-	94.3 [3.713]	-
F_{DS}	Force from optional deployment switches, summated, Z axis (3)	When contacting CSD ejection plate. Per CSD ejection Spring.	N	-	5.0	-	5.0	-	5.0
D_{DS}	Payload separation from ejection plate necessary to change deployment switch state, Z axis	If switches reside on –Z face.	mm [in]	1.3 [.05]	12.7 [.50]	1.3 [.05]	12.7 [.50]	1.3 [.05]	12.7 [.50]
F_{FD}	Friction force deployables impart on CSD walls during ejection	summated (all 4 sides), per CSD ejection spring	N	-	2.0	-	2.0	-	2.0
TML	Total Mass Loss	Per ASTM E 595-77/84/90	%	-	1.0	-	1.0	-	1.0
CVCM	Collected Volatile Condensable Material	Per ASTM E 595-77/84/90	%	-	.1	-	.1	-	.1
DP	CSD de-pressurization rate	During launch	psi/s	-	1.0	-	1.0	-	1.0
D_X	Location of optional separation electrical connector, +X dimension		mm [in]	40.67 [1.601]	41.17 [1.621]	103.84 [4.088]	104.34 [4.108]	103.84 [4.088]	104.34 [4.108]

(1) The total loading at the payload tabs, not the overall mass, is the design driver and limitation for the accompanying dispenser. The load is a function of the payload's stiffness, mass distribution, damping and external loading environment. Typically, the maximum loading results from random vibration or shock and not just the launch vehicle load factors. See Section 10.

(2) Some contact zones are not present on the 3U. Refer to Figure 5-2 for locations.

(3) Ensures payload will not gap from CSD ejection plate prior to separating.

4. COMMON REQUIREMENTS

1. Tabs
    a. Tabs shall be aluminum alloy with yield strength ≥56ksi. 7075-T7351 is common but numerous other alloys also meet this strength requirement. See Metallic Materials Properties Development and Standardization (MMPDS, formerly MIL-HDBK-5) for details.
    b. Holes, countersinks, and any protruding features are prohibited anywhere along the Tabs.
    c. Tabs shall be Hard Anodized per MIL-A-8625, Type III, Class 1. All dimensions apply AFTER hard anodize. Note that anodize thickness refers to the total thickness. As a guideline, approximately half will penetrate and half will build-up (example .002 thickness ≈ .001 penetration + .001 build-up).
    d. Max surface roughness is N7 (1.6 μm Ra, 63 μin AA).
    e. By default, tabs shall run the entire length of the payload. However, discontinuities or gaps are allowed per Section 7. When stowed in the CSD no portion of the payload may extend beyond the tabs in the +Z direction.
2. Dimensions and tolerances in Figure 5-2 shall be maintained under all temperatures. Consider deformation and warping if structure is not aluminum.
3. The structure comprising the –Z face (face that contacts CSD ejection plate) may be a uniform surface or consist of discrete contact points. The discrete contact points shall be located such that they envelope the payload's C.M. and any deployment switches.
4. Contact the launch service provider to determine if payload inhibits (deployment switches) are required. If required, locating on the –Z face such that they contact the CSD's ejection plate is recommended. The deployable contact areas may also be used but consider the effect of tolerance build-up in the dispenser. See Figure 5-2 and Section 12. Also consider using the optional Separation Electrical Connector (ref. 3) as a loopback.
5. Safe/Arm plug, if necessary, shall reside in specified zone on +Z (preferred), +X, or -X face.
6. Deployables shall be verified with the CSD prior to flight.
7. If electrical grounding to the CSD is desired, the Separation Electrical Connector (in-flight disconnect) must be used. See ref. 3.
8. The two tabs and the structure that contacts the CSD ejection plate on the –Z face are the only required features of the payload. The rest of the payload may be any shape that fits within the max dynamic envelope.
9. The maximum dimensions stated in this document are the payload's dynamic envelope and shall include all load cases (vibration, thermal, acoustic, etc.).
10. No debris shall be generated that will inhibit separation.

5. DIMENSIONS

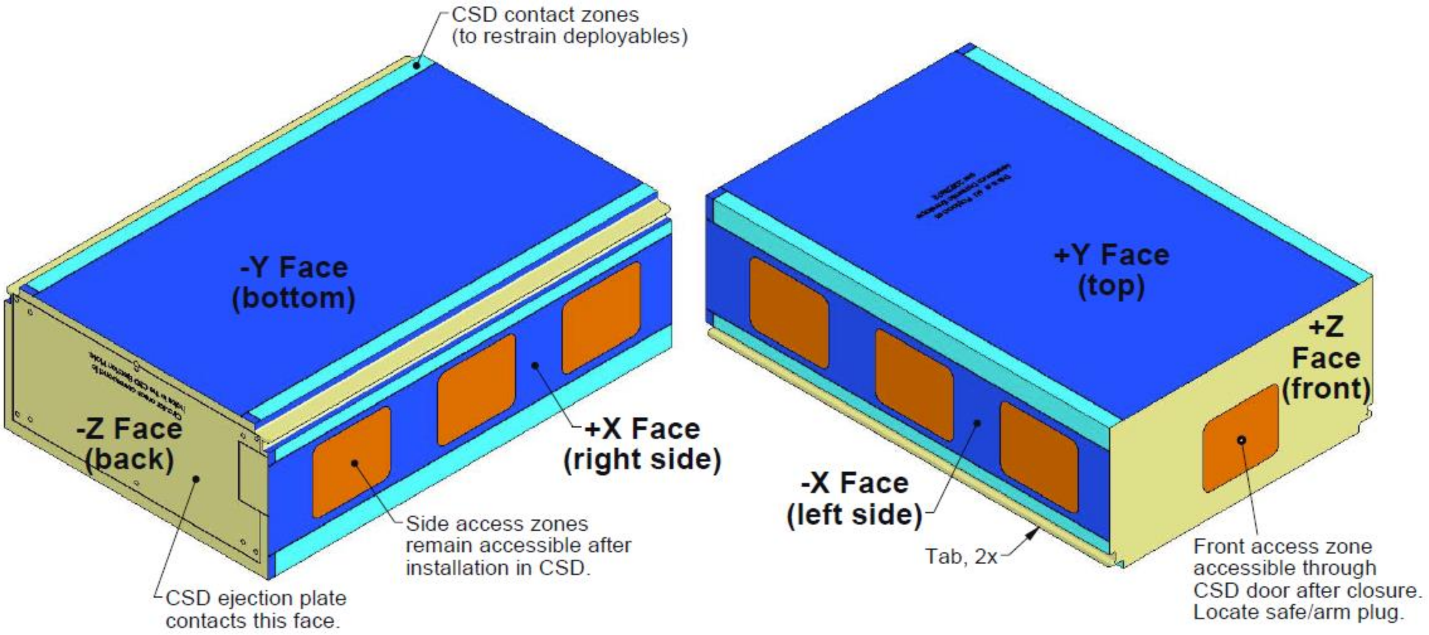
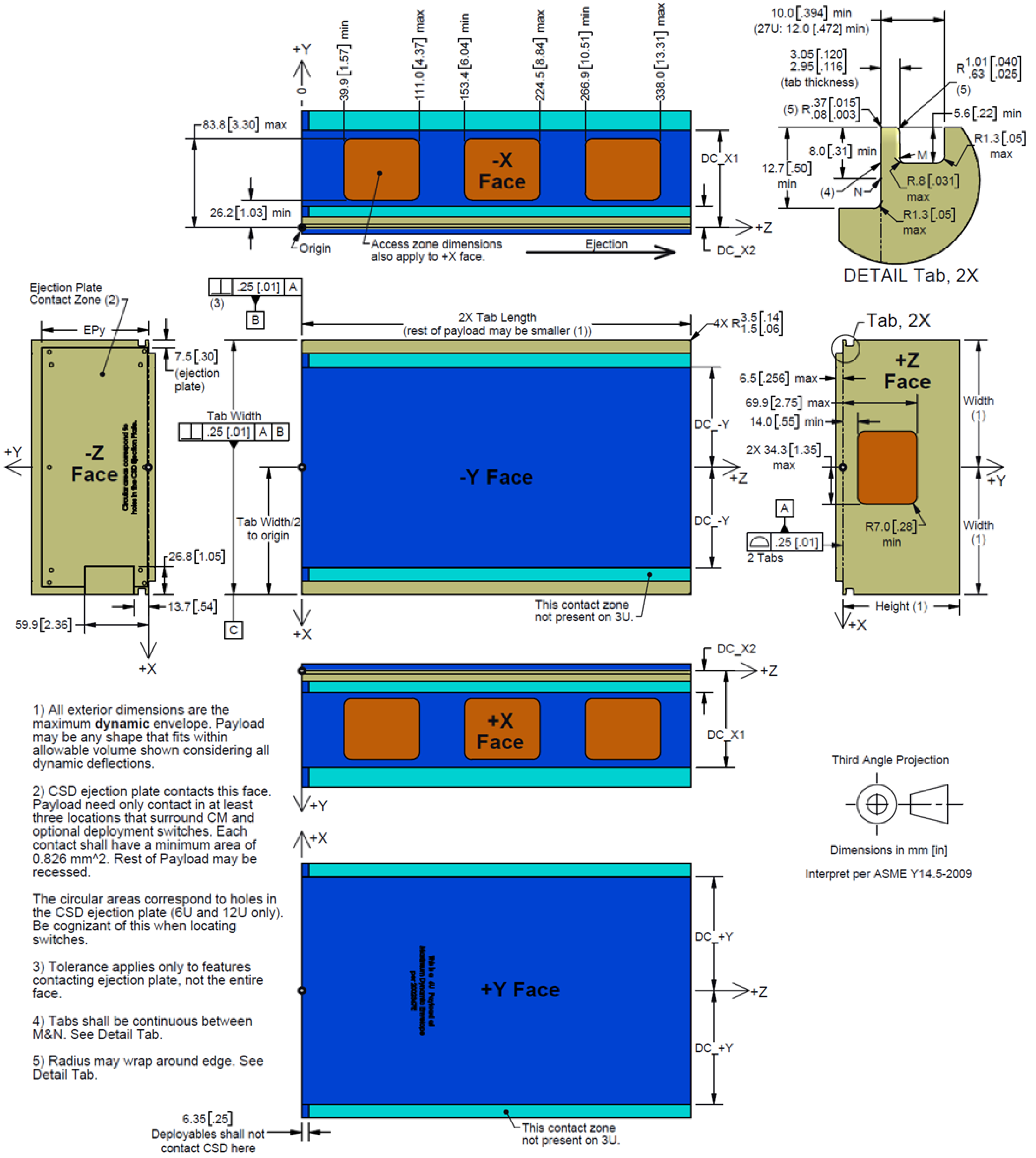


Figure 5-1: Payload features (6U shown)



1) All exterior dimensions are the maximum **dynamic** envelope. Payload may be any shape that fits within allowable volume shown considering all dynamic deflections.

2) CSD ejection plate contacts this face. Payload need only contact in at least three locations that surround CM and optional deployment switches. Each contact shall have a minimum area of 0.826 mm^2. Rest of Payload may be recessed.

The circular areas correspond to holes in the CSD ejection plate (6U and 12U only). Be cognizant of this when locating switches.

3) Tolerance applies only to features contacting ejection plate, not the entire face.

4) Tabs shall be continuous between M&N. See Detail Tab.

5) Radius may wrap around edge. See Detail Tab.

Figure 5-2: Payload dimensions

6. ELECTRICAL SCHEMATIC

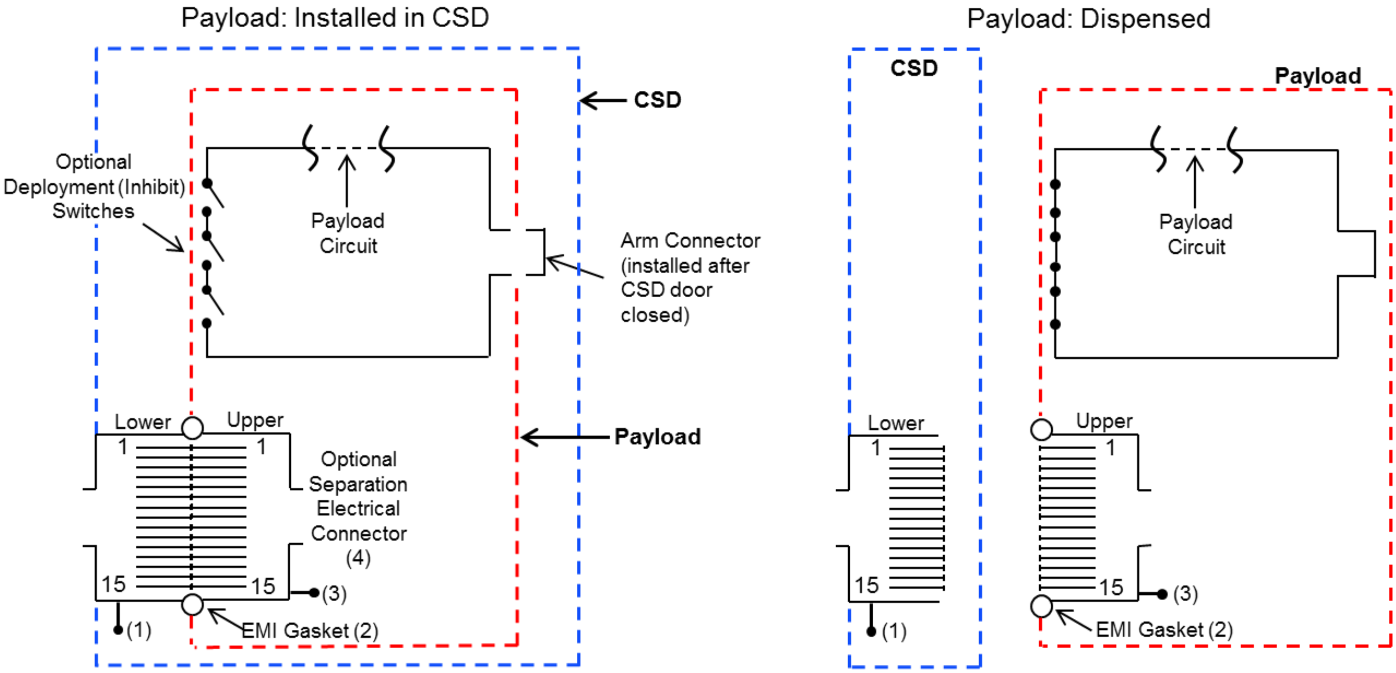


Figure 6-1: Electrical schematic

1) The metal shell conducts to the CSD via conductive surface treatments.
2) Required to assure electrical continuity between shells. Retained by Upper.
3) The metal shell conducts to the Payload via conductive surface treatments.
4) The Separation Electrical Connector is an in-flight disconnect (IFD). It is a custom connector provided by PSC that has significant space-flight heritage. It can be used to transmit power or telemetry. The launch vehicle side of the connector must be removed from the CSD prior to the initial payload installation. It may be re-attached to the CSD after payload installation and door closure. This ensures proper alignment of the connector halves.

The Separation Connector can also be wired as a loopback to indicate separation or in-lieu of the optional payload inhibit switches. This is more mass and volume efficient than employing three discrete limit switches. If doing so, it is recommended to use three loop-back circuits, all of which must go open. This is due to the potential intermittencies in the pins at high shock and vibration levels. See Figure 6-2.

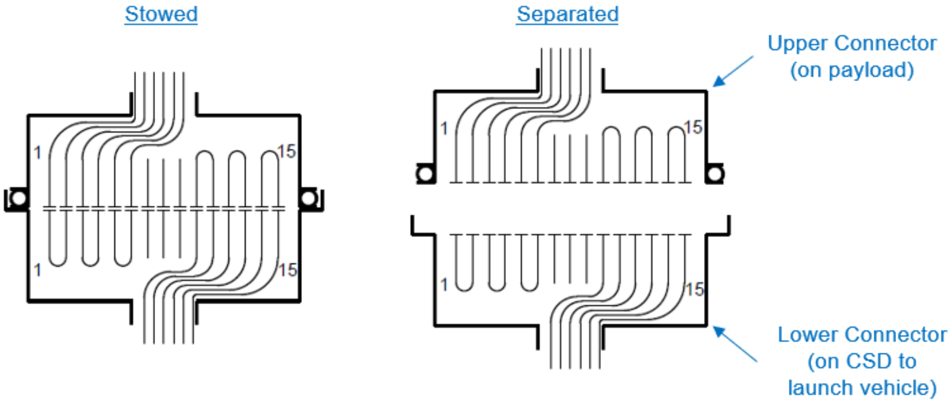


Figure 6-2: Separation Connector loop-back wiring

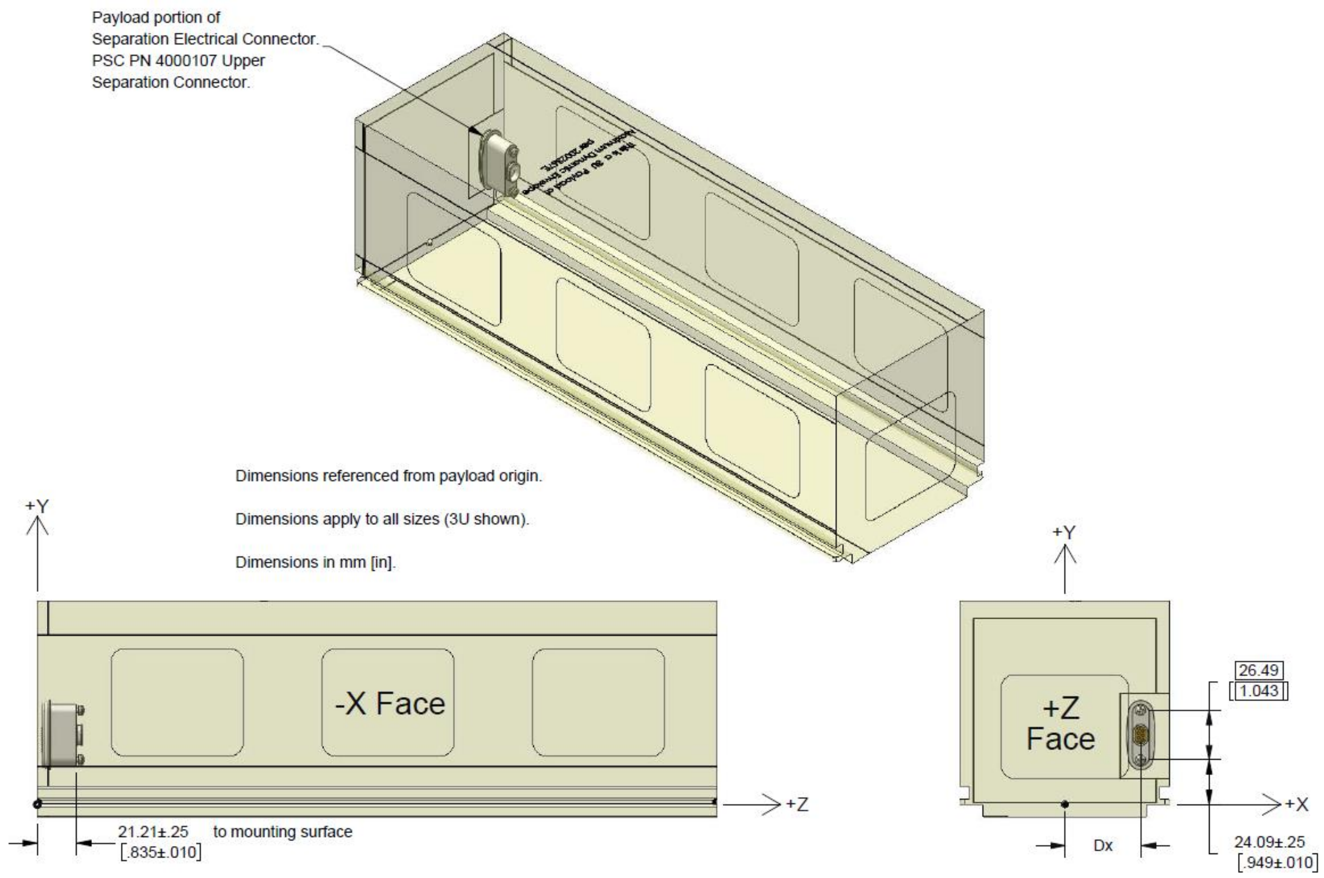
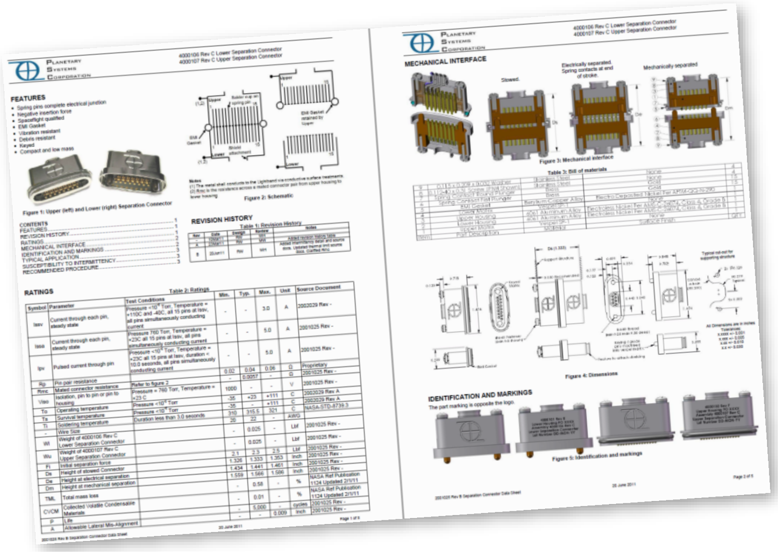


Figure 6-3: Location of optional separation electrical connector

For more information on the Separation Electrical Connector see PSC document 2001025 Separation Connector Data Sheet (ref. 3). Also see section 16.



7. TAB GAPS

A payload may have gaps in the tabs as defined in Figure 7-1. Break or fillet to remove all sharp edges at the gaps.

It is important to note that the allowable payload response, parameter TL in Table 3-1, must decrease as a percentage of the tab length removed. Reducing the payload mass or using an isolation system may be necessary depending on the severity of the launch environment. Consider this when electing to utilize gaps.

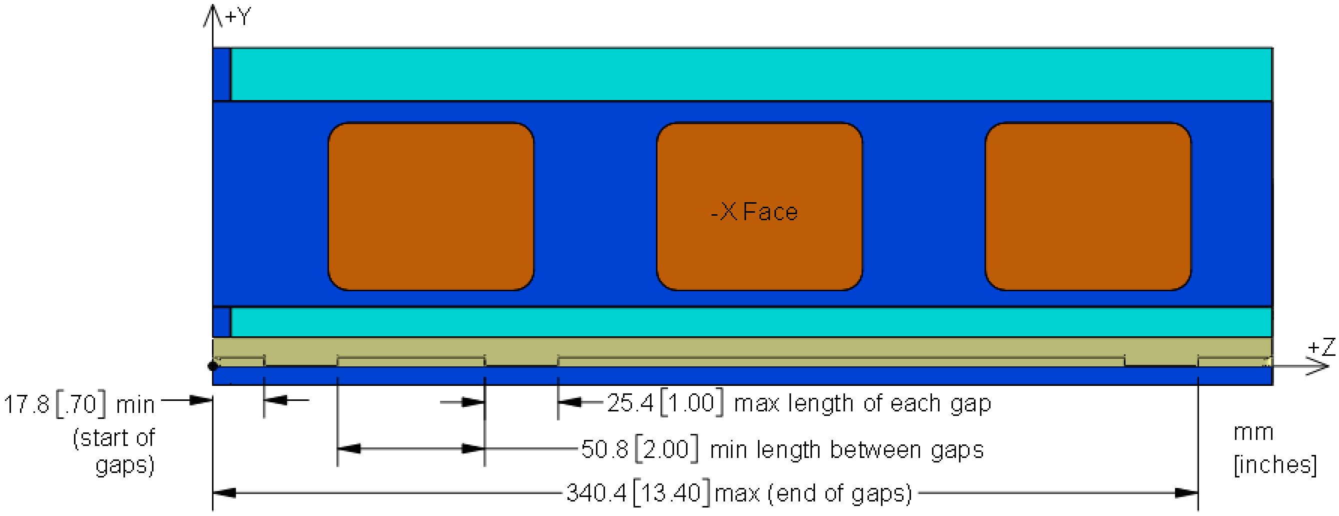


Figure 7-1: Tab gap requirements

8. DISCRETE PAYLOADS

Multi-piece payloads are allowed provided they meet the following requirements.

1) Total length of all pieces: must comply with ‘Tab Length’ in Section 3.
2) Minimum allowable tab length of a single piece: 50 mm [2.0 in].
3) Tab thickness of the extreme fore and aft pieces: equal to or greater than the adjoining piece.
4) All tab gaps shall comply with Section 7.

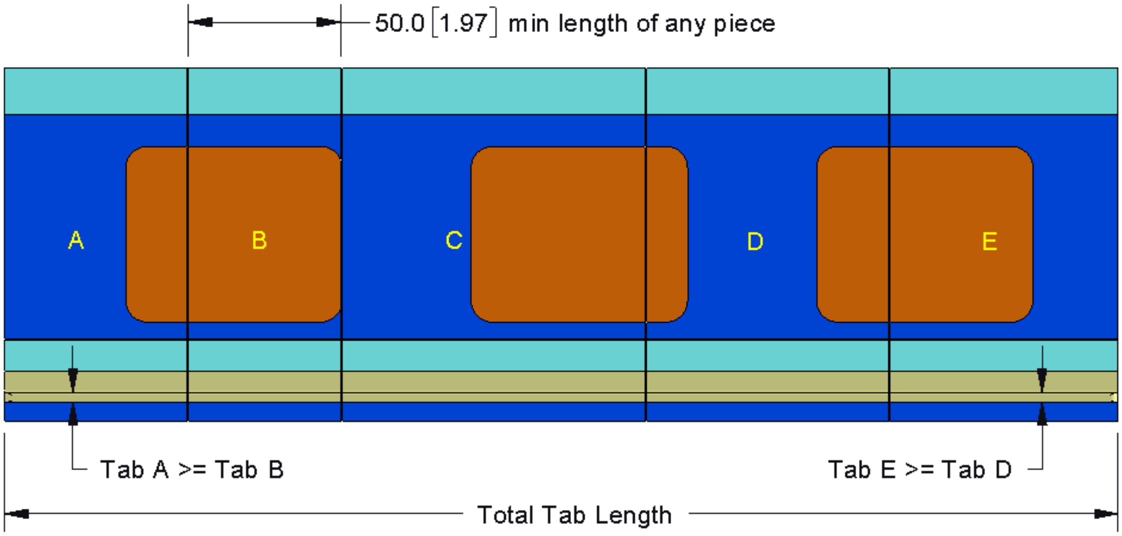
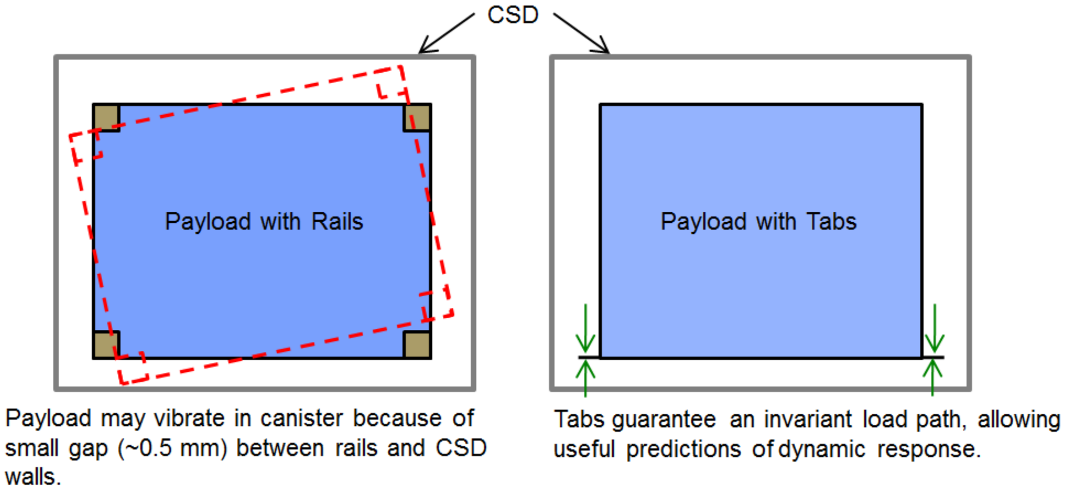


Figure 8-1: Multi-piece payload

9. BENEFIT OF TABS

Preloading the payload to the CSD by virtue of clamping the tabs creates a stiff invariant load path. This allows for accurate dynamic modeling to predict responses in anticipation of vibratory testing and space flight. Confidently predicting response is critical for aerospace structures and sensitive components. A payload that can move inside its dispenser is unmodelable and therefore the loading of sensitive components can not be predicted.



Payload may vibrate in canister because of small gap (~0.5 mm) between rails and CSD walls.

Tabs guarantee an invariant load path, allowing useful predictions of dynamic response.

Figure 9-1: Tabs vs. rails

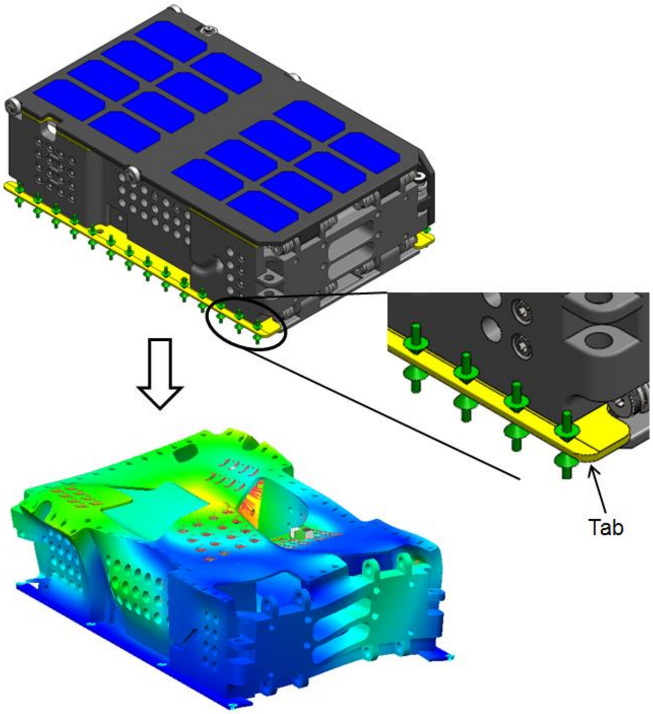
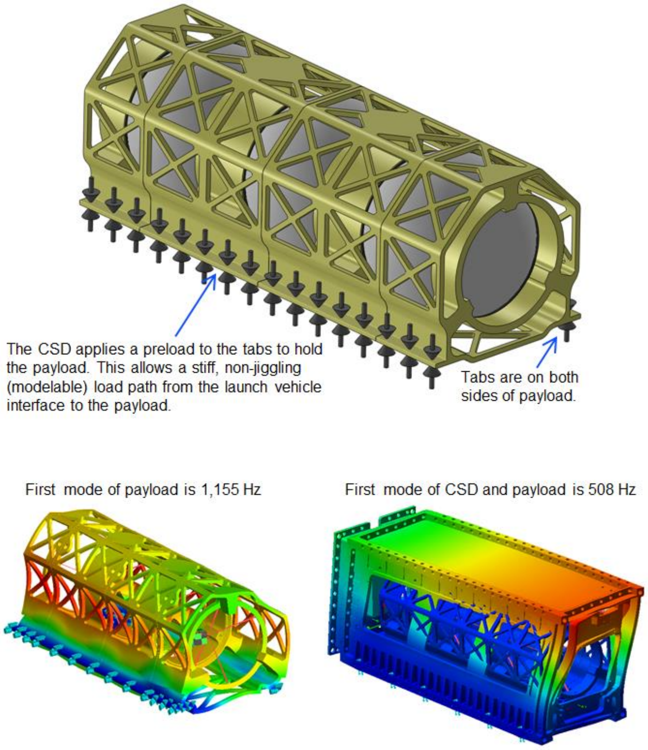


Figure 9-2: Prediction of 6U dynamic response



The CSD applies a preload to the tabs to hold the payload. This allows a stiff, non-jiggling (modelable) load path from the launch vehicle interface to the payload.

Tabs are on both sides of payload.

First mode of payload is 1,155 Hz

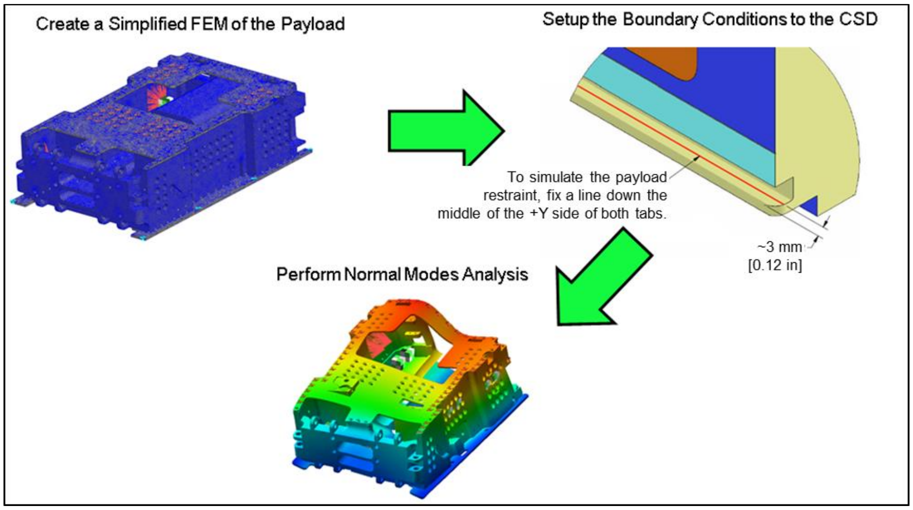
First mode of CSD and payload is 508 Hz

Figure 9-3: Prediction of 3U dynamic response

10. PREDICTING DESIGN LIMIT LOADS

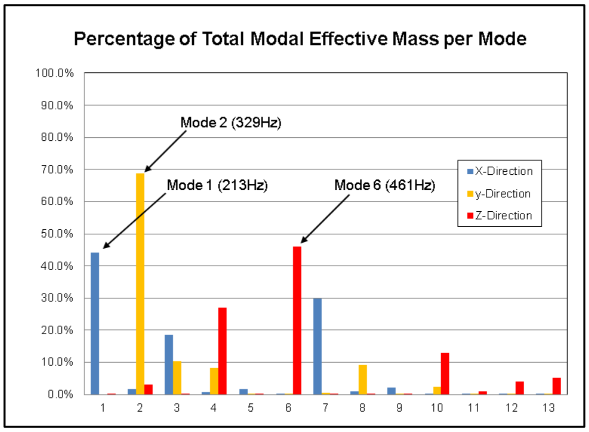
The maximum structural loading typically results from the dynamic response during random vibration testing and/or shock testing. These loads are dependent on the mass, stiffness, and damping properties unique to each payload. The method below provides a rudimentary means of predicting these loads.

1) Create a simplified model of the payload consisting of the primary structure and significant components for a Normal Modes Analysis from 20-2,000Hz.



To simulate the payload restraint, fix a line down the middle of the +Y side of both tabs.

2) Identify the dominant resonant frequencies and mode shapes for each orthogonal direction (X, Y, Z). These modes can be identified as having the highest percentage of Modal Effective Mass relative to all modes modeled within the frequency bandwidth stated above.

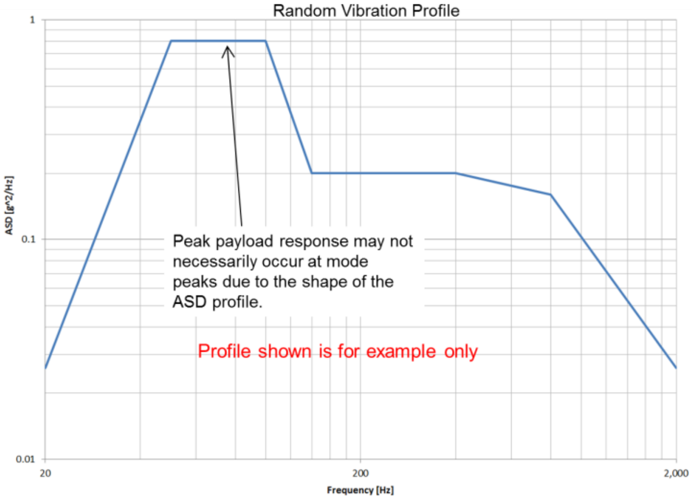


3) The response for a random vibration profile can be predicted by using the Miles Relation shown below:

$$\mathbf{grms} = \sqrt{\mathbf{0.5 * \pi * f_n * Q * ASD}}$$

g_{rms} [g] = 1σ acceleration response
f_n [Hz] = natural frequency (frequency of selected mode)
Q [-] = $\frac{1}{2*\zeta}$ = quality factor (use 10 as an estimate if unsure)
ζ [-] = critical dampening
ASD [g^2/Hz] = input acceleration spectral density at the desired frequency f_n

Assume the peak response is 3σ = 3*g_{rms}



Peak payload response may not necessarily occur at mode peaks due to the shape of the ASD profile.

Profile shown is for example only

Payload design is almost always an iterative process as shown in Figure 10-1. Although small, these payloads are just as complicated as larger satellites. Therefore, the same process of coupled loads analysis and confidently predicted flight loads, stresses and strains is essential.

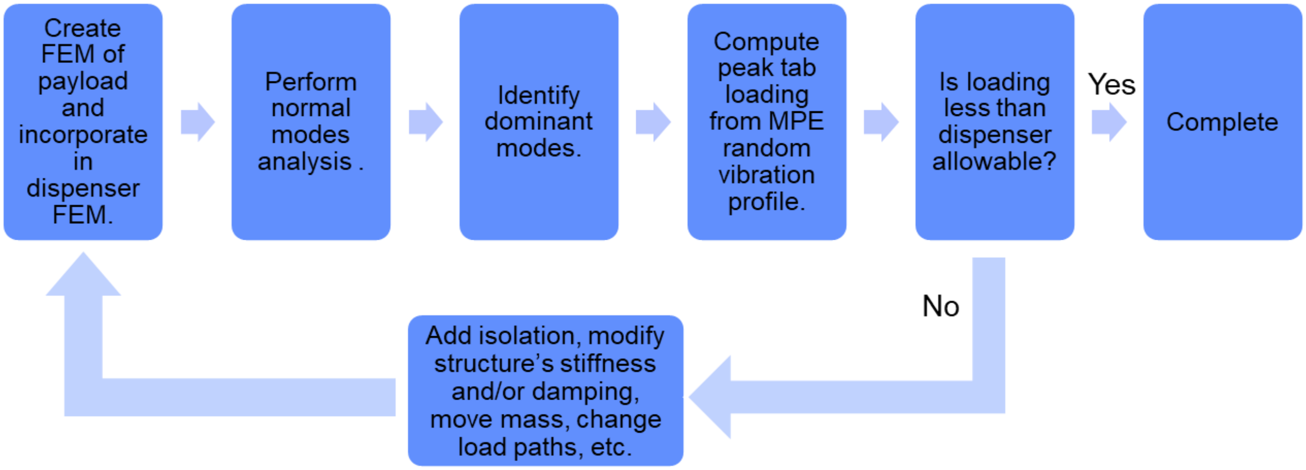


Figure 10-1: Payload dynamic response design process

All payloads behave uniquely. The figure below shows two payload mockups of the same mass with very different responses. The mockup on the left has numerous discrete masses and bolted joints. There are many modes and the damping is typical of many payloads. The mockup on the right consists of a few very stiff aluminum plates. There is one very dominate mode over a wide frequency range and with great amplification that results in significant loading. While heavy and simpler structures are often easier to design and manufacture, they often do not create an optimal load environment for the payload's components because they over simplify and under damp.

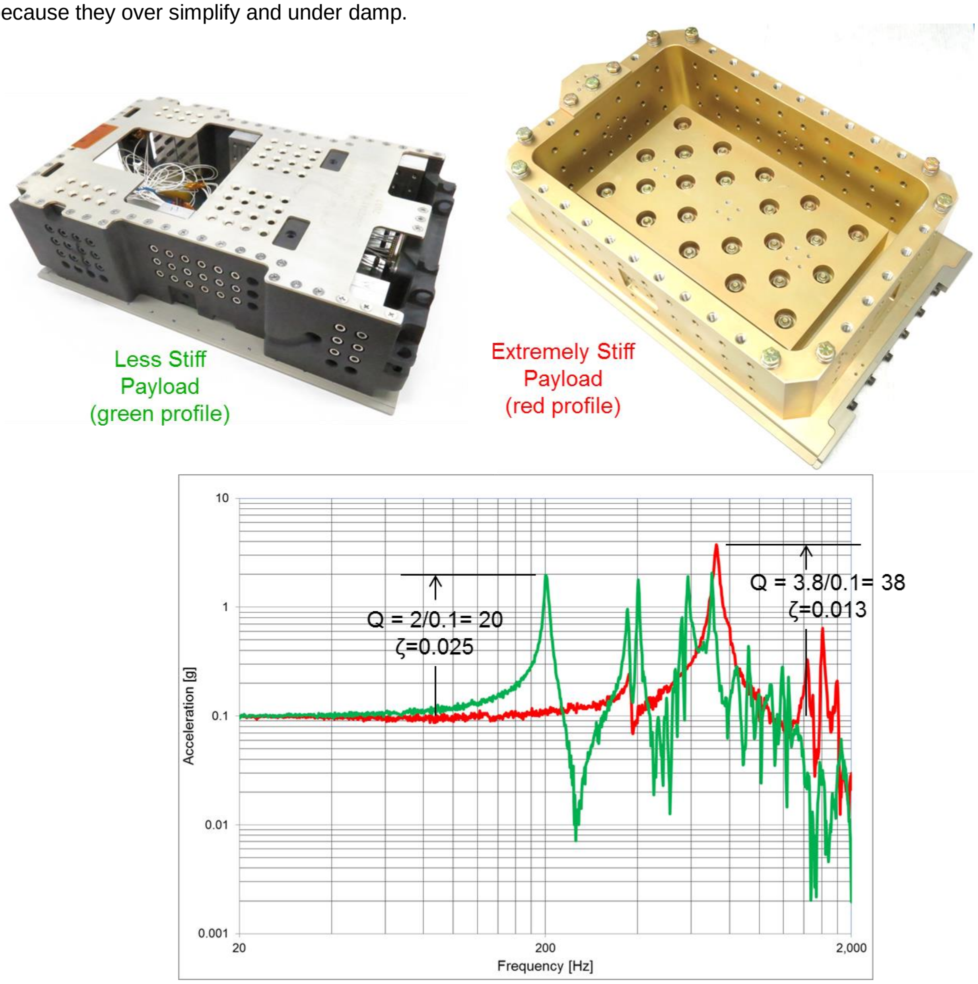


Figure 10-2: Comparison of payload responses

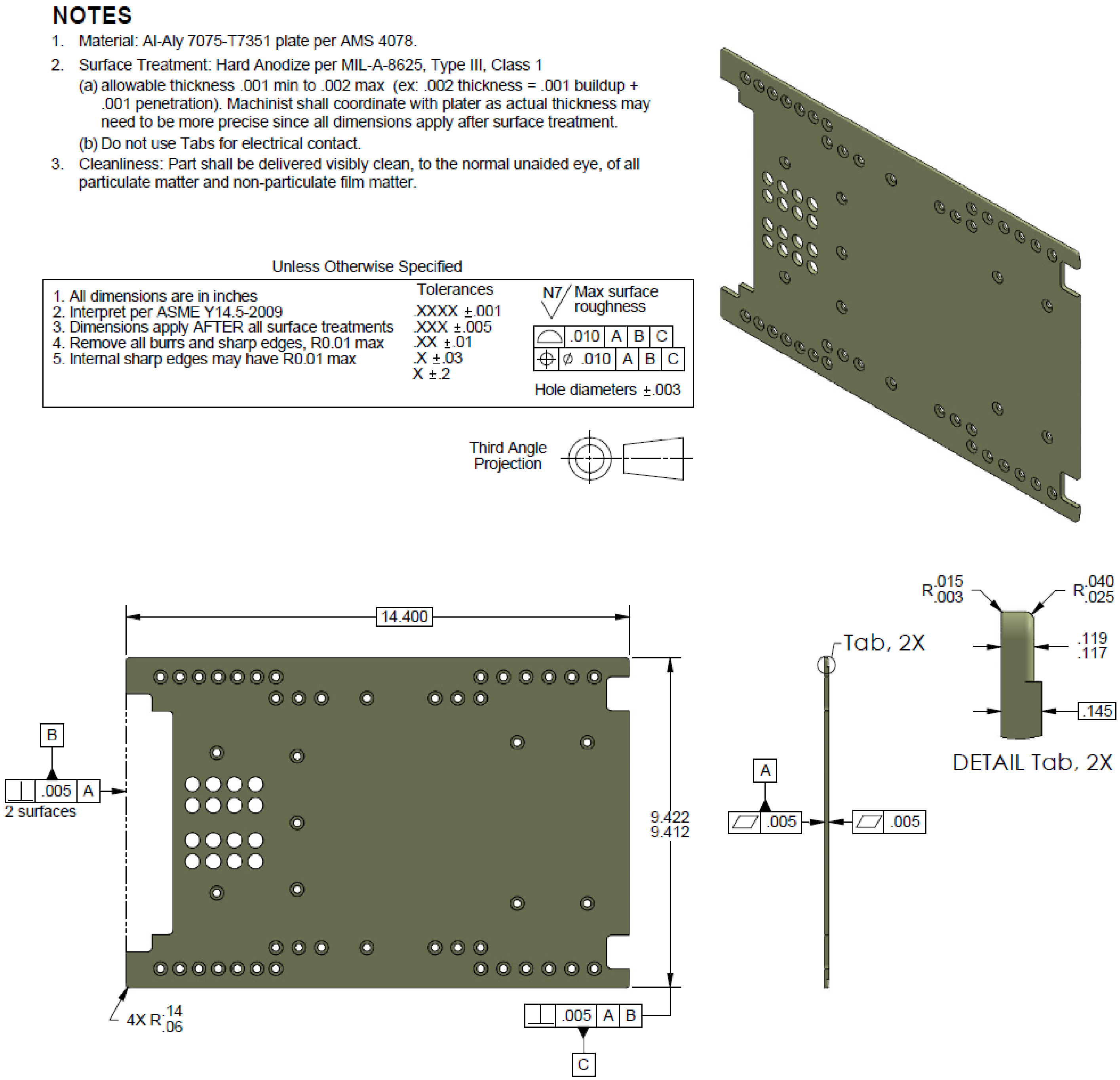
The response of the payload will significantly affect the loading on critical parts like reaction wheel bearings, complex mechanisms, electronic components and optics. Ensuring a consistent load path from the launch vehicle to the payload (i.e. preloading) is the only way to accurately predict the loading from thermal, vibration and shock.

11. TAB MANUFACTURING

Designing and manufacturing tabs that meet the requirements of this document are critical for successful integration and deployment of a payload. As the interface to the CSD, the tabs shall be designed, dimensioned, manufactured, and inspected with care.

Example Production Drawing

The figure below shows an example production drawing of a plate with tabs. **Some of the tolerances are tighter than this specification requires,** ensuring compliance after assembly of the entire payload structure.



NOTES

1. Material: Al-Aly 7075-T7351 plate per AMS 4078.
2. Surface Treatment: Hard Anodize per MIL-A-8625, Type III, Class 1
   (a) allowable thickness .001 min to .002 max (ex: .002 thickness = .001 buildup + .001 penetration). Machinist shall coordinate with plater as actual thickness may need to be more precise since all dimensions apply after surface treatment.
   (b) Do not use Tabs for electrical contact.
3. Cleanliness: Part shall be delivered visibly clean, to the normal unaided eye, of all particulate matter and non-particulate film matter.

Unless Otherwise Specified

1. All dimensions are in inches
2. Interpret per ASME Y14.5-2009
3. Dimensions apply AFTER all surface treatments
4. Remove all burrs and sharp edges, R0.01 max
5. Internal sharp edges may have R0.01 max

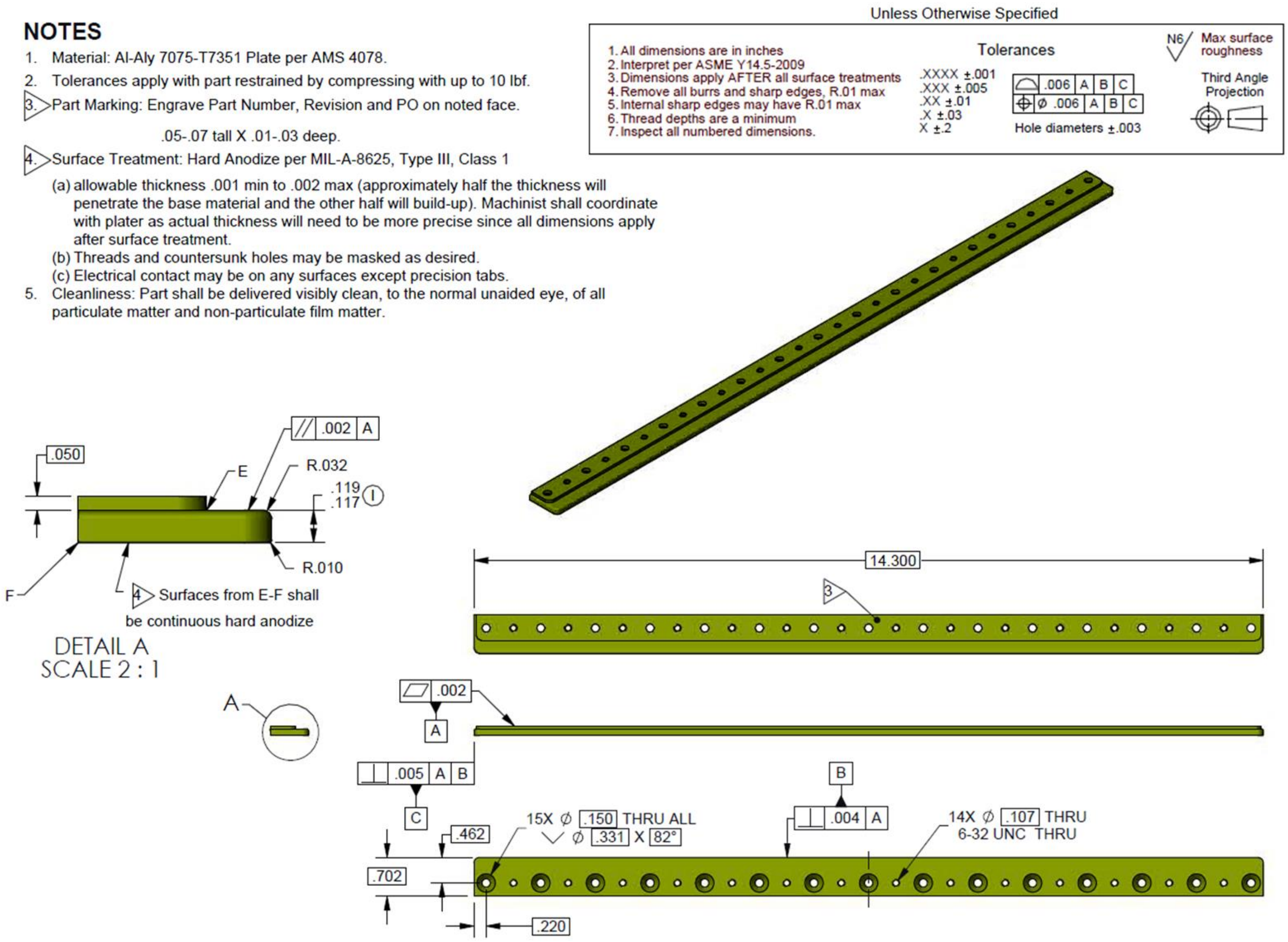
Tolerances
.XXXX ±.001
.XXX ±.005
.XX ±.01
.X ±.03
X ±.2

N7 Max surface roughness

Hole diameters ±.003

Figure 11-1: An example tab plate production drawing

The tabs do not have to be on a discrete plate. They can be bolt-on features or machined into a more intricate structure. Individual bolt-on tabs are beneficial as they can be easily replaced if damaged or manufactured improperly.



NOTES

1. Material: Al-Aly 7075-T7351 Plate per AMS 4078.
2. Tolerances apply with part restrained by compressing with up to 10 lbf.
3. Part Marking: Engrave Part Number, Revision and PO on noted face.
   .05-.07 tall X .01-.03 deep.
4. Surface Treatment: Hard Anodize per MIL-A-8625, Type III, Class 1
   (a) allowable thickness .001 min to .002 max (approximately half the thickness will penetrate the base material and the other half will build-up). Machinist shall coordinate with plater as actual thickness will need to be more precise since all dimensions apply after surface treatment.
   (b) Threads and countersunk holes may be masked as desired.
   (c) Electrical contact may be on any surfaces except precision tabs.
5. Cleanliness: Part shall be delivered visibly clean, to the normal unaided eye, of all particulate matter and non-particulate film matter.

Unless Otherwise Specified

1. All dimensions are in inches
2. Interpret per ASME Y14.5-2009
3. Dimensions apply AFTER all surface treatments
4. Remove all burrs and sharp edges, R.01 max
5. Internal sharp edges may have R.01 max
6. Thread depths are a minimum
7. Inspect all numbered dimensions.

Tolerances

.XXXX ±.001
.XXX ±.005
.XX ±.01
.X ±.03
X ±.2

Hole diameters ±.003

Figure 11-2: Example bolt-on tab drawing

Inspection

Measure the tab thickness using a micrometer as follows. A digital caliper lacks the required accuracy.

Figure 11-3: Measuring tab thickness with micrometer

1) Select a micrometer with an accuracy and resolution of .00005 inches (.001 mm).
2) Ensure micrometer surfaces and tabs are clean.
3) Use a gauge block to verify micrometer accuracy and operator technique.
4) Mark increments at every inch along tab length.
5) Take minimum three measurements at each location to ensure repeatability.
6) Record and plot measurements.
7) All measurements shall be within tolerance. The figure below shows an example of tabs that are NOT acceptable.

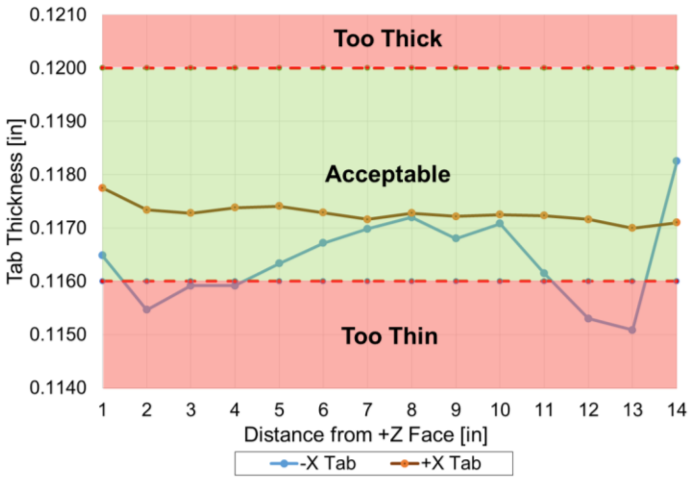


Figure 11-4: Tab thickness measurement

Also verify the following critical aspects of the tabs.

1) All Tab edge fillets are in tolerance. See Detail Tab in Figure 5-2.
2) Hard anodize is continuous along entire tab surface (top, bottom and sides). Location defined as between M-N in Detail Tab in Figure 5-2.

After the payload structure is assembled the tabs shall remain flat per Figure 5-2. Place the payload on a verified flat surface (granite surface plates are ideal). A .010 inch thick feeler (thickness) gauge or diameter .010 gauge pin (plug gauge) shall not fit under any portion of the tab. See Figure 11-5 and Figure 11-6.

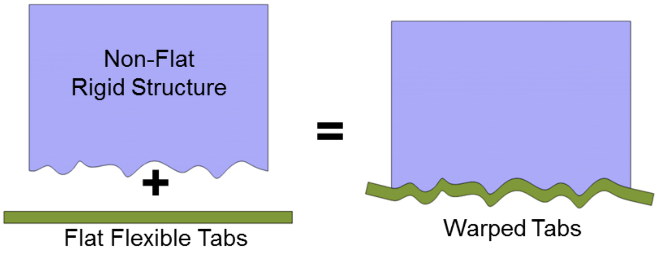


Figure 11-5: Example of structure warping tabs

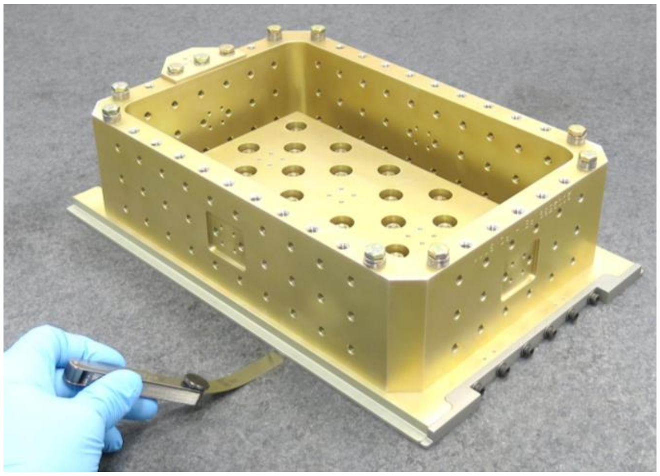


Figure 11-6: Verifying assembled flatness

The following figure is a worksheet that should be used when inspecting Tabs. Fill in the worksheet and verify that the measured values meet all the requirements defined within this document. The flatness and perpendicularity measurements shall be taken after the entire payload structure is assembled. It is still prudent to ensure the entire payload complies with this specification in addition to the tabs. See Sections 3, 4 and 5 for requirements.

Item	**Value**
Tab material	
Tab anodize type and class	
Tab (datum A) flatness [mm or in]	
-Z face perpendicularity to datum A [mm or in]	

Width	
Location	Value [mm or in]
Back (near -Z side)	
Middle	
Front (near +Z side)	

Length	
Location	Value [mm or in]
Left (near -X side)	
Middle	
Right (near +X side)	

Distance from -Z face [mm (in)]	**Thickness [mm or in]**		**Radius of Edge Fillets [mm or in]**	
	-X Side	+X Side	-Y Side	+Y Side
13 (0.5)				
25 (1)				
51 (2)				
76 (3)				
102 (4)				
127 (5)				
152 (6)				
178 (7)				
203 (8)				
229 (9)				
254 (10)				
279 (11)				
305 (12)				
330 (13)				
356 (14)				

Figure 11-7: Tab inspection worksheet

12. CSD CONSTRAINED DEPLOYABLES

The payload may use the CSD to constrain deployables in designated areas as defined in sections 3, 4 and 5. At these designated contact zones the CSD interior surface shall be nominally 1.3mm [.05 in] from the maximum allowable dynamic envelope of the payload defined as ‘Width’ and ‘Height’. Only the portion of the payload directly contacting the CSD Walls (bearing, etc.) may exceed the payload dynamic envelope in Section 5. Ensure all other areas of the deployable remain within the dynamic envelope.

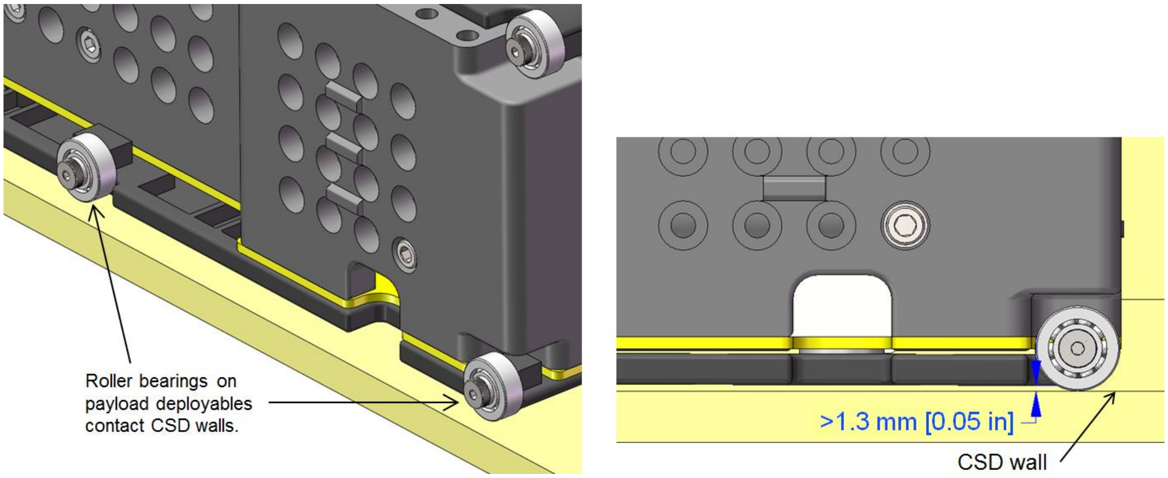


Figure 12-1: Deployable contact with CSD

Deployable Design Notes:

1) Ensure sufficient CSD contact spacing and panel stiffness to prevent the panel from rubbing on the dispenser as the payload ejects.
2) Deployables should have features to react shear loading at end opposite hinge. This prevents excessive loading on the hinge and deflection at the end of the deployable during launch.
3) The deployable panels shall be sufficiently preloaded against the payload structure to minimize rattling during launch. This can be accomplished by incorporating a leaf spring, spring plunger, etc.
4) Consider potential disturbance torques from the deployable adjacent the CSD door remaining in contact after the payload has ejected the CSD.
5) Account for tolerance build-up in the deployable preload system. By necessity, the dispenser width will be greater than the payload’s tab width. During payload installation there could be up to .5 mm [.020 in] of play relative to nominal in the +X or –X positioning of the payload. Therefore the +X or –X contact walls of the dispenser may be .8 to 1.8 mm [.03 to .07 in] from the payload’s nominal max dynamic envelope. These values are estimates. Refer to the dispenser manufacturer for specific values.

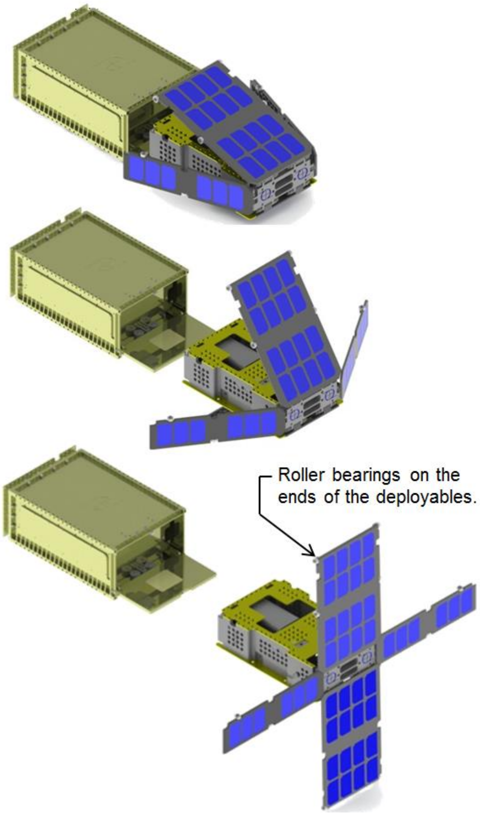


Figure 12-2: Payload dispensing from CSD

13. PAYLOAD VOLUME

The allowable volume of the payloads is larger than existing CubeSats.

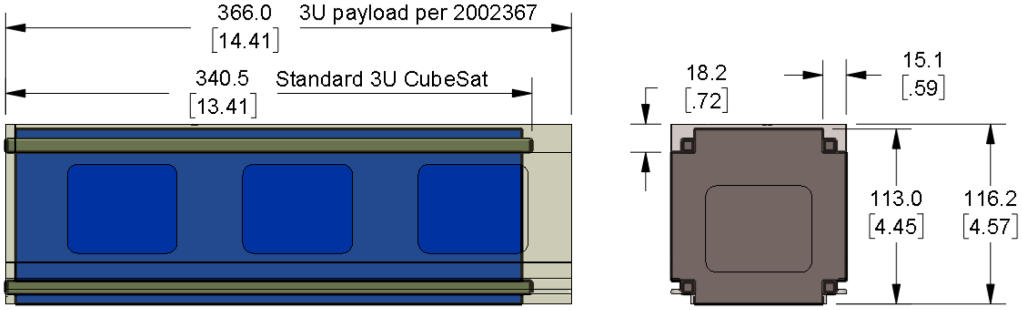


Figure 13-1: Comparison of 3U payload volumes. This specification allows 15% more volume.

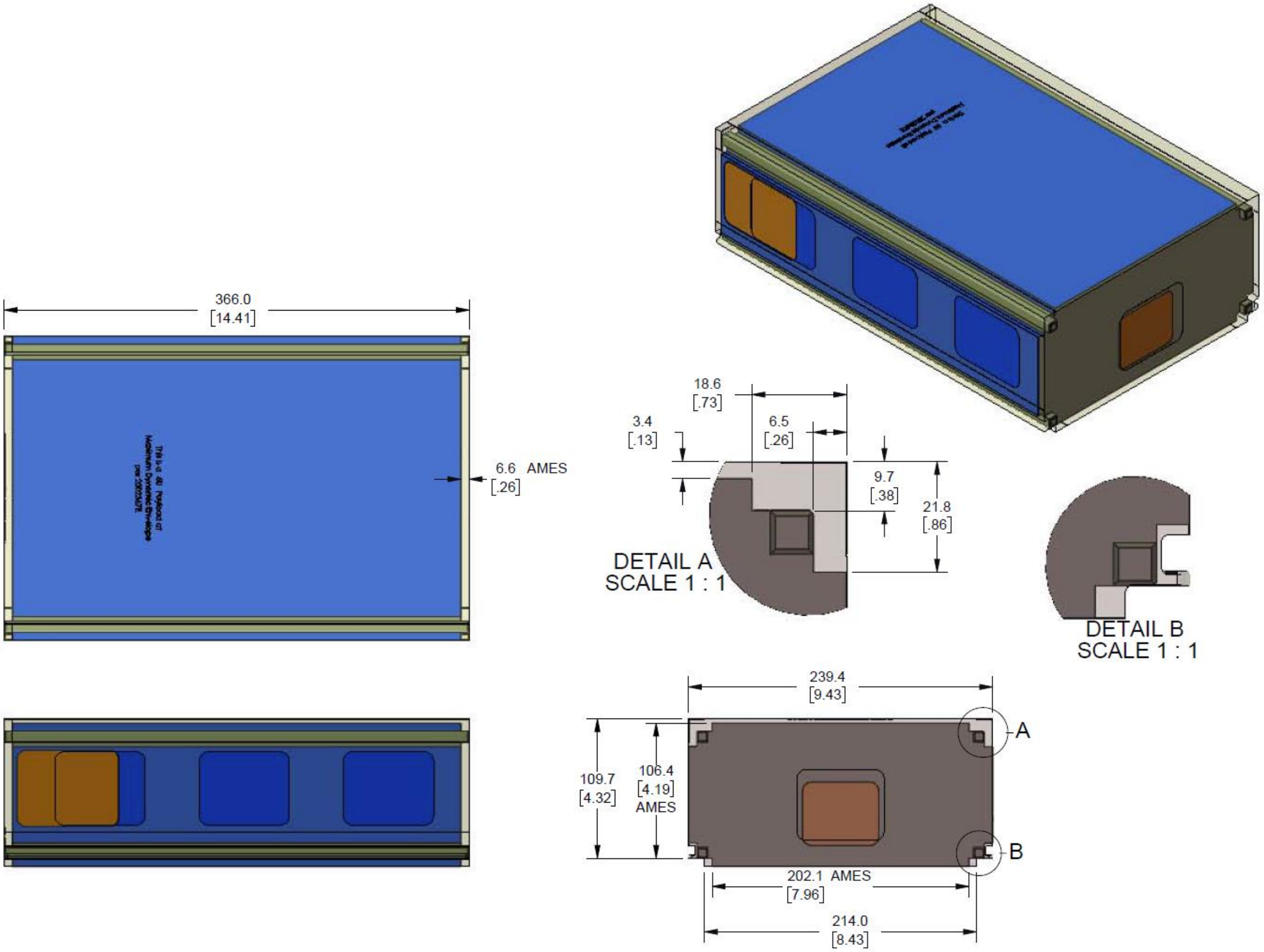


Figure 13-2: Comparison of 6U payload volumes. This specification allows 9% more volume.

14. PAYLOAD DESIGN

Design of a payload's structure is a complicated and iterative process when done properly. PSC spent numerous iterations obtaining an effective structure to use as a payload simulator for GSE testing. Over the course of these iterations, several optimal features were converged upon.

- Discrete bolt-on tabs. This allows inexpensive and rapid replacement due to damage, improper tolerances, improper manufacturing, etc.
- Numerous bolted joints to increase damping and reduce shock transmissibility.
- Easy access to mechanically attach and remove the Separation Connector after the harness is attached.
- A parametric structure that enables movement and replacement of components. Both in the cases of optimizing dynamic response locations and changes to mission hardware.
- High damping materials to isolate sensitive components from the structure. For example, using Viton washers between the structure and electronic boards.
- Precision control of flatness for structures adjoining the tabs.

Despite the numerous components and tight tolerances, the payload assemblies shown below were inexpensive to manufacture. The individual parts were simple compared to a structure comprised of just a few intricately machined components.

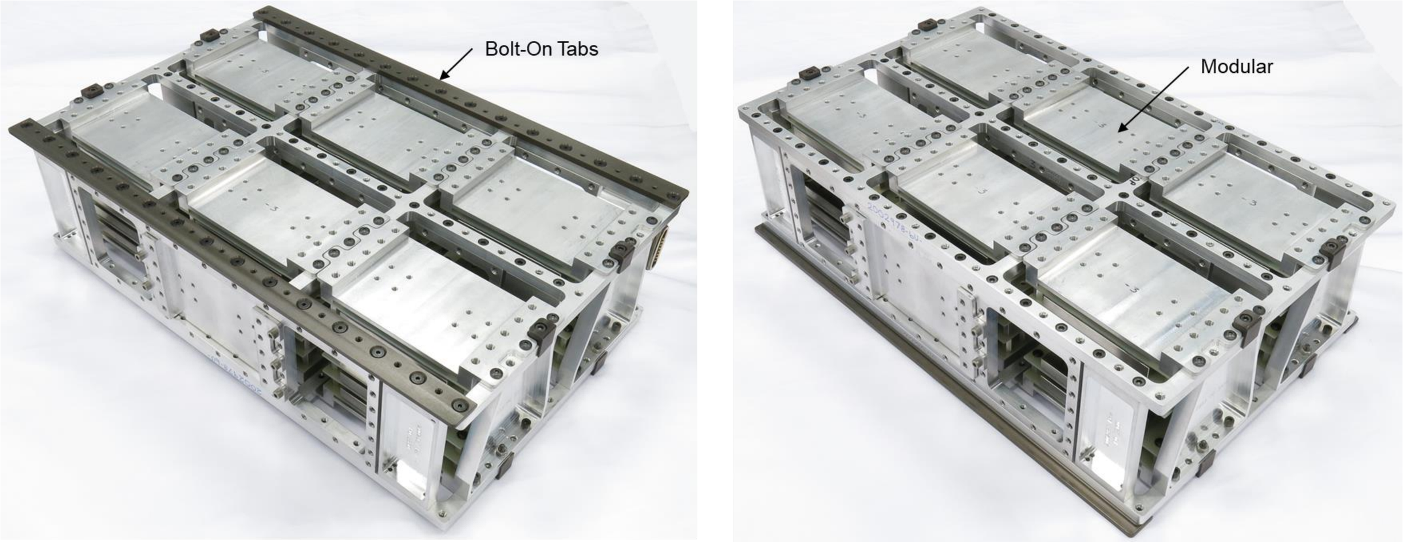


Figure 14-1: Example 6U GSE payloads

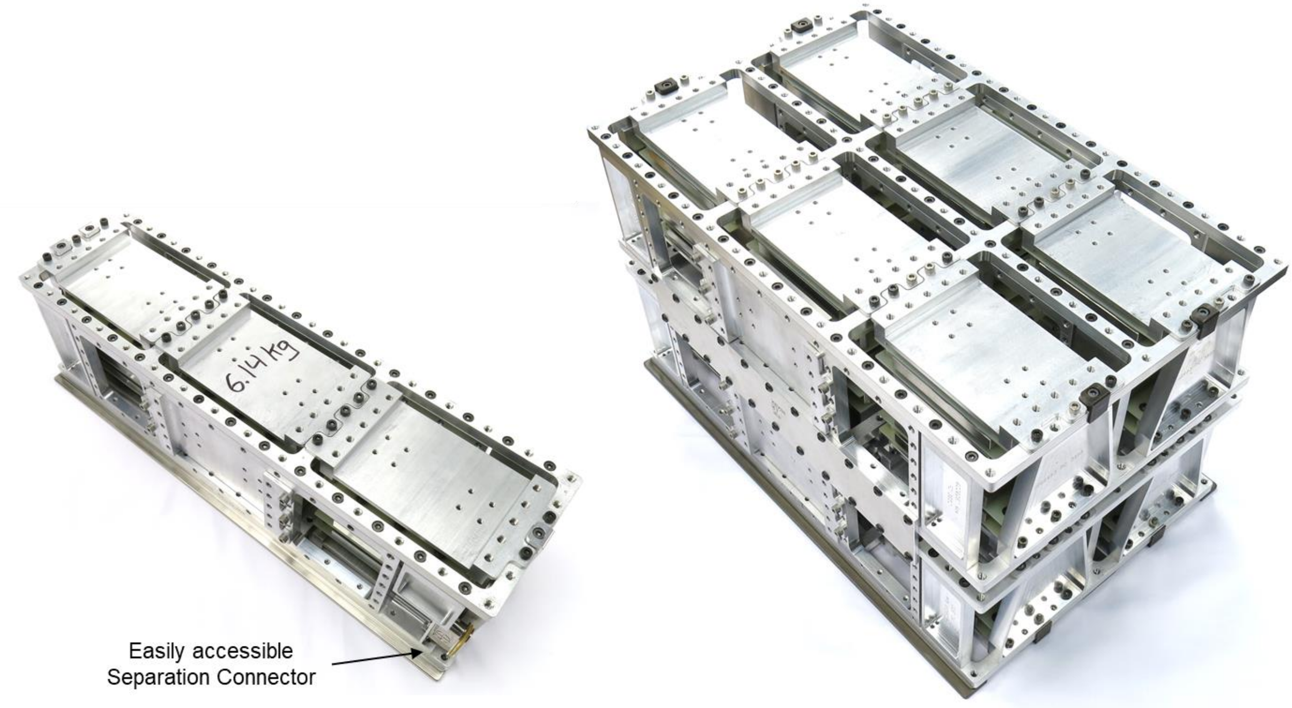


Figure 14-2: Example 3U and 12U GSE payloads

15. TYPICAL APPLICATIONS

The payload need not occupy the entire volume provided the tabs are present.

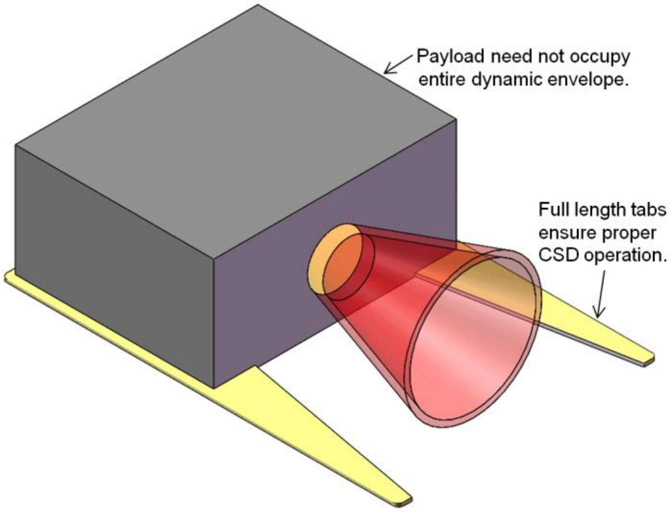


Figure 15-1: 6U payload example

Figure 15-2: POPACS, a multi-piece 3U payload

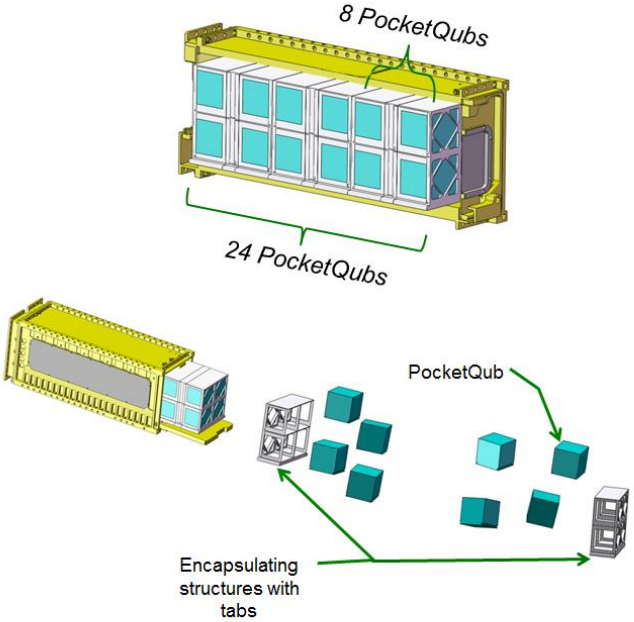


Figure 15-3: Encapsulating PocketQubs in a tabbed structure

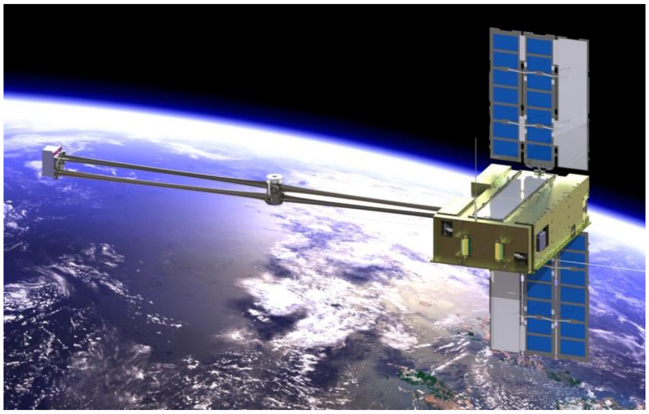


Figure 15-4: 6U payload

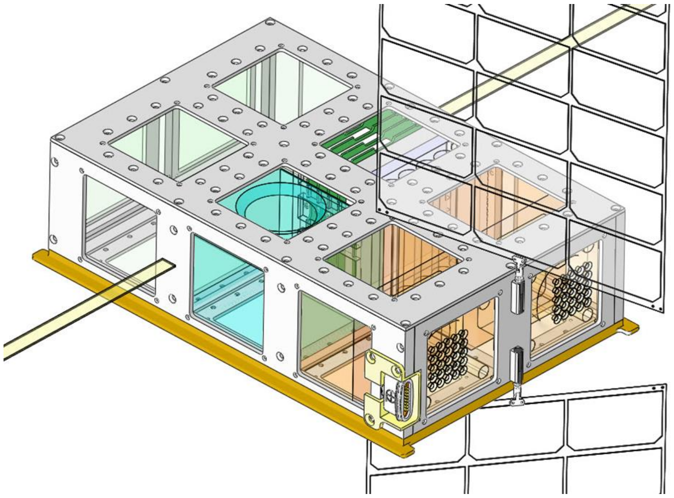


Figure 15-5: 6 X 1U bus

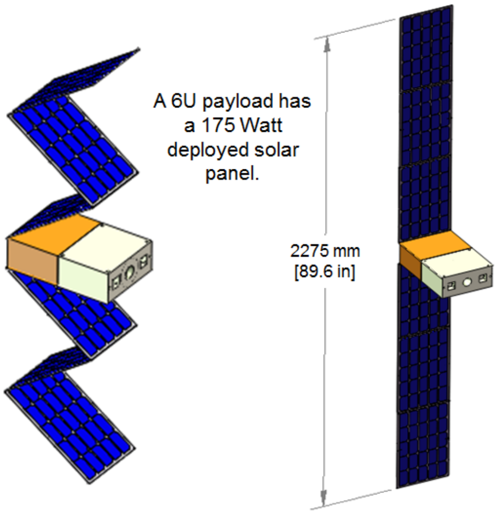
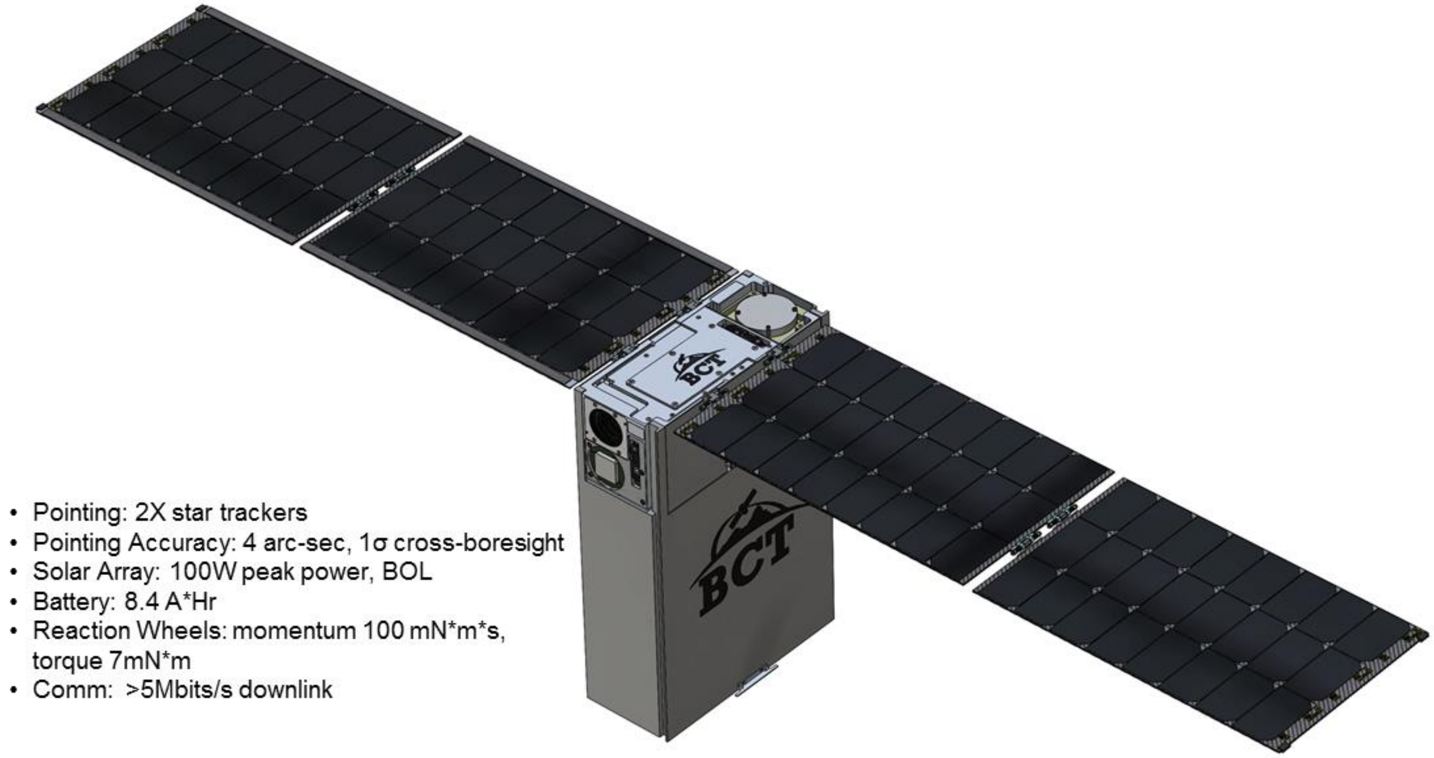


Figure 15-6: Solar array potential

Figure 15-7 and Figure 15-8 below show sophisticated 6U spacecraft from several manufacturers. In 2016 these designs represent state of the art.

Figure 15-7: Pumpkin Inc.'s 6U SUPERNOVA bus



- Pointing: 2X star trackers
- Pointing Accuracy: 4 arc-sec, 1σ cross-boresight
- Solar Array: 100W peak power, BOL
- Battery: 8.4 A*Hr
- Reaction Wheels: momentum 100 mN*m*s, torque 7mN*m
- Comm: >5Mbits/s downlink

Figure 15-8: Blue Canyon Technologies’ 6U payload bus

An existing CubeSat with 4 corner rails can easily comply with this specification by fastening on custom tabs. Note the residual stresses from many press-fit nuts may tend to warp thin panels. Ensure the structure is sufficiently stiff to maintain tab flatness after assembly.

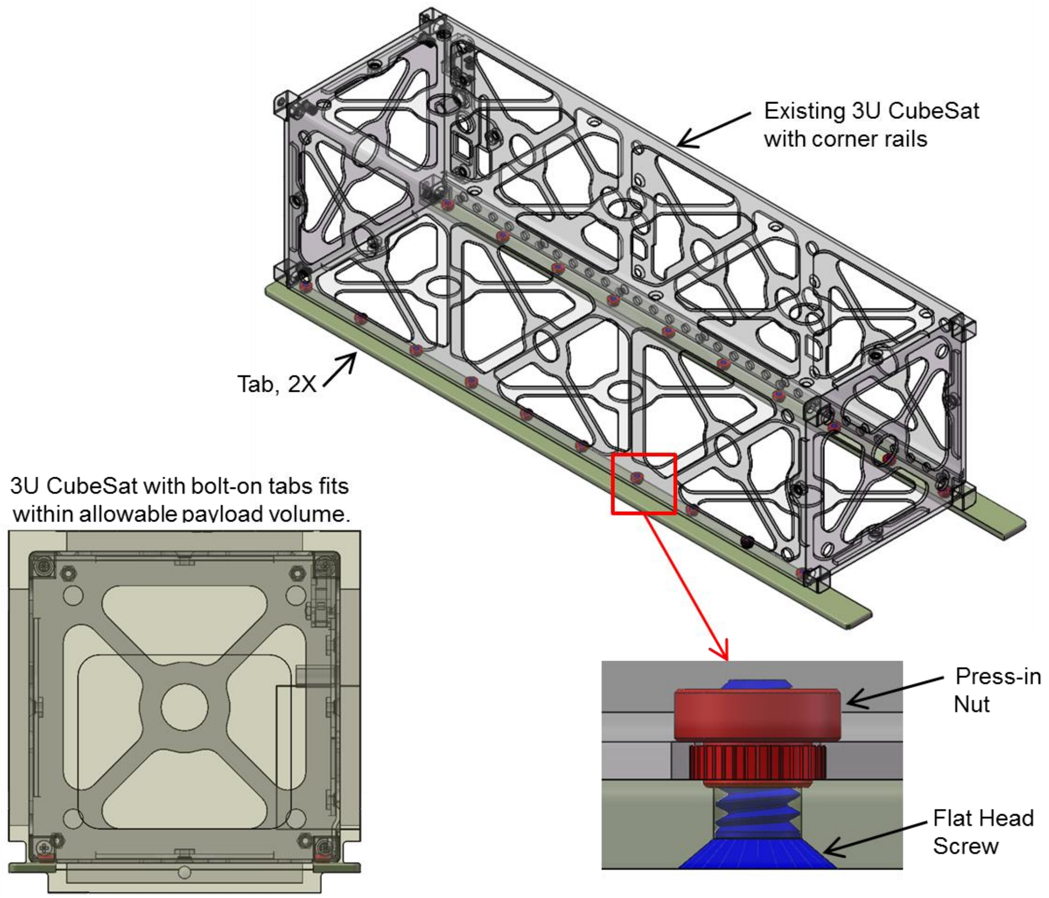


Figure 15-9: 3U CubeSat tab conversion

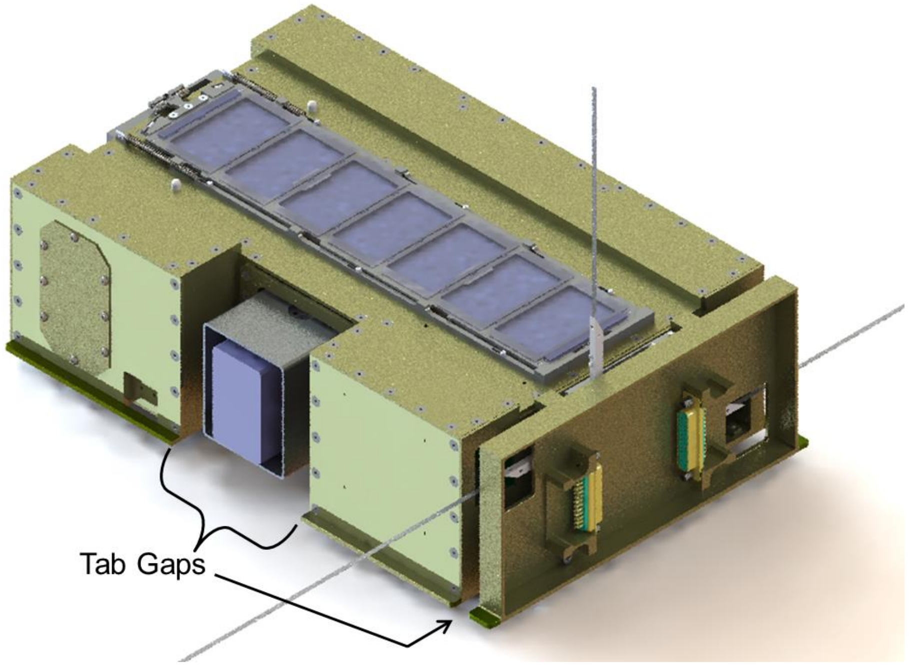


Figure 15-10: 6U payload with non-continuous tabs (large middle gap requires a custom dispenser)

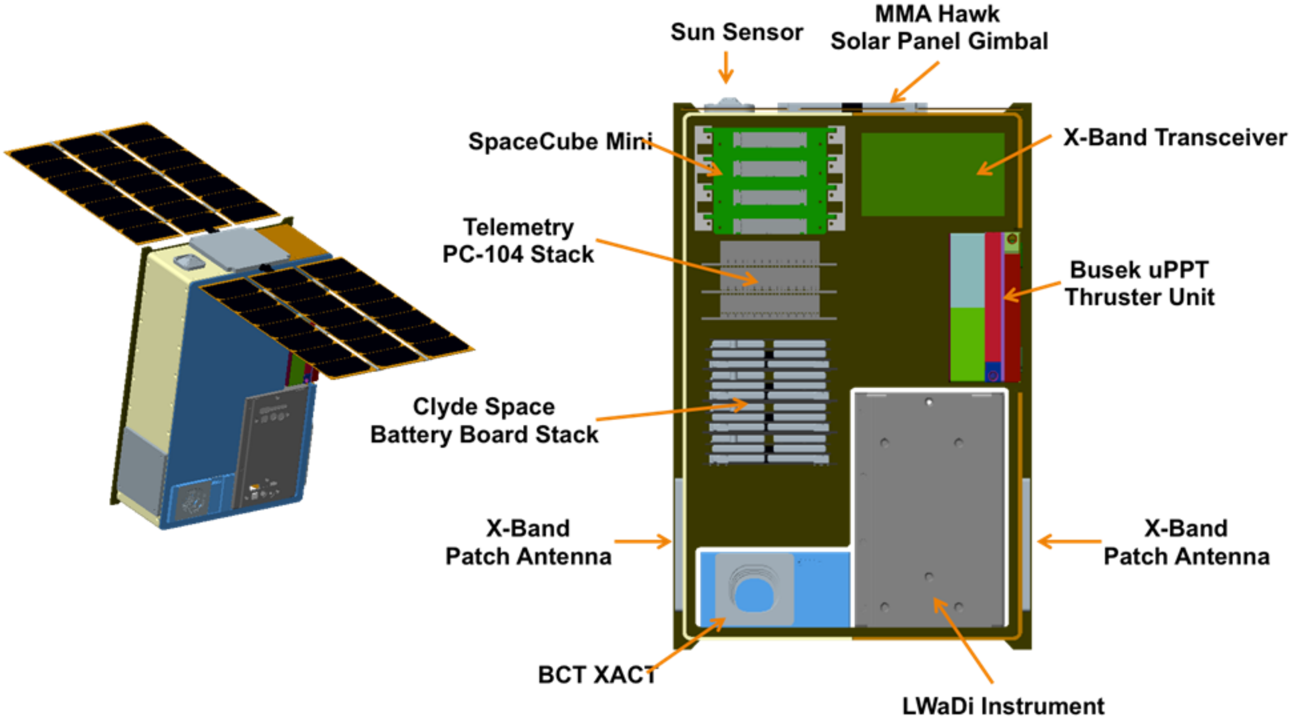


Figure 15-11: Lunar Water Distribution (LWADI), a 6U interplanetary spacecraft. Ref. 6.

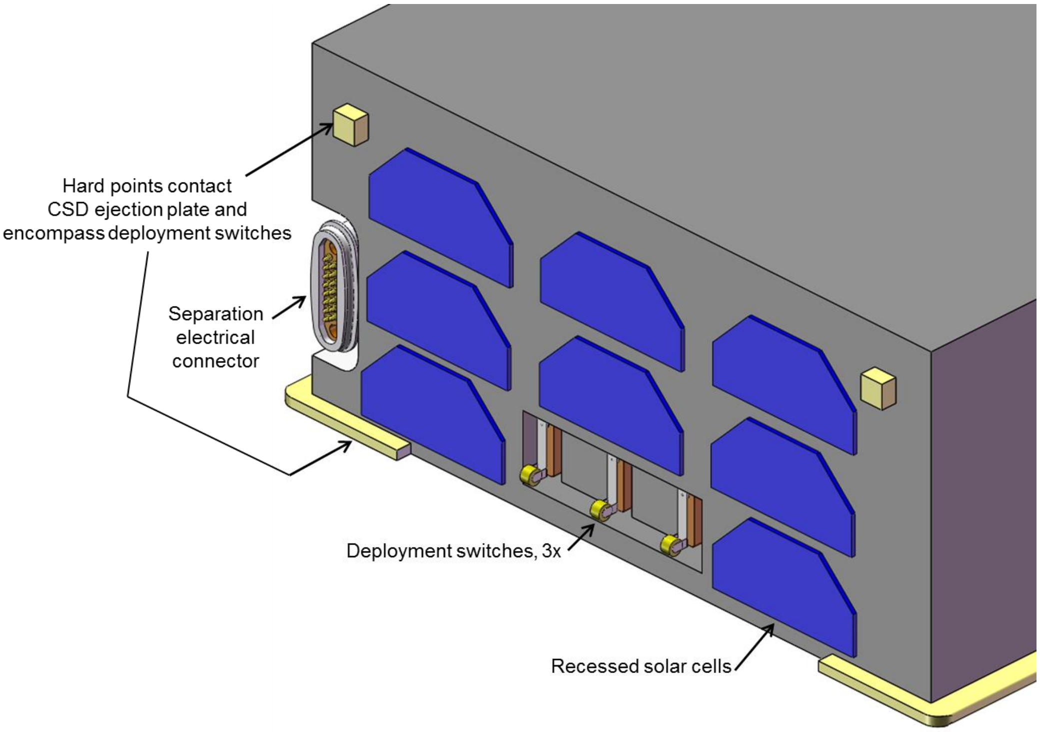


Figure 15-12: Example of -Z face that contacts dispenser ejection plate

16. SEPARATION ELECTRICAL CONNECTOR ATTACHMENT

The figures below show a means of mounting the Separation Electrical Connector. It only need be mounted via the flat face that contains the two 4-40 UNC screws. Additional support around the side of the connector shell is unnecessary. An open cutout in the mounting bracket is beneficial as it allows the connector to be removed after the harness is wired.

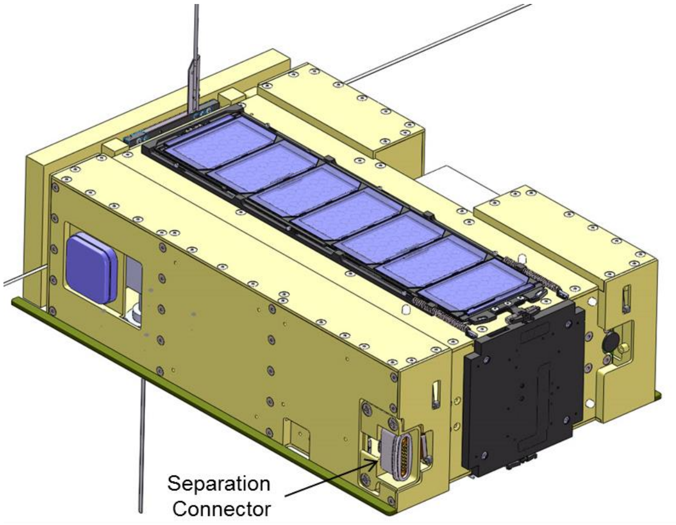


Figure 16-1: Separation Connector on payload

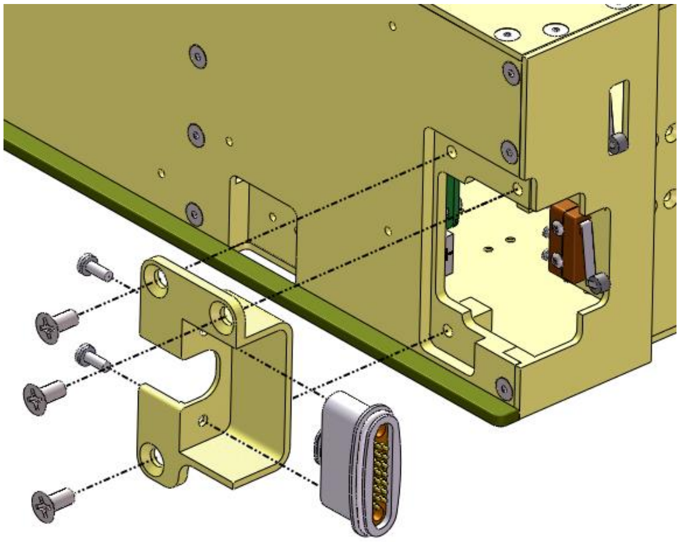
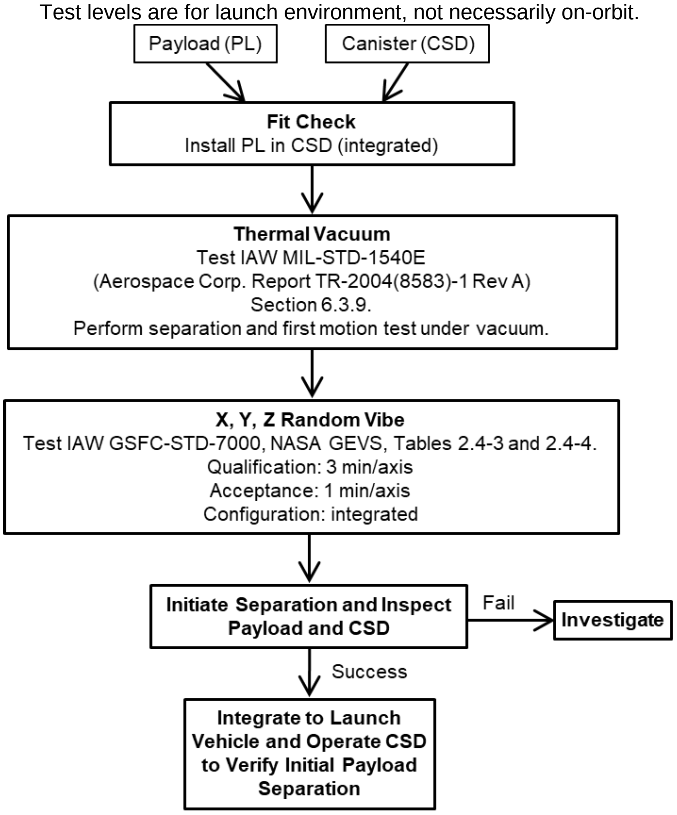


Figure 16-2: Separation Connector mounting example

17. RECOMMENDED TEST AND INTEGRATION

Test levels are for launch environment, not necessarily on-orbit.



Be cognizant that vibration testing with the flight CSD will consume test life margin. See the CSD's qualification test campaign to determine remaining life and margin. An alternative is to test with an EDU CSD and then verify operation with the flight CSD prior to integration.

18. TIPS AND CONSIDERATIONS

1. Electrical Wiring: Include the electrical harness in the CAD model. Ensure there are sufficient routing options, strain relief and clearances. Also, the harness can consume a significant portion of the allowable payload mass.
2. Installation in CSD: The payload may end up being installed vertically in the CSD (gravity in –Z). Add a removable handle on the +Z face to aide installation.
3. CSD Ejection: When possible, verify complete ejection of the payload from the CSD during testing.

19. CAD MODELS

Solid models of the payloads at their maximum dynamic envelope are available for download at www.planetarysys.com. The payload may be inside a simplified model of the CSD. Reminder that PSC does not design or manufacture payloads, structures or buses.

20. ADDITIONAL INFORMATION

Verify this is the latest revision of the specification by visiting www.planetarysys.com.

Please contact info@planetarysystemscorp.com with questions or comments. Feedback is welcome to realize the full potential of this technology.

21. REFERENCES

1 Hevner, Ryan; Holemans, Walter, “An Advanced Standard for CubeSats”, Paper SSC11-II-3, *25th Annual AIAA/USU Conference on Small Satellites*, Logan, UT, August 2011.
2 Holemans, Walter; Moore, Gilbert; Kang, Jin, “Counting Down to the Launch of POPACS”, Paper SSC12-X-3, *26th Annual AIAA/USU Conference on Small Satellites*, Logan, UT, August 2012.
3 *Separation Connector Data Sheet*, 2001025 Rev C, Planetary Systems Corp, Silver Spring, MD, July 2013.
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12 Azure, Floyd; Hevner, Ryan; Holemans, Walter, “Methods to Predict Fatigue in CubeSat Structures and Mechanisms”, *12th Annual Summer CubeSat Developers’ Workshop*, Logan, UT, 08-09 August 2015.

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Dr. Eric Swenson, AFIT
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Dr. Robert Twiggs, Morehead State
Rex Ridenoure, Ecliptic Enterprises
Jason Armstrong, ORS
SpaceX

23. REVISION HISTORY

Revision	Release Date	Created By	Reviewed By
-	25-Jul-2012	RH	WH
A	6-Aug-2013	RH	WH
B	21-Jul-2014	RH	WH
C	3-Aug-2015	HM	WH
D	4-Aug-2016	RH	WH
E	4-Aug-2017	RH	WH
F	6-Aug-2018	RH	WH

Changes from previous revision:

Section	Changes
All	- Removed 27U size from this specification. - Reordered several sections.
2. Description	- Figure 2-2: Removed 27U.
3. Parameters	- Table 3-1: Removed 27U. Replaced Mass (M) with Tab Load (TL)
5. Dimensions	- Figure 5-2: Updated note 1.
6. Electrical Schematic	- Figure 6-2: Added. - Added loopback discussion.
10. Predicting Design Limit Loads	- Figure 10-1: Added.
14. Payload Design	- Added.
17. Recommended Test and Integration	- Added discussion on CSD test life.