An Advanced Standard for CubeSats

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ABSTRACT
It is critical for cost effective growth of CubeSats and other canisterized satellites to standardize a specification for payloads larger than those encapsulated and governed by the existing and highly successful 3U Poly Picosatellite Orbital Deployer (P-POD) standard. The US government wants larger CubeSats than the existing P-POD can dispense. Based on extensive consultation with Dr. Jordi Puig-Suari, Dr. Bob Twiggs, several individuals at Space Test Program (STP), Air Force Research Lab (AFRL), and many university CubeSat teams an advanced CubeSat and its dispenser specification is presented. The new specification currently governs CubeSats larger than the 3U size. This includes a 6U (12 Kg, 12 x 24 x 36 cm), 12U (24 Kg, 23 x 24 x 36 cm) and 27U (54 Kg, 34 x 35 x 36 cm).

Canisterized Satellite Dispensers (CSDs) are boxes that small payloads (CubeSats) are housed in during launch and dispensed from once in space. These dispensers reduce the risk that small secondary or tertiary payloads in the dispenser can damage the primary or be damaged by the primary.

Standardization of the electrical and mechanical interfaces allows satellite builders and launch service providers to minimize the cost of integration to a launch vehicle because it greatly reduces the cost and time associated with non-recurring engineering. Further, standardization allows the greatest number of competitors to offer competing products so the end user has many low cost choices.
INTRODUCTION

CubeSats have been extremely successful in easing access to space. The small size and encapsulation maximize launch opportunities and allow the payload designer liberties with materials and manufacturing techniques. It also enables the launch vehicle (LV) to utilize existing capability with minimal risk to the primary payload. Expanding upon the success of the 1U and 3U, a larger family of payloads will enable even greater scientific and military capabilities. These 6U, 12 and 27U payloads feature advanced technologies that streamline integration and ensure mission success. A 6U payload is shown deploying from its canister in Figure 1. These new sizes fill the existing mass and volume gap between 3U CubeSats and traditional separation system restrained secondary payloads (ESPA and similar). See Figure 2

![Figure 1: A 6U Payload and CSD](image1)

![Figure 2: Need for 6U, 12U and 27U Payloads](image2)
ADVANCED FEATURES
The 6U, 12U and 27U payloads and canisters incorporate several features aimed at increasing performance, reducing complexity and minimizing integration costs.

1. Tabs: Two tabs run the length of the payload and are intended to be gripped by the canister, functioning similar to an automobile's brake caliper and rotor. This eliminates excessive payload chatter during launch. It also provides a predictable and thus model-able dynamic environment. This is significant for the launch vehicle, especially as payloads increase in mass. It is also reassuring for critical payloads with sensitive instruments. The tabs also serve the benefit of reducing manufacturing complexity as only the tab thickness is tightly controlled. Furthermore, eliminating the rails at the other two corners provides more room for body-mounted or deployable solar panels.

2. Mass: The density of the 6U-27U payloads has increased slightly allowing more mission enabling technologies. The considerable mass can reduce thermal extremes on-orbit and increase orbit life.

3. Non-Constrained Deployables: The payload has the option to use the canister as the means of constraining deployables. This reduces the complexity and volume of the restraint/release mechanism. It also eliminates a potential failure mode.

4. LV Electrical Interface: A DB-9 socket connector is the standardized canister interface to the LV. The pin-outs and electrical parameters are pre-defined, allowing the LV to plan ahead and eliminate variances that inevitability increase cost. The connector is located on a consistent face to enable the LV to size and locate their harness. This inexpensive and compact connector has significant flight heritage on several separation systems.

5. LV Mechanical Interface: The standard mounting pattern is a repeatable square grid pattern, independent of canister size. Additional patterns may be added to allow compatibility with existing deployers.

6. Placard: The payload and canisters may be integrated several months or years ahead of launch. A placard informs the LV of the contents, provides traceability, and reaffirms conformance to a specification giving the LV and primary payload assurance of mission success.

PAYLOAD AND CSD SPECIFICATIONS
Following are the 6U, 12U and 27U Payload and CSD specifications. The Payload, 2002206 Rev A, is a standalone specification intended for payload designers. They can build to this spec without need to reference the CSD. The CSD, 2002220 Rev -, is intimately linked to the Payload. It is intended to inform canister designers as well as launch service providers. The CSD designers must necessarily examine the payload spec to ensure compatibility. By examining both the payload and CSD specs the launch service provider has all information necessary for integration. The launch vehicle can allocate space for one or multiple CSDs without knowledge of the specific payload.
PAYLOAD SPECIFICATION FOR 6U, 12U AND 27U

This is a standalone specification intended to inform payload designers. CSD manufacturers may also reference this specification to ensure compatibility.

FEATURES

These payloads are designed to be fully contained within Canisterized Satellite Dispensers (canister or CSD) during launch. A canister encapsulates the payload during launch and dispenses it on orbit. Canisters reduce risk to the primary payload and so maximize potential launch opportunity. Canisters also ease restrictions on payload materials and components. This specification currently encompasses three sizes of payloads. The 6U, 12U and 27U incorporate two tabs running the length of the ejection axis. The canister may grip these tabs, providing a secure, modelable, preloaded junction during launch. To maintain compatibility with existing standards the 6U can be made with typical rails as used in CubeSat. Note however with rails the payload is not preloaded in its canister and may chatter during launch.

Figure 1: Payload deploying from Canister

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Changes from previous revision:
### PAYLOAD SPECIFICATION FOR 6U, 12U AND 27U

#### PARAMETERS

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<th>SYM</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Unit</th>
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<th>6U with Tabs</th>
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<tr>
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<td></td>
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<td>Min</td>
<td>Max</td>
<td>Min</td>
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<tr>
<td>DP</td>
<td>Canister de-pressurization rate</td>
<td>During launch</td>
<td>psig/sec</td>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
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</tbody>
</table>

(1) Load increases with reduced payload mass. Load(g) = 51-8.75{in/(mass[kg])}.

#### COMMON REQUIREMENTS

1. Tabs or rails shall be 100% continuous hard anodized aluminum per MIL-A-8625 or similar. Minimum 0.001 inch total thickness (0.0005 penetration + 0.0005 build-up). Teflon impregnation is acceptable. Maximum surface roughness of rails is 0.6 μm Ra.
2. No orifices shall be generated that will inhibit separation.
3. Deployment (inhibit) switches shall reside in specified zone on +Z face. Will activate upon contact with canister ejection plate.
4. SafeArm plug, if necessary, shall reside in specified zone on +Z, +Y, or -Y face.
5. All non-constrained deployables shall be hinged near the +Z face to minimize snagging hazards during ejection.
6. -Z face of payload shall withstand a 200 N force imparted by canister ejection plate during launch or ejection.
7. Payload may be electrically grounded by contacting canister ejection plate with inhibit switch zone.
8. Perform fit-check of payload with canister at earliest possible time.

#### BENEFIT OF TABS

- **Canister**

**Payload with Rails**

Payload may vibrate in canister because of small gap between rails and canister walls.

**Payload with Tabs**

Tabs guarantee an invariant load path, allowing useful predictions of dynamic response.
6U, 12U & 27U PAYLOADS WITH TABS

Figure 4: Tabbed payload (6U shown)

Figure 5: Tabbed payload, mm [in]

Notes:
1) Minimum three structural points must reside in X-Y plane of deployment mechanism and encompass CM.
2) Payload can be any shape that fits within allowable volume.

Continuous hard anodize from X to Y at a minimum.

payload may contact edges in areas. See Figure 5.

Deployment  switches shall be located on -Z face.

Figure 6: Payload with rails (6U only)

Figure 7: Payload with rails (6U only), mm [in]
PAYLOAD SPECIFICATION FOR 6U, 12U AND 27U

TEST AND INTEGRATION FLOW
Test levels are for launch environment, not necessarily on-orbit.

Payload (PL)  Canister (CSD)

Fit Check
Install PL in CSD (integrated)

Thermal Vacuum
Test IAW Air Force Space and Missile Systems Center standard
SMC-S-016 dated 13 June 2006, Section 6.3.9.
(Intended to supersede MIL-STD-1540 D)
Perform separation and first motion test under vacuum.

X, Y, Z Random Vibe
Test IAW GSFC-STD-7000, NASA GEVS, Tables 2.4.3 and 2.4.4.
Qualification: 3 min/axis
Acceptance: 1 min/axis
Configuration: integrated

Initiate Separation and Record Results

Success
Integrate to Launch Vehicle

Fail

ADDITIONAL INFORMATION
Verify this is the latest revision of the specification by visiting www.planetarysystemsCorp.com. Simple step models and 3D PDFs of the payloads and canisters are also available. Please contact Ryan Hevner, ryanh@planetarysystemsCorp.com with questions or comments. Feedback is welcome in order to realize the full potential of this technology.

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Jim White, Colorado Satellite Services
Andrew Kalman, Pumpkin Inc.
Adam Reif, Pumpkin Inc.
This specification is intended to inform CSD manufacturers and launch service providers. It is compatible with 2002206 Rev A "Payload Specification for 8U, 12U and 27U".

FEATURES
A Canisterized Satellite Dispenser (canister or CSD) is a box that encases the payload (PL) during launch and dispenses it on orbit. Canisters reduce risk to the primary payload and so maximize potential launch opportunity. Their relatively small size enables placement on most launch vehicles (LV). Canisters also have restrictions on payload materials and components. This specification currently encompasses canisters for three sizes of payloads. The 8U, 12U and 27U incorporate two tabs running the length of the ejection axis. The canister may grip these tabs, providing a secure, modular, preloaded junction during launch. To maintain compatibility with existing standards the 8U can be made with typical rails as used in CubeSat. Note however with rails the payload is not preloaded in its canister and may chitter during launch.

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<td>13-Jun-2011</td>
<td>RH</td>
<td>WH</td>
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Changes from previous revision:
This is the initial release.

COMMON REQUIREMENTS
1. Mounting surface to LV shall be electrically conductive.
2. Access panels to payload shall be removable with small flat or Phillips screwdriver or 3/32 in hex key. Torque spec, if applicable, shall be imprinted on CSD.
3. An ejection plate shall push on Z face of payload to deploy. Plate shall fully encompass payload deployment switch zone and be flat to 0.5mm. See payload specification for deployment switch zone dimensions.
4. Payload shall be oriented in CSD per Figure 6.
5. Ejection Plate shall be electrically grounded to CSD walls. Payload side of ejection plate shall be conductive.
## Parameters

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<th>6U Min</th>
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<td></td>
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<td>Door closed</td>
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<td>Dv</td>
<td>Payload ejection velocity</td>
<td>Max payload mass, infinite CSD mass</td>
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## Placard

Canister: Complies with Specification 2002220 Rev. ___
Payload: Complies with Specification 2002220 Rev. ___

**Responsible Organization:**

**Contact Name, Email and Phone Number:**

**PN and SN:**

**Empty Mass [kg]:**

**Responsible Organization:**

**Contact Name, Email and Phone Number:**

**PN and SN:**

**Installed Mass [kg]:**

**Installation Date:**

**Assembly**

**Total Launch Mass [kg]:**

**Ready for Launch (Date and Name):**

### Requirements

1. Locate on $+Z$ face (door).
2. Minimum text height 0.12 in.
3. Engrave, etch or stamp.
4. Tag shall be replaceable.
5. Text shall be legible in poorly lit room and under direct sunshine.
6. May add additional information as desired.
TEST AND INTEGRATION FLOW
Test levels are for launch environment, not necessarily on-orbit.

Payload (PL) Canister (CSD)

Fit Check
Install PL in CSD (Integrated)

Thermal Vacuum
Test IAW Air Force Space and Missile Systems Center standard
SMC-S-016 dated 13 June 2008, Section 6.3.9
(Intended to supersed MIL-STD-1540 D)
Perform separation and first motion test under vacuum.

X, Y, Z Random Vibe
Test IAW GSFC-STD-7000, NASA GSYS, Tables 2.4-3 and 2.4-4.
Qualification: 3 min/axis
Acceptance: 1 min/axis
Configuration: integrated

Initiate Separation and Record Results

Success
Integrate to Launch Vehicle

Fail