30th Space Symposium, Technical Track, Colorado Springs, Colorado, United States of America
Presented on May 21, 2014

CANISTERIZED SATELLITE DISPENSER (CSD) AS A STANDARD FOR INTEGRATING AND DISPENSING HOSTED PAYLOADS ON LARGE SPACECRAFT AND LAUNCH VEHICLES

Walter Holemans
Planetary Systems Corporation, walt@planetarysystemscorp.com

Ryan Williams
Planetary Systems Corporation, ryanw@planetarysystemscorp.com

ABSTRACT

Larger spacecraft and launch vehicles can gain additional revenue by adopting a non-proprietary CSD standard to streamline the electro-mechanical integration and dispensing of 3U, 6U, and 12U payloads. A ‘U’ is a 10 cm cubed volume encapsulating a mass of up to 2 Kg. This standard is an advancement of the Cubesat standard.

Originally developed for attachment to launch vehicles, the CSD standard now represents a flight-validated revenue opportunity directly applicable to hosted payloads. Risk to the hosting spacecraft is minimized by qualification testing and spaceflight heritage of the CSD. Therefore, the adoption of the CSD standard by industry and government spacecraft manufacturers assures a steady a consistent, reliable, and versatile opportunity for both hosting and hosted payloads.

The standard was reviewed by an experienced team composed of industry, government and university personnel at the Air Force research Lab, Operationally Responsive Space, NASA Ames, Cal Poly, Pumpkin Inc., Moorehead State University, ULA, SpaceX and PSC.

The mechanical integration options are shown for the three sizes of the CSD. This includes the means to mechanically attach the CSD from any one of the six faces.

When dispensing is required, the electrical interface conforms to pyro-pulse signals. The initiator is non-pyrotechnic. The interface includes 15 pin electrical pass-throughs to support the transfer of electric power and signal to the payload(s) and chassis grounding.

INTRODUCTION

As an advancement and enlargement of the original CubeSat standard* originally developed and promoted by Robert Twiggs and Jordi Puig-Suari herein is presented an overview of a standard for larger and heavier Cubesats. The following exhibits illustrate the original standard.

Exhibit 1: A P-POD Canister and 3U CubeSat (30 x 10 x 10 cm)

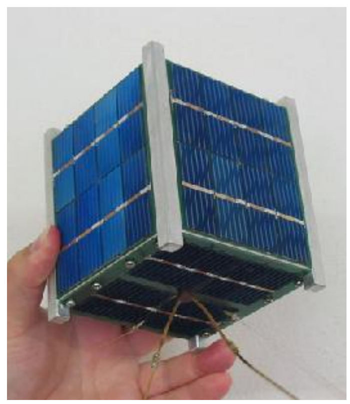

Exhibit 2: A 1 U CubeSat (10 x 10 x 10 Cm)

DoD and commercial users desire larger CubeSats because they are more capable of having larger apertures like antennas and optics which enable greater information transfer. Larger Cubesats may deploy larger solar panels to power the larger instruments. Steve Buckley of the Air Force Research Laboratory (AFRL) and Bruce Yost of NASA AMES began the development of the larger standard in 2008. This led to the 6U size which was twice the size of the original, 3U.

* http://www.cubesat.org/index.php/documents/developers

Exhibit 3: And example of the standard presented herein

PSC expanded the design to include a 12U size. A 27U is anticipated. Contributing to this standard are Dr. Andrew Kalman, Pumpkin Inc.; Adam Reif, Pumpkin Inc.; Shaun Houlihan, Pumpkin Inc.; Hans-Peter Dumm, AFRL; Steve Buckley, ORS; Dr. Jeff Welsh, ORS; Craig Kief, COSMIAC; Dr. Eric Swenson, AFIT; Philip Smith, AFIT; Dr. Jordi Puig-Suari, CalPoly; Roland Coelho, CalPoly and Dr. Robert Twiggs, Morehead State

A standard defining the payload and a standard defining its dispenser are what make up this standard. This allows hosting payloads to focus on integration of the dispenser to their spacecraft and the spacecraft designers to focus on their payload design. As in any standard, the adherence to the standard allows all the participants the certainty that the parts will fit together and operate nominally across a broad spectrum of missions. The CubeSat industry is growing rapidly in quantity of CubeSats launched and in size: PocketQubs are one eight a U in volume; constellations of printed circuit boards are being launched as operable spacecraft. Along with this rapid growth comes the potential for a many variations leading to incompatibility across platforms which has the undesirable effect of limiting growth by limiting compatible launch services.

Useful Cubesats of all sizes are a manifestation of Moore's Law--the observation that, over the history of computing hardware, the number of transistors on integrated circuits doubles approximately every two years.[†] The electronics of spacecraft have shrunk enough in size and lowered enough in price that CubeSats are now viewed as useful to make commercially viable constellations such as Planet Labs's Flock1 a 28 of 3U spacecraft forming and earth imaging constellation. Planet Labs's Cubesats are deployed from the International Space Station ISS.

[†] http://en.wikipedia.org/wiki/Moore%27s_law

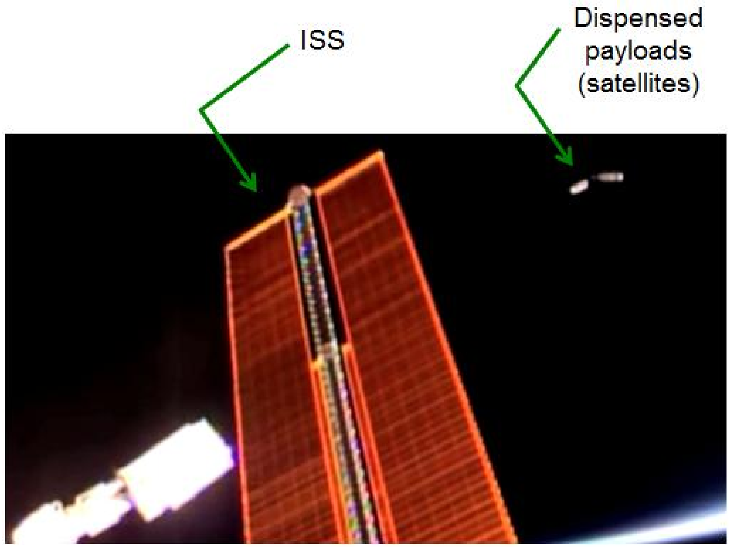

Exhibit 4: Two 3U Planet Lab's Cubesats (hosted payload) being dispensed from the ISS, the hoster of the payload

Planetary scientists at are also adopting Cubesats as a means to deliver sensors to the moon and the other planets. Robert Steahle of Jet Propulsion Laboratory (JPL) anticipates a 6U CubeSat propelled by a solar sail to study the solar system[‡]

The scope of these standards is limited to the mechanical dimensions of dispenser and payload; the electrical interface between the host, the dispenser and payload; and minimum required testing. The detail presented herein represents a summary of the actual standard[§].

[‡] Staehle, Robert L. *Lunar Flashlight: Finding Lunar Volatiles Using CubeSats,* Third International Workshop on LunarCubes Palo Alto, California, 2013 November 13

[§] http://www.planetarysystemscorp.com/#!__downloads

MECHANICAL STANDARDS

Dispenser to hosting payload

The hosting payload may be a spacecraft like ISS; a launch vehicle like SpaceX's Falcon 9; or a geostationary commercial spacecraft

Exhibit 5: The Polar Orbiting Passive Atmospheric Calibration Sphere (POPACS) mission integrated to the final stage of the Falcon 9 Launch vehicle[**]

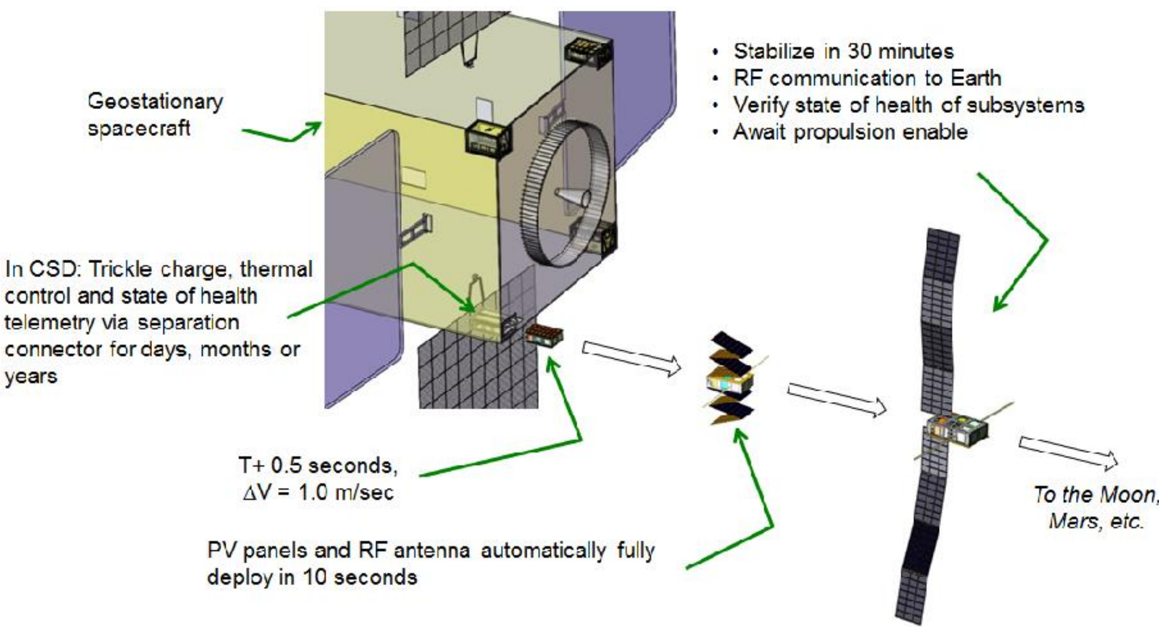

Exhibit 6: Hosting and dispensing the Lunar Water and Detection (LWaDi) from a geostationary spacecraft[††]

The dispenser's interface to the host allows for attachment from all six faces as a means to minimize the need to design custom structures and to allow for as broad an application as possible.

[**] http://space.skyrocket.de/doc_sdat/popacs.htm
[††] https://lunarscience.nasa.gov/lsf2013/content/lwadi-lunar-water-distribution-lunarcube

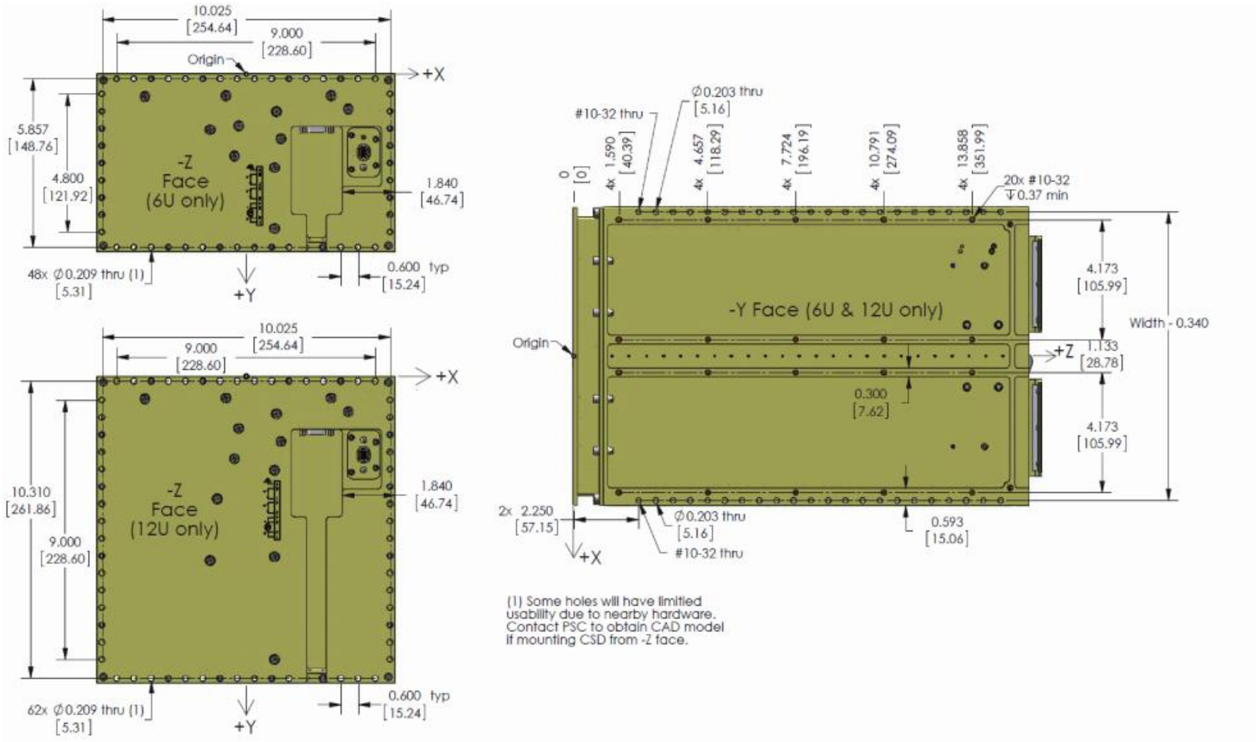

Exhibit 7: Mounting Patterns Unique to 6U and 12U

Many configurations to adjoining structures are possible. Following are several examples.

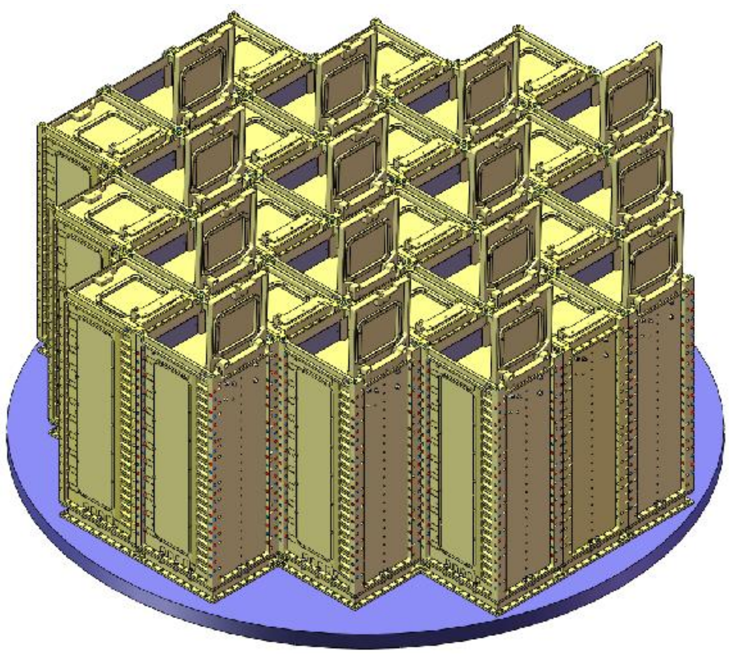

Exhibit 8: Thirty 3U Dispensers Mounted on 41 inch Diameter Plate

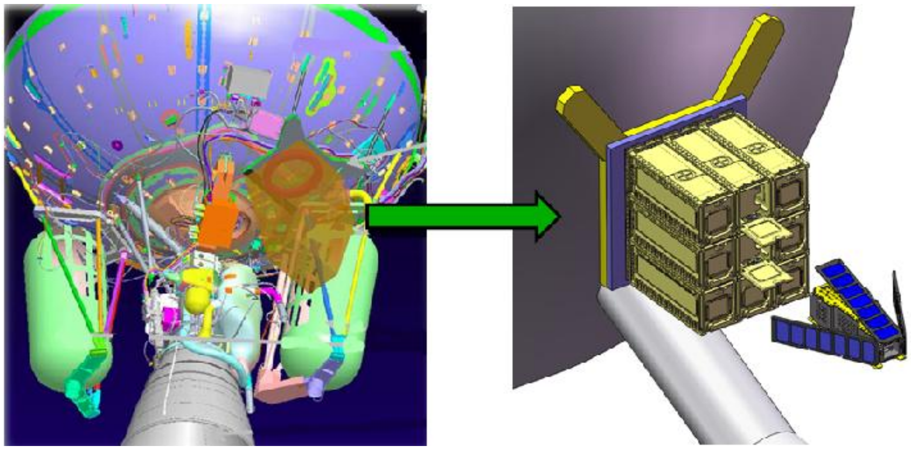

Exhibit 9: Nine 3U CSDs Mounted to Atlas V Aft Bulkhead Carrier (ABC)

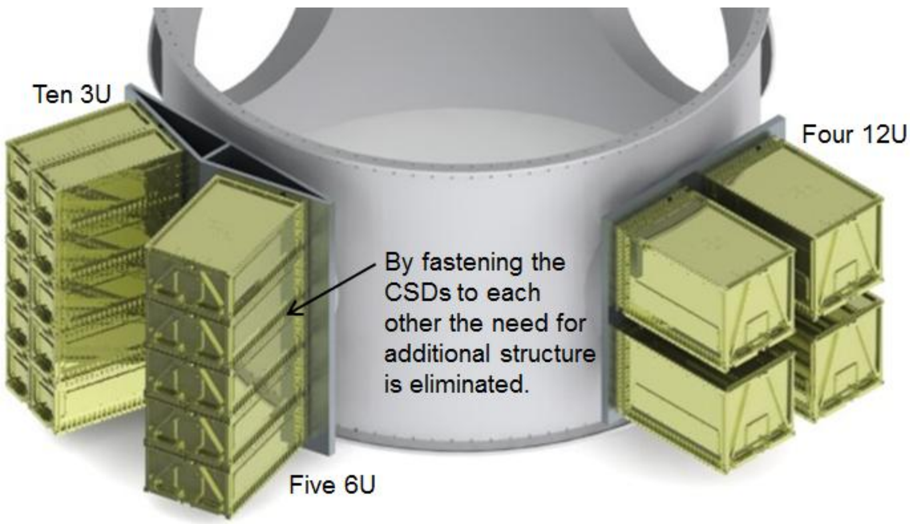

Exhibit 10: Dispensers Mounted to ESPA Grande

The volume beneath the primary payload and the thrust cone of the final stage is often unused. Since the volume of the Cubesats is so small, this volume becomes useful by the development of

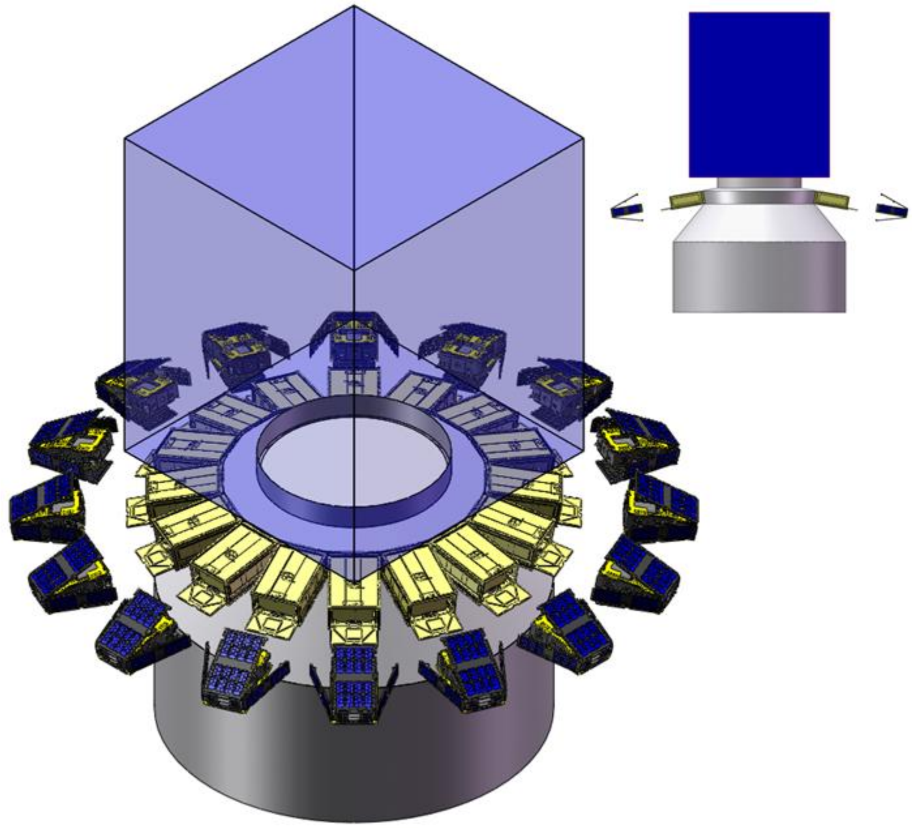

Exhibit 11: Sixteen 6U dispensers mounted underneath primary Payload. Thus an entire constellation may be deployed as a secondary payload.

Hosted payload to dispenser

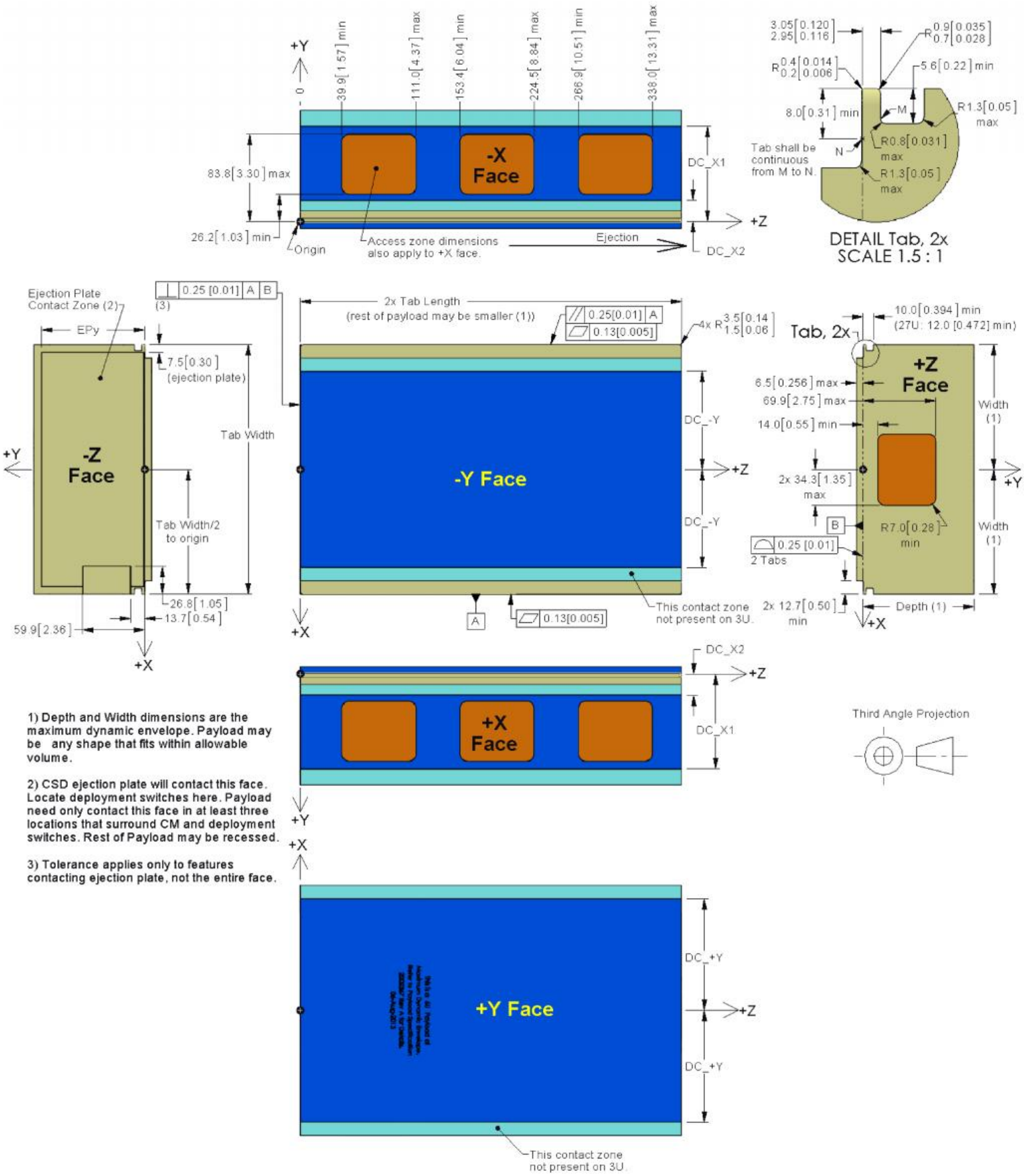

Exhibit 12: Payload Dimensions, mm [in]

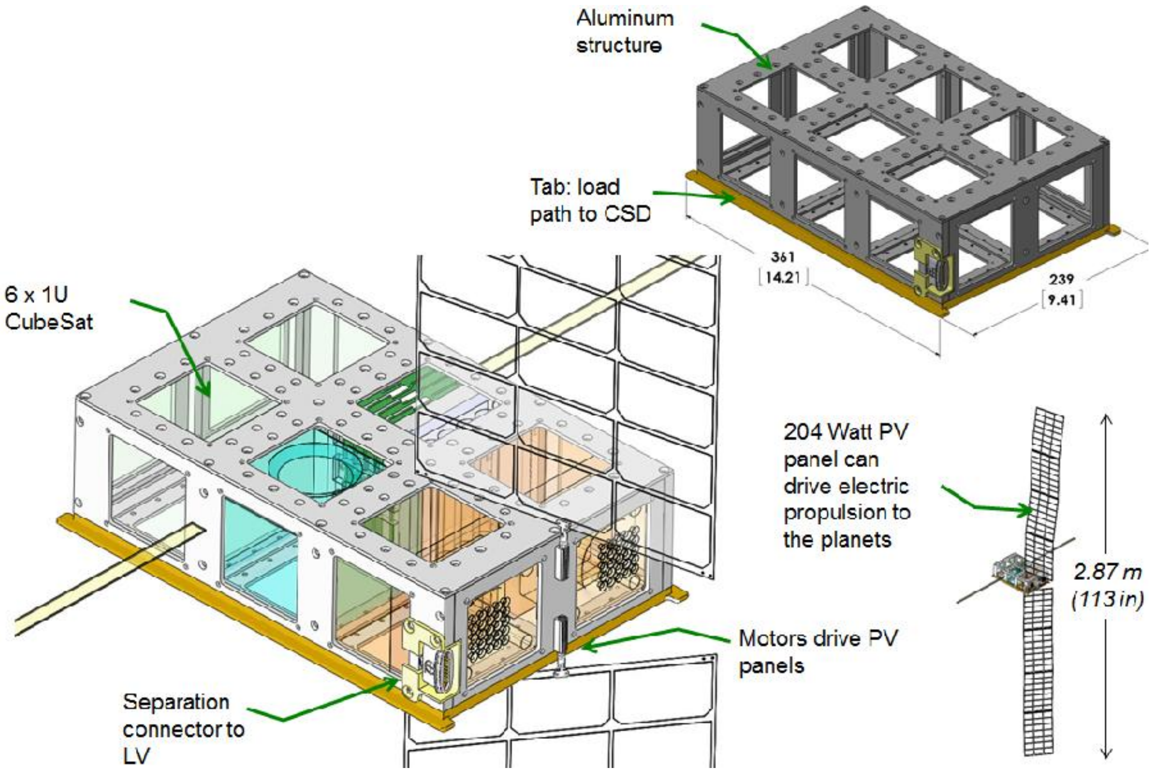

Exhibit 13: A 6U Payload (LWaDi)

The tabs are a critical structural component: they allow a preloaded load path that is modelable via finite element analysis and prevents the spacecraft from detrimentally jiggling inside the dispenser. Modeling is essential to determine if random vibration or shock applied to the outside of the dispenser will be amplified beyond allowable on locations in the payload. The following illustrates results of a modelable load path.

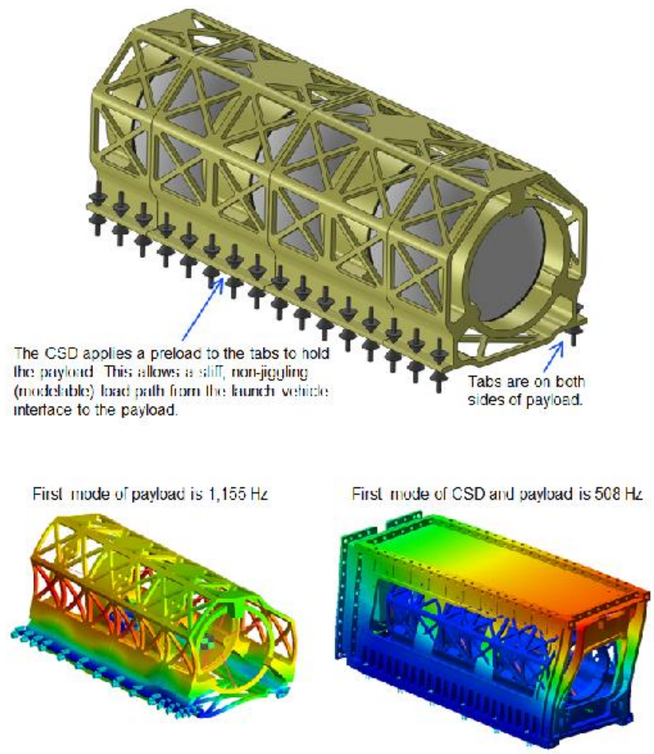

Exhibit 14: Prediction of 3U Dynamic Response

Solar panels may beneficially be restrained by the dispenser. Doing so unburdens the spacecraft from the need to hold down and subsequently release the arrays. Roller bearings at the perimeter of the array serve to reduce friction and so minimize the possibility of snagging during dispensing and minimize tip-off rotation.

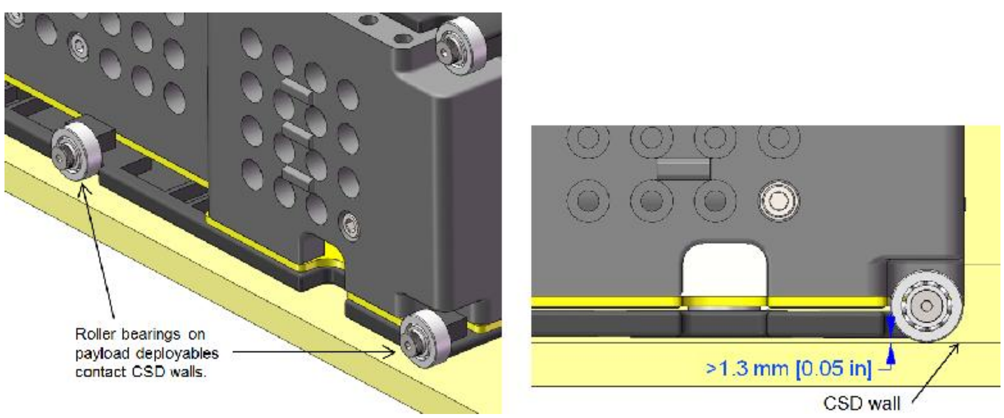

Exhibit 15: Deployable Contact with CSD

ELECTRICAL STANDARDS

Between the host and the dispenser

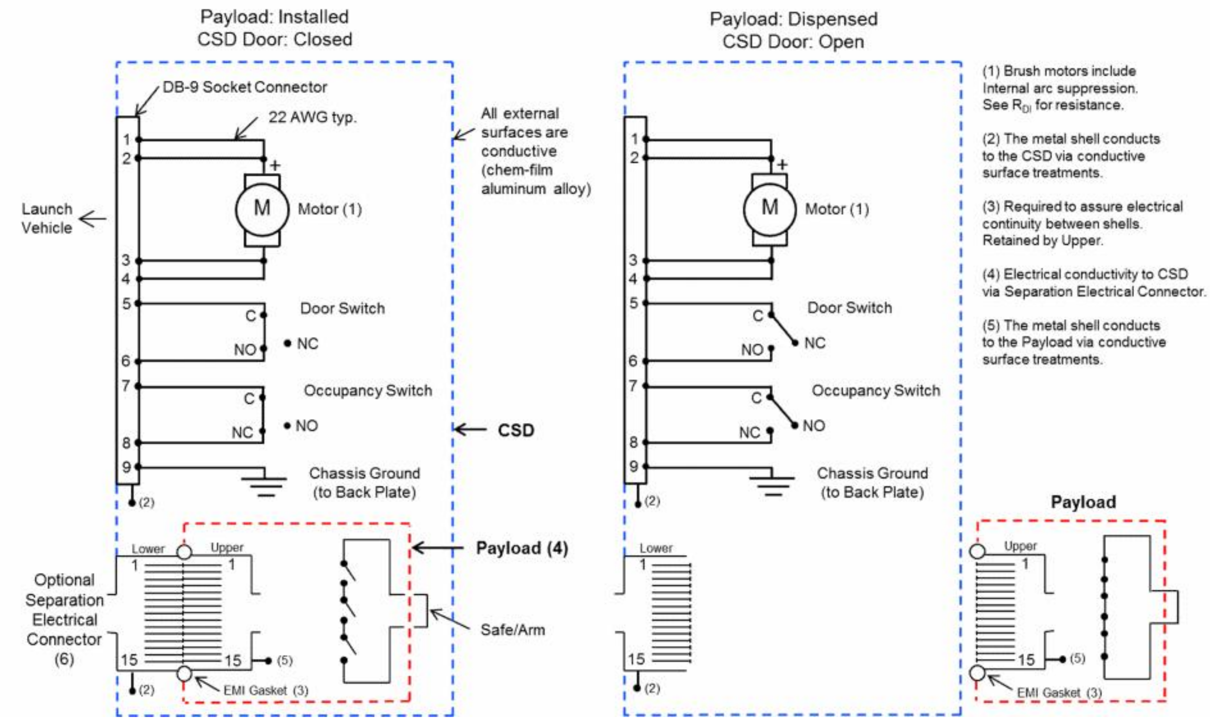

Exhibit 16: Dispenser Electrical Schematic

The electrical interface affords the host the means to initiate the dispensing and to provide power and signals to the payload in the dispenser. Limit switches serve three purposes: to indicate the door is open, to indicate the spacecraft is away and by the measurement of the times between the aforementioned, the dispensing velocity.

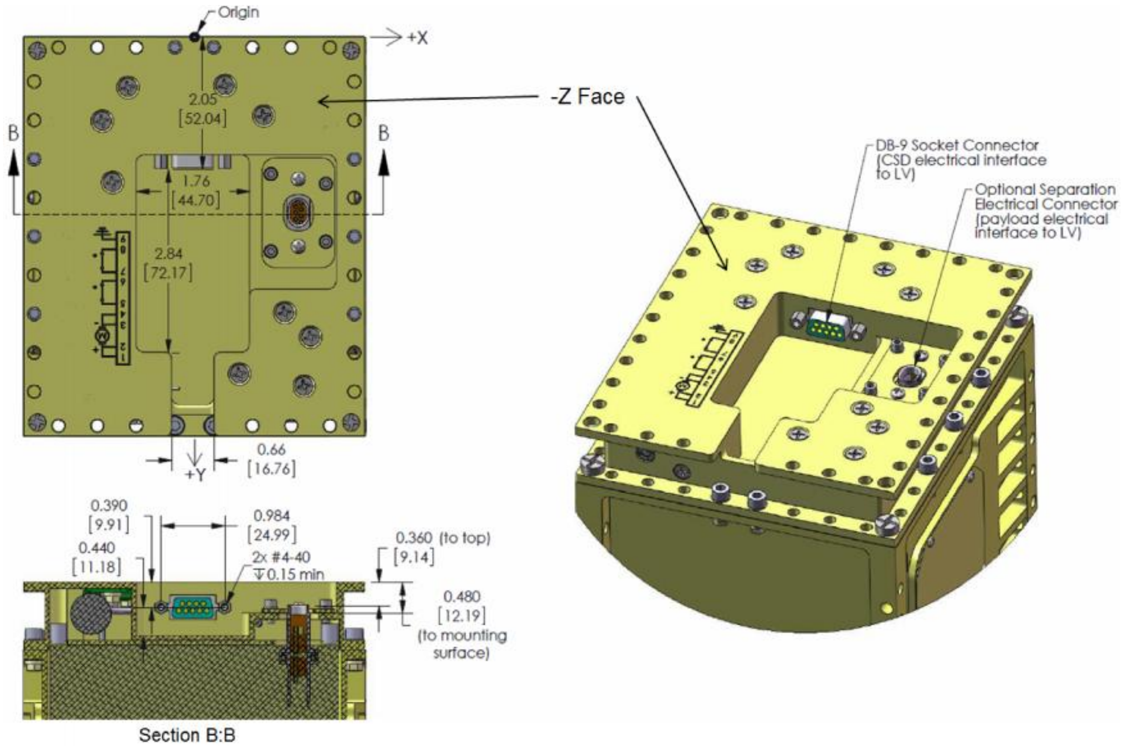

Exhibit 17: Host Electrical Interface

Between the dispenser and the payload

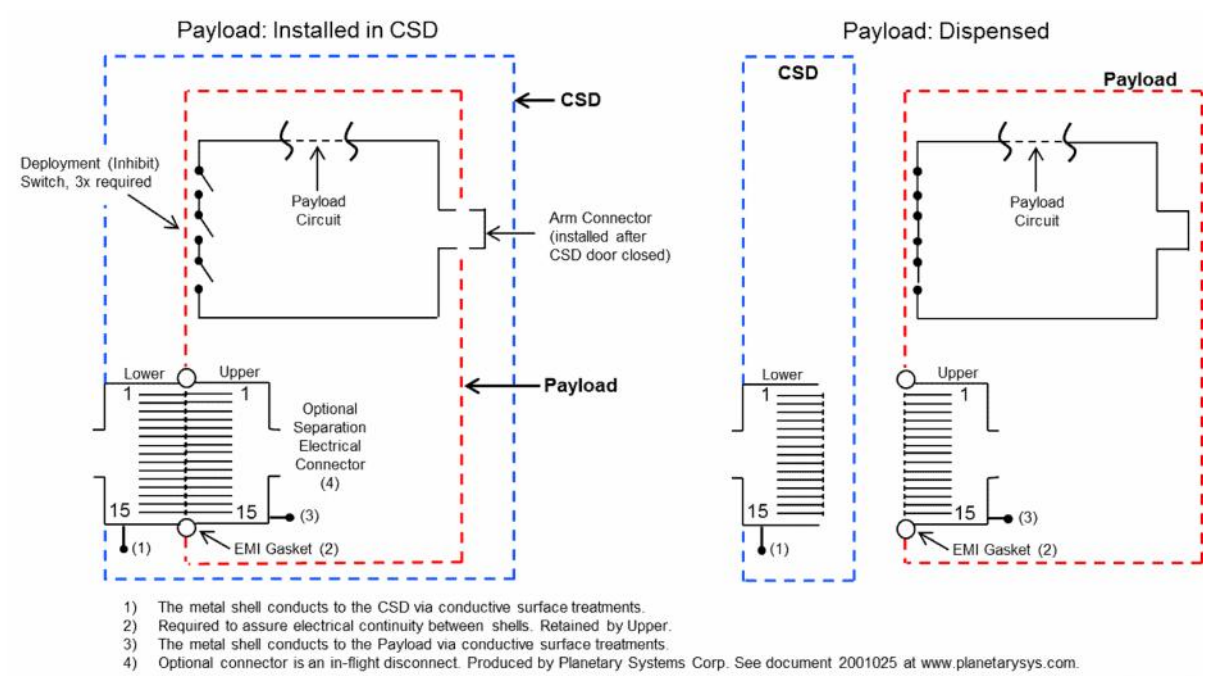

Exhibit 18: Payload Electrical Schematic

The payload includes the mating connector to provide power and signals to the payload in the dispenser and at least three limit switches to inhibit active operation of the payload such as turning on radios. Once dispensed the switches close the circuit to enable the payload to be fully operational.

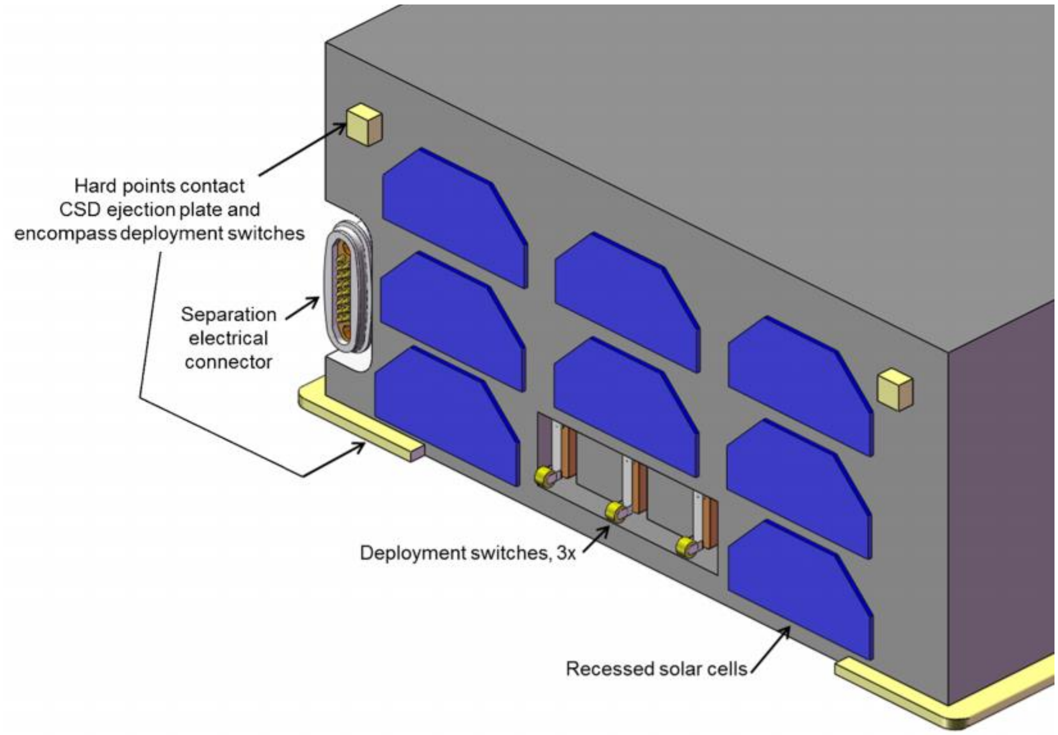

Exhibit 19: The ejector plate side of the payload showing the separation connector and three limit (deployment) switches

TEST REQUIREMENTS

To assure the hosted payload represents a minimum risk and the payload is likely to be operable, standard spacecraft testing is required.

Dispenser Test requirements

Test	Qualification	Flight
Benchtop Separations (1)	200 separations	10 separations
Thermal Vacuum	Temperature: -45°C to +90°C	Temperature: -20°C to +70°C
	Pressure: <10E-5 torr	Pressure: <10E-5 torr
	Cycles: 27	Cycles: 8
	9 Separations +90°C: 22V, 28V, 36 V +23°C: 22V, 28V, 36 V -45°C: 22V, 28V, 36V	1 Separation (hot or cold, 22V)
Strength as Sine Burst (3)	Level: 50g (3U), 40g (6U) Cycles: 5 per axis	Level: 20g Cycles: 5 per axis
Random Vibration (2,3)	Level: 14.1 Grms	Level: 10.0 Grms
	Duration: 3 min/axis	Duration: 1 min/axis
	Payload Mass: Maximum	Payload Mass: Maximum
Shock (2,3)	See Exhibit 21 3 impacts per axis	Not Tested

Exhibit 20: Test requirements

(1) 1atm, ~23°C.
(2) Full qualification was performed with CSD mounted via –Y face. Contact PSC if planning to mount CSD via any other face.
(3) 3U qualified with 6.1 kg payload. 6U qualified with 9.1 kg payload. Contact PSC if 6U payload is heavier than 9.1 kg.

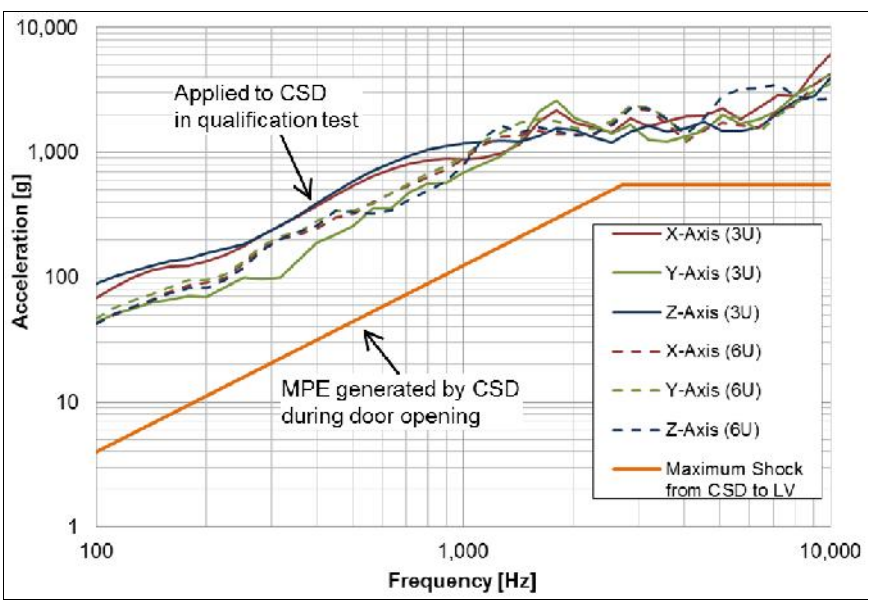

Exhibit 21: Shock Levels

Payload Test Requirements

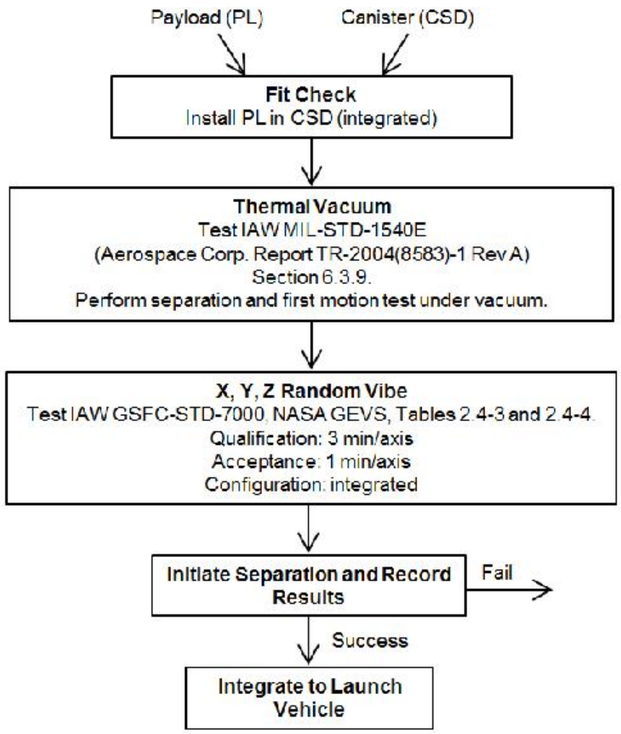

Exhibit 22: Test flow and requirements for payload

