National Aeronautics and Space Administration
John F. Kennedy Space Center, Florida
Launch Services Program

LSP-REQ-317.01
Revision B

Launch Services Program
Program Level Dispenser and CubeSat Requirements Document

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RECORD OF REVISIONS		
REV	**DESCRIPTION**	**DATE**
Basic	Basic Issue	July 24, 2009
A	ERB-09-102-2(7/7/2011): 1. Update 6.2.2 to remove CubeSat structural qualification requirement, 2. Update 6.2.3 and 6.3.3 to allow any sized CubeSats between 1U and 3U, 3. Update Table 1 for clarity, 4. Editorial corrections.	October 13, 2011
B	PRCB 7/12/2013 1. Update 5.1.12 to allow waivers per LSP-P-317.01 PRCB 11/15/2013 - ERB-09-102-3 (7/11/13) 1. Changed all instances of “PPOD” to “Dispenser” 2. Update 6.2.4 to allow CubeSat pressure containers 3. Update 6.2.9 to allow CubeSat real time clocks 4. Editorial Corrections PRCB 12/13/2013 – ERB-09-102-4 Reconvene 1. Update 6.2.3 to increase CubeSat upper size limit to 6U. 2. Update 6.2.1 CubeSat T-Vac not required if specified by LSP 3. Update 6.2.11 to 3 inhibits for RF Transmission. This change is effective for CubeSat Launch Initiative call 6 and subsequent calls. 4. Terminology Clarification pressurant to “contents”	January 30, 2014

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1. Introduction

1.1. Purpose

The purpose of this document is to define the Launch Services Program (LSP) program level and technical requirements placed on containerized CubeSat dispenser and Picosatellite (CubeSats) satellites for integration on NASA LSP ELV mission. These requirements are to ensure no increase in baseline risk to the Primary Mission. The requirements within this document are generic and independent of the Launch Vehicle (LV). The technical requirements contained in the document will be either implemented or flowed down to mission specific dispenser Interface Control Documents (ICDs) as well as dispenser and CubeSats specification documents.

It is the responsibility of the LSP to provide Certification of Flight Readiness (CoFR) statements for the integrated dispenser systems that fly on NASA ELV missions. LSP will perform verification of the LV to dispenser and the dispenser to CubeSat ICD requirements. LSP will have insight into all other CubeSat development activities such as design, development, testing and integration.

1.2. CubeSat Concept

The CubeSat Project was developed by California Polytechnic State University, San Luis Obispo (Cal Poly) and Stanford University's Space Systems Development Lab. The Project is an international collaboration of universities, high schools, and private firms developing picosatellites containing scientific, private, and government payloads. The primary mission of the CubeSat program is to provide access to space for small payloads. Cal Poly standardized the form factors for the CubeSat and the most common is a 1U, which is a approx. 10 cm cube. There are multiple CubeSat configurations based on the 1U form factor such as a 2U (22cm x 10cm x 10cm), 3U (34cm x 10cm x 10cm), 6U (34cm x 20cm x 10cm) etc.

1.3. Dispensers Description

The dispenser provides a standard interface between picosatellites class satellites and a launch vehicle. It also serves as a deployment system for the CubeSats.

The dispensers are a standard CubeSat deployment system, which ensures all CubeSat developers conform to a common CubeSat form factor 1U (10cm x 10cm x 10cm), which in turn reduces cost and development time. The most common dispenser has an internal volume of 34cm x 10cm x 10cm, and is called a 3U dispenser. There are other dispensers in industry using the CubeSat form factor of 6U which has an internal volume of 34cm x 20cm x 10cm. Other larger CubeSat dispensers are in development today that are consistent with the Cubesat form factor of 12U and 24U. The dispensers are versatile, with a small profile and the ability to mount to different launch vehicles in a variety of configurations and hold differing CubeSat form factors.

The design of the dispensers creates a predictable linear trajectory for the picosatellites resulting in a low spin rate upon deployment. The launch vehicle sends a signal to open a spring-loaded door, then the satellites are deployed from the dispenser by means of a spring and glide along smooth flat rails as they exit the dispenser.

2. Applicable Documents

All Compliance and Reference documents are compiled into this section. Documents listed herein are applicable to this document to the extent specified in the requirement.

2.1. Compliance Documents

a.	AFSPCMAN 91-710	Range Safety User Requirements Manual Volume 3 – Launch Vehicle, Payloads, and Ground Support Systems Requirements
b.	MIL-STD-1540C	Military Standard Test Requirements for Launch, Upper-Stage, and Space Vehicles
c.	NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft
d.	NPR 8715.6	NASA Procedural Requirements for Limiting Orbital Debris

2.2. Reference Documents

a.	LSP-P-321.01	Engineering Review Process (ERP)
b.	LSP-P-317.01	Dispenser and CubeSat Program Level Requirements Violation and Waiver Process
c.	GSFC-STD-7000	General Environmental Verification Standard (GEVS) for GSFC Flight Program and projects
d.	JPL D-26086D	Environmental Requirements documents (ERD)
e.	MMPDS	Metallic Materials Properties Development and Standardization
f.	MIL-HDBK-5	Military Handbook 5, Metallic Materials and Elements for Aerospace Vehicle Structures

3. Definitions

Primary Mission: All hardware, software, systems, and analysis products pertaining to the manifested primary spacecraft customer (includes both primary and secondary payloads).

Auxiliary Payload: Are considered in this document as the picosatellites or CubeSats that have no interface (mechanical, electrical or RF) with the LV.

CubeSat(s): All hardware, software, systems, and analysis products pertaining to a Cube Satellite that is intended to be installed within a dispenser. This includes CubeSat mass simulators.

Dispenser(s): All hardware, software, systems, and analysis products pertaining to a CubeSat Deployer.

Dispenser System: An integrated system consisting of dispenser and installed CubeSats.

Launch Vehicle (LV): The selected Launch Vehicle for a specified CubeSat mission.

Launch Services Program (LSP): The NASA Launch Services Program.

Mandatory Compliance Requirements (MCRs): Are those requirements within the dispenser to CubeSat ICD, which LSP is required to verify to sign the CoFR.

Maximum Predicted Environment (MPE):

- Dynamic Environments MPE: Envelopes a P95/50 or mean + 5 dB of flight environments.
- Thermal MPE: Derived via simulation + 11° C for uncertainty

4. Mission Objective

The LSP desires to launch CubeSats utilizing containerized dispensers as an auxiliary payload.

5. Programmatic Requirements

Dispenser systems shall pose no increase to the baseline risk for the Primary Mission.

5.1. Program Requirements

5.1.1. LSP will procure integrated services and flight qualified dispensers per the requirement in this document and mission specific Dispenser to LV ICD.

5.1.2. LSP will apply best effort for the mission success of the individual CubeSats (LSP is not responsible for mission success of the CubeSats).

5.1.3. CubeSat mission will be approved by the Flight Planning Board before manifesting on NASA missions.

5.1.4. Flight Planning Board will inform the Primary Mission that CubeSats have been manifested on their mission.

5.1.5. LSP will provide resources to accommodate the integration of selected CubeSats mission.

5.1.6. LSP will not require attendance from the Primary Mission for Dispenser or CubeSat reviews and assessments; however, the Primary Mission will be informed and invited.

5.1.7. LSP will have approval authority for dispensers and CubeSat requirements and insight into all other dispenser and CubeSat development activities (e.g. design, development and test) as required.

5.1.8. CubeSats will be manifested per Manifesting Policy (TBD).

5.1.9. CubeSats will not interfere with the mission success of other CubeSats integrated in the same dispenser.

5.1.10. CubeSats shall be delivered to the integration contractor in a time frame that does not affect the dispenser integration-processing schedule.

5.1.11. Dispenser system shall be delivered to Launch Service Contractor in a time frame that does not affect the Primary Mission integration cycle or launch timeline.

5.1.12. All violations of the requirements listed in this document shall be reviewed and dispositioned per LSP-P-317.01, *Dispenser and CubeSat Program Level Requirement Violation and Waiver Process.* All technical requirement changes shall be approved by LSP Engineering Review Board.

6. Program Technical Requirements

This section defines the technical requirements for LSP, CubeSats, dispensers and LV.

6.1. LSP Technical Requirements

6.1.1. LSP will conduct verifications for the Dispenser to LV ICD as well as the MCRs with the Dispenser to CubeSat ICD.

6.1.2. LSP will follow their standard review process for non-conformances, new flight items, changes is qualification status etc. per LSP-P-321.01 *Engineering Review Process (ERP)*.

6.2. CubeSat Technical Requirements

6.2.1. CubeSats shall be designed, and verified to the environments defined in Table 1 - *Dispenser and CubeSat Test Environments Testing Table* and per Figure 1 - *Dispenser and CubeSat Qualification and Acceptance Test Flow Diagram*.

6.2.2. CubeSat Structural qualification is adequately achieved through environmental testing only. (PR 6.3.1, Table 1) During periods where all flight loads are applied, CubeSats are considered to be internal components of the dispenser assembly.

6.2.3. CubeSats shall be no smaller than a 1U (10x10x10cm) form factor and no larger than a 6U (30x20x10cm) form factor. (dimensions are nominal)

6.2.4. CubeSats shall not contain pressurized vessels. CubeSat containing non-ventable pressure containers are permitted if the satisfy the following requirements.

6.2.4.1. Pressure shall be no more than 1 atmosphere while on Orbit.

6.2.4.2. Pressure container contents shall be not endanger personnel or equipment or create a mishap (accident) if released.

6.2.4.3. Pressure containers shall be structurally qualified in accordance with Table 2 - Strength Qualification Requirements

6.2.5. CubeSat shall not contain propulsion systems.

6.2.6. CubeSats shall not contain radioactive material.

6.2.7. CubeSats shall not contain any explosive devices

6.2.8. CubeSats hazardous material shall conform to AFSPCMAN 91-710, Range Safety User Requirements Manual Volume 3 – Launch Vehicles, Payloads, and Ground Support Systems Requirements.

6.2.9. CubeSats shall remain powered off from the time of delivery to LV through on orbit deployment. Real time clock circuits are permitted if they satisfy the following requirements. (Reference ELVL-2013-0043486)

6.2.9.1. Real time clock circuits shall be isolated from the CubeSats main power system.

6.2.9.2. Real time clock frequencies shall be less than 320 kHz.

6.2.9.3. Real time clock circuits shall be current limited to less than 10 mA.

6.2.10. CubeSats shall not radiate RF from the time of delivery to LV through 45 minutes after on-orbit deployment.

6.2.11. CubeSats shall be designed with at least 3 independent inhibits to prevent inadvertent RF transmission.

6.2.12. CubeSats shall be self-contained, and provide their own power, sequencing, and wiring.

6.2.13. CubeSats shall be designed to accommodate ascent venting per Ventable Volume/Area < 2000 inches in accordance with accepted standards such as JPL D-26086, *Revision D, Environmental Requirements Document (ERD)*.

6.2.14. CubeSats mission design and hardware shall be in accordance with NPR 8715.6 *NASA Procedural Requirements for Limiting Orbital Debris*.

6.2.15. CubeSats materials shall be selected in accordance with NASA-STD-6016 (Section 4.2)*, Standard Materials and Processes Requirements for Spacecraft.*

6.3. Dispenser Technical Requirements

6.3.1. Dispensers shall be designed, and verified to the environments defined in Table 1 - *PPOD and CubeSat Test Environments Testing Table* and per Figure 1 - *Dispenser and CubeSat Qualification and Acceptance Test Flow Diagram*.

6.3.2. Dispensers shall be structurally qualified in accordance with Table 2 - Strength Qualification Requirements.

6.3.3. CubeSat size limitations are established in 6.2.3 and occupy the full usable volume of a Dispenser.

6.3.4. Dispensers shall not violate the primary mission static and/or dynamic envelopes.

6.3.5. Dispensers shall not affect LV avionics qualification status or architecture.

6.3.6. Dispensers shall incorporate a sensor for door position (Open/Closed).

6.3.7. Dispensers' door release mechanism shall be designed to accept redundantly initiated signals.

6.3.8. Dispensers shall be designed to accommodate ascent venting per Ventable Volume/Area < 2000 inches in accordance with accepted standards such as JPL D-26086, *Revision D, Environmental Requirements Document (ERD).*

6.3.9. Dispensers shall deploy CubeSats at a velocity sufficient to prevent re-contact with Primary Mission hardware.

6.3.10. Dispensers shall not deploy CubeSat mass simulator(s).

6.3.11. Dispensers shall utilize industry standards for locking methodologies on all fasteners consistent with NASA-STD-6016.

6.3.12. Dispensers' material shall be in accordance with NASA-STD-6016 (Section 4.2), *Standard Materials and Processes Requirements for Spacecraft.*

6.3.13. Dispensers shall conduct vehicle specific CubeSat separation analyses.

6.3.13.1. The separation analysis shall determine the nominal and 3 sigma dispersion values of the impulse imparted to the LV for each CubeSat separation event to include consideration of separation system mechanism and CubeSat mass properties uncertainties.

6.3.13.2. The separation analysis shall confirm that deploying CubeSat(s) during the CubeSat separation event(s) remain within the allowable separation cone(s) as specified by the LV contractor.

6.3.14. Dispenser System shall be designed to provide a minimum of 20 dB EMI Safety Margin (EMISM) for non-explosive actuator (NEA) circuits.

6.3.15. Dispenser System shall have a fixed base frequency greater than 120 Hz.

Table 1 – Dispenser and CubeSat Environments Test Table

Tests	Qualification by Test	Protoflight Test	Acceptance Test
Random vibration[6] (CubeSat and Dispenser) Ref Mil-Std 1540C	MPE + 6 dB for (3) minutes, each of (3) axes [1]	MPE+3 dB for (2) minutes, each of (3) axes [1]	MPE for (1) minute, each of (3) axes [1]
Sinusoidal Vibration[6] (CubeSat and Dispenser) Ref Mil-Std 1540C	MPE + 6 dB. Testing shall be performed for content that is not covered by random vibration testing	1.25 x MPE. Testing shall be performed for content that is not covered by random vibration testing	MPE. Testing shall be performed for content that is not covered by random vibration testing [1]
Shock[6] (CubeSat and Dispenser) Ref Mil-Std 1540C	MPE + 6 dB, 3 times in both directions of 3 axes [1, 3]	MPE + 3 dB, 1 times in both directions of 3 axes [1, 3]	N/A
Thermal Vacuum Cycle (Dispenser Only) Ref.: MIL-STD 1540 B, GSFC-STD-7000	MPE[2] +/- 10° C Minimum Range = -14 -3/+0°C to +71 -0/+3°C Cycles = 8 Dwell Time = 1 hour min. @ extreme Temp. after thermal stabilization Transition = < 5° C/minute Vacuum = $1x10^{-4}$ Torr	MPE[2] +/- 10° C Minimum Range = -14 -3/+0°C to +71 -0/+3°C Cycles = 4 Dwell Time = 1 hour min. @ extreme Temp. after thermal stabilization Transition = < 5° C/minute Vacuum = $1x10^{-4}$ Torr	MPE[2] +/- 5° C Minimum Range = -9 -3/+0°C to +66-0/+3°C Cycles = 2 Dwell Time = 1 hour min. @ extreme Temp. after thermal stabilization Transition = < 5° C/minute Vacuum = $1x10^{-4}$ Torr
Thermal Vacuum Bake out (Dispenser Only) Ref.: MIL-STD 1540 B, GSFC-STD-7000	N/A	Min. Temp 70°C [4, 7] Cycles = 1 Dwell Time = Min. 3 hour after thermal stabilization Transition = N/A Vacuum = $1x10^{-4}$ Torr	Min. Temp 70°C [4, 7] Cycles = 1 Dwell Time = Min. 3 hour after thermal stabilization Transition = N/A Vacuum = $1x10^{-4}$ Torr
Thermal Vac Bake out (CubeSat Only) Ref.: MIL-STD 1540 B, GSFC-STD-7000	N/A	Min. Temp 70°C [5, 8] Cycles = 1 Dwell Time = Min. 3 hour after thermal stabilization Transition = < 5° C/minute Vacuum = $1x10^{-4}$ Torr	Min. Temp 70°C [5, 8] Cycles = 1 Dwell Time = Min. 3 hour after thermal stabilization Transiton = < 5° C/minute Vacuum = $1x10^{-4}$ Torr
Hardware Configuration	Dispenser – Flight identical unit (includes NEA, cable and connector) **CubeSat** – Flight Identical unit	Dispenser – Flight unit (includes flight NEA, cable and connector) **CubeSat** – Flight unit	Dispenser – Flight unit (includes flight NEA, cable and connector) **CubeSat** – Flight unit

(1) Dynamic Environments random MPE envelopes a P95/50 or mean + 5 dB of flight environments. Sinusoidal levels envelope loads predictions and flight environments. Shock MPE envelops P95/50 for at least (3) samples, with 4.5 dB uncertainty factor applied where less than (3) samples are used.

(2) Thermal MPE = Max predicted via simulation + 11° C for uncertainty.

(3) Shock testing is not required when the following conditions are met: 1) The qualification random vibration test spectrum when converted to an equivalent shock response spectrum (3-sigma response for Q=10) exceeds the qualification shock spectrum requirement at all frequencies below 2000 Hz. 2) The maximum expected shock spectrum above 2000 Hz does not exceed (g) values equal to 0.8 times the frequency in Hz at all frequencies above 2000 Hz, corresponding to the velocity of (50 inches/second).

(4) Maximum bake out temperature set to same maximum temperature for thermal cycle test for consistency, assuming bake out would be performed during same vacuum exposure.

(5) If the CubeSat cannot achieve these temperature levels, the CubeSat shall hold a minimum temperature of 60°C for a minimum of 6 hours.

(6) Levels are defined to be at the dispenser to Launch Vehicle mechanical interface.

(7) Thermal bake out temperatures are not to exceed qualification temperatures

(8) **CubeSat Thermal vacuum bakeout is required unless LSP removes the requirement for individual CubeSats based on material selection, quantities and manifesting.**

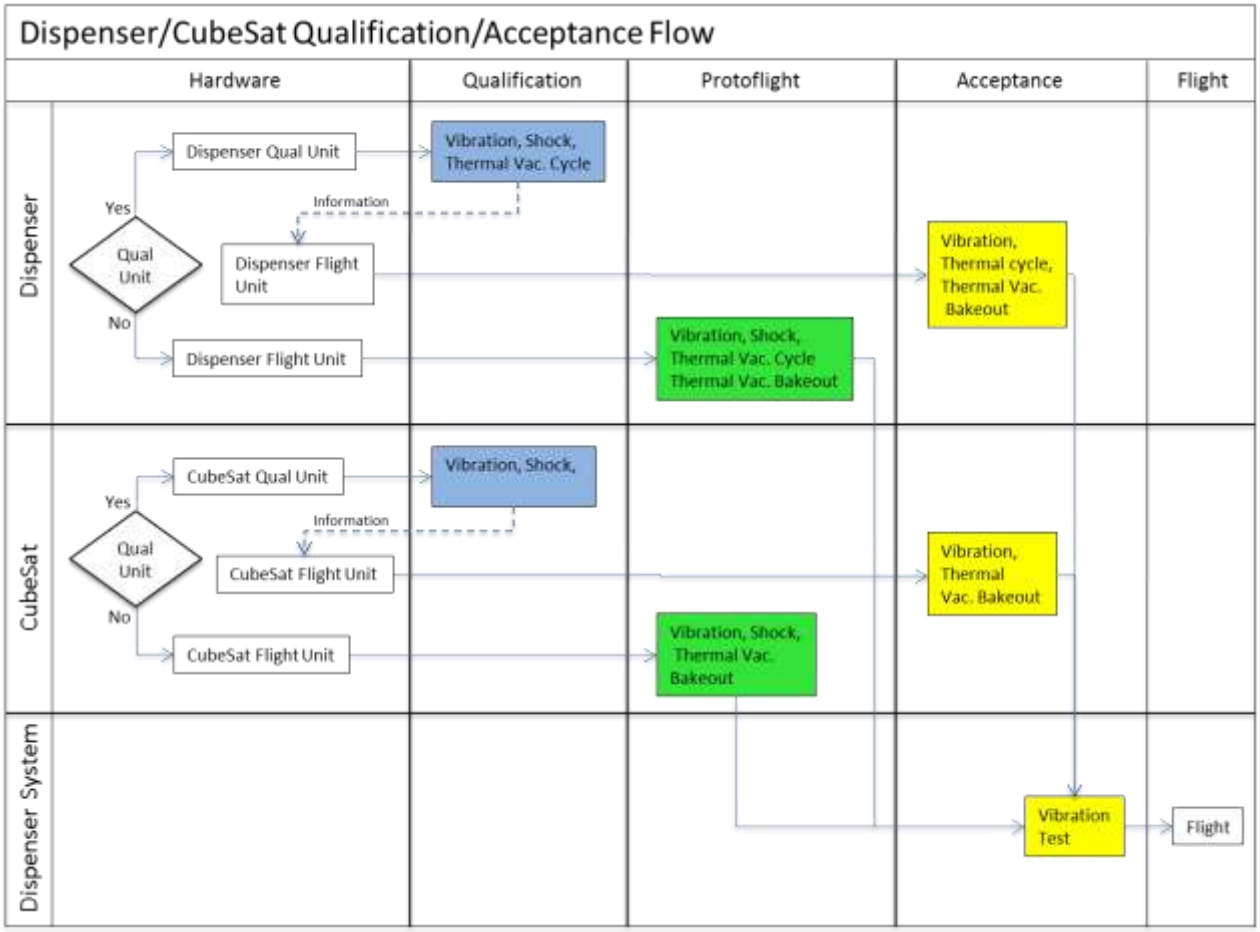

Figure 1 Dispenser and CubeSat Qualification Acceptance Flow Diagram

Table 2, Strength Qualification Requirements

Qualification Method	Qualification Factors of Safety
Strength Analysis Only	1.6 X Limit load with respect to material yield strength 2.0 x limit load with respect to material ultimate strength
Structural Test*	1.1 X Limit load with respect to material yield strength with no detrimental yielding of test article 1.25 x limit load with respect to material ultimate strength with no structural failure of test article
Note: Material Strength properties shall be "A" basis allowable as shown in either MIL-HDBK-5 or MMPDS. Limit loads are worst-case combination of flight loads and environments occurring during the launch phase of a mission. * A combination of structural test and analysis maybe used for qualification. Factors of safety used in the analysis are those shown above for Structural Test.	

6.4. LV Technical Requirements

6.4.1. LV shall integrate and/or install Dispenser System onto a NASA/Launch Vehicle Contractor agreed upon location.

6.4.2. LV integration of a dispensers System shall not delay primary mission integration cycle.

6.4.3. LV shall not modify the Primary Spacecraft interface to accommodate a Dispenser.

6.4.4. LV shall accommodate Dispenser door position indicator in the flight telemetry stream.

6.4.5. Deleted

6.4.6. LV shall provide fault tolerance for inadvertent actuation equal to or better than that used on the primary/secondary spacecraft.

6.4.7. LV shall not alter the mechanical and electrical interface design of the Dispensers.

6.4.8. LV shall design, qualify and acceptance test the LV Dispenser interface.

6.4.9. LV shall command deployment of the dispenser's CubeSats.

6.4.10. LV trajectory design shall not result in LV contact with deployed CubeSats.

6.4.11. LV shall not deploy the CubeSats in a trajectory that will contact the Primary Mission or LV.

6.4.12. LV shall define the CubeSat allowable deployment cone for each dispenser.

Appendix A

Acronyms

Cal Poly	**California Polytechnic State University**
cm	**Centimeter**
ELV	**Expendable Launch Vehicle**
ICD	**Interface Control Document**
kg	**Kilograms**
LSP	**Launch Services Program**
LV	**Launch Vehicle**
MCR	**Mandatory Compliance Requirements**
MPE	**Maximum Predicted Environments**
NEA	**Non-Explosive Actuator**
RF	**Radio Frequency**