UMD Balloon Payload Program Payload Requirements Document
Revision A

Prepared by: _____ Date: 16/OCT/17
Bianca Foltan

Prepared by: _____ Date: 16/OCT/17
Luke Renegar

Reviewed by: _____ Date: 10/16/17
Steve Lentine

Approved by: _____ Date: 16 Oct 17
Dr. Mary Bowden, *UMDBPP Principal Investigator*

Change History

Revision	Date	Changes	Approved by
A	16/OCT/17	Extensive revisions; added structural requirements; began tracking changes	M. Bowden

Introduction

The purpose of the Balloon Payload Program is to launch payloads into near-space environments for the purpose of conducting scientific and engineering research. A number of rules have been developed during the numerous previous flights to guide the design, construction, and flight of payloads to maximize their chance of success and the safety of the launch, flight, and recovery crews.

The following document is designed to codify those lessons into a guide which payload designers can use when formulating their payload to ensure the safety and maximize the effectiveness of the payload.

In this document, a requirement is identified by “SHALL” or “MUST”, a good practice by “SHOULD,” permission by “MAY”, expectation by “WILL,” and descriptive material by “IS.”

Scope

This document is intended as a design document and does not attempt to cover safe launch, flight, or landing operations or procedures.

Applicability

Each payload which wishes to be eligible to fly on a BPP launch MUST address the following requirements in one of two ways.

- They MAY certify that they meet both the intent and letter of each requirement.
- Alternatively, if a payload cannot meet one or more of the requirements because of a design feature critical to its purpose and goals, the payloads MAY request a waiver from that requirement. The request MUST be accompanied by a written justification for the necessity of the waiver.

Waivers WILL generally be granted, unless there is a specific safety concern created by not conforming to the requirement.

Verification

Verification of these requirements WILL occur throughout the payload development life cycle.

Verification WILL begin at the payload design review, which SHALL be completed during initial design and after major changes. In addition to mission assurance concerns, the design reviewers WILL look for adherence to system-level design requirements identified in this document (e.g., general shape of payload, electrical architecture, ability to fly anywhere on the string).

Payloads SHALL go through a thermal test to verify environmental requirements. Pressure is generally not a problem for payloads, but payloads concerned concerned about the pressure environment MAY request a thermal test. A pressure test MAY also be required if the design review raises concerns.

Payloads SHALL complete a flight readiness form, which WILL be used to verify dimensional requirements.

Payloads SHALL be inspected by 5:30 pm on the day prior to launch by designated members of the program. This inspection WILL focus on verifying structural requirements but WILL also check for implementation details (e.g., harmless payload sticker). Flight code SHOULD be functional, and any structural changes recommended by the inspectors MUST be made by 9 pm the same day. Generally, no formal documentation is required (except in special circumstances).

General Payload Requirements

Requirement	Description
BPP-Req-010	The sum of the payload dimensions (length+width+height) shall NOT exceed 1 meter (40 in). Rationale: Large payloads pose complications for transport, launch, and recoveries from trees. Trace: Experience
BPP-Req-015	A payload's area density shall NOT exceed 13.2 g/cm^2 (3 oz./in^2) on the most dense face. Rationale: FAA regulations place restrictions on maximum payload area density. Trace: FAR §101.1.4.i
BPP-Req-020	A payload shall NOT have total launch mass exceeding 1.36kg (3lbs). Rationale: FAA regulations limit payloads to 6 lbs, and heavy payloads limit the number of payloads that can fly. Trace: FAR §101.1.4.ii
BPP-Req-030	A payload SHALL provide a method for running a continuous line close to its center of gravity for attachment to the balloon above and other payloads below. Rationale: The safest method for attaching payloads is for payloads not to bear the tensile load of the payload string. The payload string SHOULD pass as close as possible to the payload center of gravity so that the payload remains stable during the flight. Trace: Experience

Requirement	Description
BPP-Req-031	A payload SHALL protect the continuous line from damage by the payload internals. Rationale: Payloads contain things that could damage a taut line by abrasion (e.g., PCB edges). If the line breaks, the payloads below it will fall to the ground without a parachute, posing a hazard. Trace: Experience
BPP-Req-032	A payload SHALL be mechanically (and non-adhesively) constrained to the payload string. Rationale: Consumer-grade adhesives that can be applied at the launch side are often unreliable at high altitudes. Purely mechanical attachments and constraints are much more robust. Trace: Experience
BPP-Req-040	A payload SHALL not contain liquids. Rationale: A liquid may freeze, boil, or spill during the temperature and pressure extremes during a flight and may negatively impact the payload/other payloads if spilled/released during turbulence experienced in flight. Trace: Experience
BPP-Req-050	A payload SHALL not have external sharp corners or edges. Rationale: Payloads land at high velocities and sharp corners increase the probability of damage to objects or people at the landing site. This requirement is not intended to address antennas. Trace: FAR §101.33.e
BPP-Req-060	A payload SHALL have a sticker stating the harmless nature of the payload and contact information for BPP and UMD. The sticker SHALL be affixed, visibly, to the outside. Rationale: Assures people who find our payloads of their harmless nature and allows them to contact us to return it. Trace: Experience

Requirement	Description
BPP-Req-070	A payload SHALL be able to fly at any position on the payload string. Rationale: Payloads which require a specific position on the string complicate flight logistics. Trace: Experience
BPP-Req-080	A payload SHALL not drop any object (or itself) during flight. Rationale: Dropping things is considered hazardous. Also, the FAA doesn't like it. Trace: FAR §101.33.e
BPP-Req-090	A payload SHALL not utilize voltages higher than 28V. Rationale: High voltage is dangerous and special handling is required for launch and recovery. Only you can prevent forest fires. Trace: FAR §101.7.a
BPP-Req-100	All payload components SHALL be undamaged and fabricated properly. Payloads SHALL have no clear structural deficiencies in any mechanical components. Rationale: Parts that are structurally deficient and/or fabricated improperly can significantly increase the likelihood of mechanical failure. Trace: Experience
BPP-Req-101	A payload SHALL demonstrate, by testing or analysis, structural soundness against flight and landing dynamic loading. Payloads SHOULD refer to the BPP Structural Verification Guidance Document for recommended tests. Rationale: The payload must be mechanically robust enough to not fail during flight as falling debris poses risk to the public. Poorly/improperly fabricated parts and wear items should be replaced before flight. Trace: Experience

Requirement	Description
BPP-Req-102	A payload which is not intended to airtight, and which is constructed from non-porous material (plastic, metal, etc), SHALL have an unobstructed venting area of 0.5cm^2. Rationale: Accidental pressurization is a potential contributing factor to a past payload failure, and should be avoided either through material choice or design features. Trace: Experience
BPP-Req-105	A payload SHALL be designed in such a way that an accidental opening of the access method (ie lid) will not result in a release of the payload contents when in nominal orientation. Rationale: Contents of payloads have been lost due to loss of structural integrity of the lid. Payloads should not be designed such that their lids (which are typically just taped closed) are not load bearing when suspended from the payload line. Trace: Experience
BPP-Req-110	A payload SHALL be capable of operation at a temperature of -60 °C (-76 °F) and a pressure of 600 Pa (0.087 psi; 0.006 atm). Rationale: Payloads must operate in the environmental conditions experienced during flight. Trace: Experience
BPP-Req-120	A payload SHALL resist the effects of internal and external condensation. Rationale: Condensation does occur and can adversely affect the performance of electronics. Desiccants are a common method of mitigating the issues of internal condensation. Trace: Experience

General Payload Design Suggestions

The following are good design practices which should be employed wherever possible but are not required.

Rule	Description
BPP-Rule-010	Payloads SHOULD attempt to use standard battery connectors wherever possible. Standard connectors include the following: ● Deans connectors Rationale: Using standard batteries makes charging them easier, allows us to bring fewer tools to the launchpad, and allows us to have backups available for payloads when necessary.
BPP-Rule-020	Payload SHOULD attempt to use standard mounting hardware wherever possible. Standard mounting hardware include the following: ● 6-32 bolts Rationale: Using standard mounting hardware allows us to bring fewer tools to the launchpad and keep the hardware in stock in the lab.
BPP-Rule-030	Payloads SHOULD use an external power switch which can be actuated after the payload have been sealed for launch. Rationale: The launch process is much simplified if payloads can be closed well before liftoff and turned on when necessary.
BPP-Rule-040	Payload SHOULD have an external method of verifying that their payload and/or software is operating as expected on the launch pad. Rationale: Some problems are solvable on the launchpad if they're discovered before launch. External means of verifying functionality facilitate that.
BPP-Rule-050	Payloads SHOULD undergo thermal testing at least one week before launch. Rationale: A thermal test allows verification that all components of the payload function correctly and in the environmental conditions they will face. Doing the test early allows for time to resolve problems discovered during the test before launch.
BPP-Rule-060	Payloads SHOULD use alternatives to paper clips for attaching themselves to the payload line. Rationale: Paperclips are time consuming to install on the launch pad and difficult to work with. 3D printed paper clip holders are available upon request.
BPP-Rule-070	Payloads SHOULD utilize XBee's for inter-payload communication and SHOULD log their data on multiple payloads if practical. Rationale: Logging the data in multiple places increases redundancy in the event the payload is damaged on landing.

Rule	Description
BPP-Rule-080	Payloads SHOULD limit their use of duct tape wherever possible. Rationale: Duct tape is actually surprisingly heavy. Try not to wrap your payload in it. If your payload needs to be water proof, try masking tape instead.
BPP-Rule-090	Payloads SHOULD always thermal test and fly with desiccants. Rationale: Thermal chamber tests provide a more extreme humidity environment (closed system, large/quick temperature drop) than experienced during flight. Humidity damages microcontrollers and has caused electronic failures in the past.
BPP-Rule-100	A payload SHOULD, where possible, rely on a non-adhesive means (ie mechanical latch) to secure the access method (ie lid). Rationale: Adhesives can become less sticky in various temperature and vacuum conditions and could cause the payload to inadvertently open during flight.
BPP-Rule-110	Payloads SHOULD NOT use alkaline batteries for any purpose. Rationale: Alkaline batteries are not capable of operating in the temperatures experienced during balloon flight.
BPP-Rule-120	Payloads SHOULD be capable of outdoor exposure for at least 24 hours after landing without loss of data. Rationale: The payload string sometimes lands in locations requiring retrieval with specialized equipment and personnel, which are often not available until the following day. Payloads that fail to produce data are of limited use.