Payload User's Guide - Spark-1

Version 0.3 Pre-release (October 2026)

- Aspects of this guide are subject to change
- For more information, use the mission request form

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1.0 Introduction

1.1 Purpose of this Guide

This guide provides payloads with the necessary information to design, qualify, and integrate their payloads for missions on Spark-1.

1.2 Vehicle Overview

Spark-1 is a spacecraft that hosts payloads in orbit and returns them to Earth. It carries payloads two ways: hosted payloads mount on the spacecraft bus and stay in orbit, and returned payloads ride inside a 0.5 m reentry capsule and land by parachute. Spark-1 is designed to be launch vehicle agnostic; its first mission launches on SpaceX Transporter-22 in October 2027. Its modular design allows for rapid integration of diverse payloads, from microgravity experiments to technology demonstrations.

1.3 Mission Concept

A typical mission consists of:

1. **Launch:** SpaceX Transporter-22 rideshare (Falcon 9), launch period opening October 2027.
    - Payload off
2. **On-Orbit Phase:** Deployment into a 500 to 600 km sun-synchronous orbit, then about two years of on-orbit operations. Payloads operate in series (e.g., a few weeks of operation, about a month of analysis on the ground, then another run).
    - Payload on

3. **Reentry:** A phasing orbit lines up the landing off the coast of Vandenberg Space Force Base, then an autonomous de-orbit burn lowers perigee to about 0 km, followed by hypersonic reentry and parachute deploy. Returned payloads come back inside the capsule; hosted payloads do not return.
    - Payload off (payload power during reentry available upon request)
4. **Recovery:** Parachute landing in the ocean about 100 miles west of Vandenberg Space Force Base, and recovery by a contracted ship.
    - Payload off

2.0 Mission Overview

2.1 Standard Mission Profile

- **Orbit:** 500 to 600 km, sun-synchronous
- **Launch-to-Deployment:** About 1 to 2 hours after liftoff, set by the SpaceX Transporter deployment sequence
- **On-Orbit Duration:** About two years; payloads operate in series
- **De-orbit to Landing:** About 1 hour
- **Landing:** Ocean, about 100 miles west of Vandenberg Space Force Base
- **Recovery Access:** Payload recovery within L + 6 hours

3.0 Payload Accommodations & Environments

3.1 Payload Volume & Mass

- **Total Payload Mass:** About 80 kg
    - Hosted payloads: about 50 kg, mounted on the spacecraft bus, unpressurized; they stay in orbit
    - Returned payloads: about 30 kg, inside the 0.5 m reentry capsule; they land with the capsule
- **Payload Envelope:** Set per payload; returned payloads fit inside the 0.5 m capsule
- **Pointing:** About 23 arcsec (1σ), body pointing; an option down to about 7 arcsec is available
- **Center of Gravity (CG):** TBD

3.2 Mechanical Interface

- **Interface Options:**
    1. Preloaded tabs
    2. Mounting Rails
    3. M6 fasteners

3.3 Dynamic Environments

The payload must be designed to withstand all ground and flight environments. The values below are preliminary and will be finalized per mission.

- **Quasi-Static Loads:**
  - Qualification
    - In Plane: 20 G, Sine Sweep 20-100Hz
    - Out of Plane: 25 G, Sine Sweep, 20-100 Hz
  - For Payloads with a primary resonant frequency < 200 Hz, please reach out
- **Random Vibration:**
  - Qualification: 14.1 GRMS
    - 3 min/axis
  - Acceptance: 10 GRMS
    - 1 min/axis

3.4 Reentry Environments

This section defines the unique environments during the reentry phase, which are often the driving design case. It applies to returned payloads, which ride inside the capsule.

- **Reentry Deceleration Loads:** The QSL values in 3.3 include reentry. The peak deceleration is approximately 7 g.
- **Venting:** Payloads which are not hermetically sealed must be designed to vent to prevent pressure differentials. The max external pressure rate of change is 1 psi/sec.

3.5 Thermal Environments

- **On-Orbit:**
  - 100 W Payload Power
    - Interface Temperature (Payload Off): [-20°C to +30°C]
    - Interface Temperature (Payload On): [+50°C +/- 10 °C]
  - 10 W Payload Power
    - Interface Temperature (Payload Off): [-20°C to +30°C]
    - Interface Temperature (Payload On): [+4°C +/- 2°C]
      - Higher payload interface temperatures available upon request up to 40 C
- **Reentry Thermal:**
  - The payload is protected by the vehicle's Thermal Protection System (TPS).
  - Max Interface Temperature (Reentry): The payload interface plate will not exceed 40°C during reentry, with a duration of 15 minutes.
- **Thermal Model:** A simplified vehicle thermal model is available upon request to assist in payload design.

3.6 Contamination Control

- **Cleanliness:** Payloads shall be delivered meeting ISO 8 (Class 100,000) cleanliness standards.

- **Outgassing:** Materials which are not hermetically sealed must meet ASTM E595 requirements:
  - Total Mass Loss (TML): ≤ 1.0%
  - Collected Volatile Condensable Material (CVCM): ≤ 0.1%

4.0 Electrical & Data Interfaces

4.1 Power Interface

- **Available Power:** 100 W continuous; surges to 300 W for up to 20 minutes at a time
- **Bus Voltage:** Regulated and unregulated power both available
  - Regulated: 24 V
  - Unregulated: 28 ± 6 VDC
- **Max Current:** 10 A peak for short durations
- **Connectors:** Vehicle provides One (1) 9-pin D-sub connector for payload power and One (1) 15-pin D-sub connector for communications.
- **Grounding:** Grounding is provided through the connector and payload mounting interface

4.2 Data Interface

- **Commanding and Telemetry:**
  - RS-422, Asynchronous (preferred)
  - Data Rate: Up to 1 Mbps to flight computer
  - Ethernet also supported
  - Additional interfaces available upon request
- **On-Board Data Storage:** The vehicle provides 10 GB of on-board storage for payload data.
- **Connectors:** Vehicle provides One (1) 15-pin D-sub connector for communications.

4.3 Communications

- **TTC:** Up to 10 Mbps downlink available for payload telemetry
- **RF Blackout:** Live communication to/from the vehicle to ground terminals will be unavailable during reentry for approximately 15 minutes.
- **Payload RF Systems:** Any payload-provided transmitters must be declared and approved. Frequencies must be coordinated with Dispatch and spectrum authorities.

5.0 Payload Design & Verification Requirements

5.1 Structural Design

- **Factors of Safety:** Payloads must meet the following factors of safety (FOS):
  - Yield: 1.25
  - Ultimate: 1.50

- **Analysis:** A structural analysis report is required for verification.

5.2 Safety & Mission Assurance

- **Inhibits:** All hazardous functions (e.g. high-voltage, high pressure) must be protected by a minimum of two (2) independent inhibits.

5.3 Verification & Testing

Payloads must be subjected to an acceptance program that includes:

- **Functional Test:** Ambient conditions
- **Vibration Test:** NASA GEVS
- **Thermal Vacuum Test:** 5°C beyond on orbit conditions, payload on
- **Proto-qualification:** New designs must be tested to qualification levels Payload acceptance testing may be provided by Dispatch upon request

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6.0 Integration & Mission Operations

6.1 Integration Flow

- **L-210 Days:** Payload PDR, Interface Control Document (ICD) preliminary.
- **L-180 Days:** Payload CDR, ICD final.
- **L-60 Days:** Payload delivery to Dispatch integration facility.
    - Payload integration with vehicle interface checks.
- **L-30 Days:** Vehicle environmental testing complete.
- **L-15 Days:** Integration with Launch Vehicle.

6.2 Pre-Launch & Launch Ops

- **Payload Access:** Latest payload access is 24 hours prior to launch vehicle integration.
- **Launch Command:** Payload is powered off from launch vehicle integration to separation on orbit.

6.3 Recovery Operations

- **Landing:** Parachute landing in the ocean about 100 miles west of Vandenberg Space Force Base.
- **Timeline:** Recovery team will be on-site within L+4 hours
- **Payload Access:** Payload module will be removed and transferred to a controlled environment within L+6 hours.
- **Handover:** Payload will be handed back to the customer. Dispatch can provide data retrieval and cold-stowage services if required.