FIREFLY
AEROSPACE

ALPHA

PAYLOAD USER'S GUIDE

Overview

The goal of the Alpha Payload User's Guide is to provide summary information for preliminary mission planning for Payload Customers. The contents found herein are not intended to be mission specific and are subject to change. Firefly welcomes detailed design data such as payload-specific requirements and interfaces, and operational plans once a Launch Service Agreement is in place.

Contact Firefly

Please contact Firefly Aerospace Launch Services with inquiries into the suitability of the Alpha launch vehicle for your mission.

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Copies of this Alpha Payload User's Guide may be obtained from the Firefly website at the link above. Hardcopy and electronic copies are also available upon request.

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1 Introduction

Welcome to the Payload User's Guide for the Alpha launch vehicle - we're glad you're here!

Firefly's mission is to make space accessible by providing our customers with reliable, economical, high-frequency launches for orbital services.

Our Alpha small satellite launch vehicle enables this vision. Come aboard.

1.1 Firefly's History

Firefly Aerospace Inc. ("Firefly") was founded to provide economical, high-frequency access to space for small payloads through the design, manufacture and operation of reliable launch vehicles. The Firefly team addresses the market's need for flexible access to space with a "simplest, soonest" approach to technology selection.

Firefly's engineering team is comprised of industry-proven leaders with experience in building both commercial launch vehicles and successful technology firms. Augmenting and rounding out this team are passionate young minds from the country's top engineering schools. Each vehicle is engineered with cross-industry design insights and leverages high maturity design elements and commercial off-the-shelf (COTS) components to reduce risk and increase reliability. Firefly's manufacturing process is highly vertically integrated. Propulsion, structures and avionics are designed, built and tested in-house. The technologies employed in our Alpha flagship vehicle provide a clear pathway for future incremental improvements in vehicle capability.

Firefly's facilities include a 20,000-square foot design campus in Cedar Park, Texas, just north of Austin, which houses the corporate headquarters, engineering staff, prototyping facilities and machine shop. The Firefly Briggs operations facility, a 200-acre test and production site, is a short drive north from the design campus. It hosts extensive and growing test and manufacturing capabilities. Briggs facilities house ground systems fabrication, a test control center, surface finishing/processing, composites fabrication and assembly production. Briggs is also home to the propulsion, structures and materials testing range, whose close proximity to the design campus facilitates rapid transitions from paper to proven designs. A horizontal engine test stand, a vertical stage test stand, and high-pressure component stand are available for low-cost rapid developmental testing.

Firefly's first launch is scheduled for the third quarter of 2019. By the first quarter of 2021, production capacity will support the launch of two Alpha vehicles per month.

2 Vehicle Overview

2.1 Alpha Architecture

Alpha is a two-stage launch vehicle capable of delivering 1,000 kg (2,204 lb) of payload to 200 km (125 mi) Low-Earth Orbit. Alpha utilizes efficient technologies such as composite tanks and COTS components (e.g. Avionics electronics), and streamlines operations with all facets of design, testing, and production located near Austin, Texas. A summary of the vehicle characteristics is given in Table 1 and illustrated in Figure 1.

Table 1: Alpha Characteristics

CHARACTERISTICS	STAGE ONE	STAGE TWO
Height	29 m (95 ft) including fairing, interstage and stages	
Diameter	1.8 m (6 ft)	
Material	Carbon composite	
Propellant	LOX/RP-1	LOX/RP-1
Propellant feed system	Turbopump	Turbopump
Engine name	Reaver 1	Lightning 1
No. engines	4	1
Thrust (stage total)	736 kN (165,459 lbf)	70 kN (15,737 lbf)
Engine designer	Firefly	Firefly
Engine manufacturer	Firefly	Firefly
Restart capability	No	Yes
Tank pressurization (No.)	Heated helium (4)	Heated helium (1)
Dry mass	2,895 kg (6,382 lb)	910 kg (2,006 lb)
GLOW (SSO, 500 km)	54,000 kg (119,050 lb)	
Payload mass	1,000 kg (LEO 28.5°, 200 km) 600 kg (SSO, 500 km)	

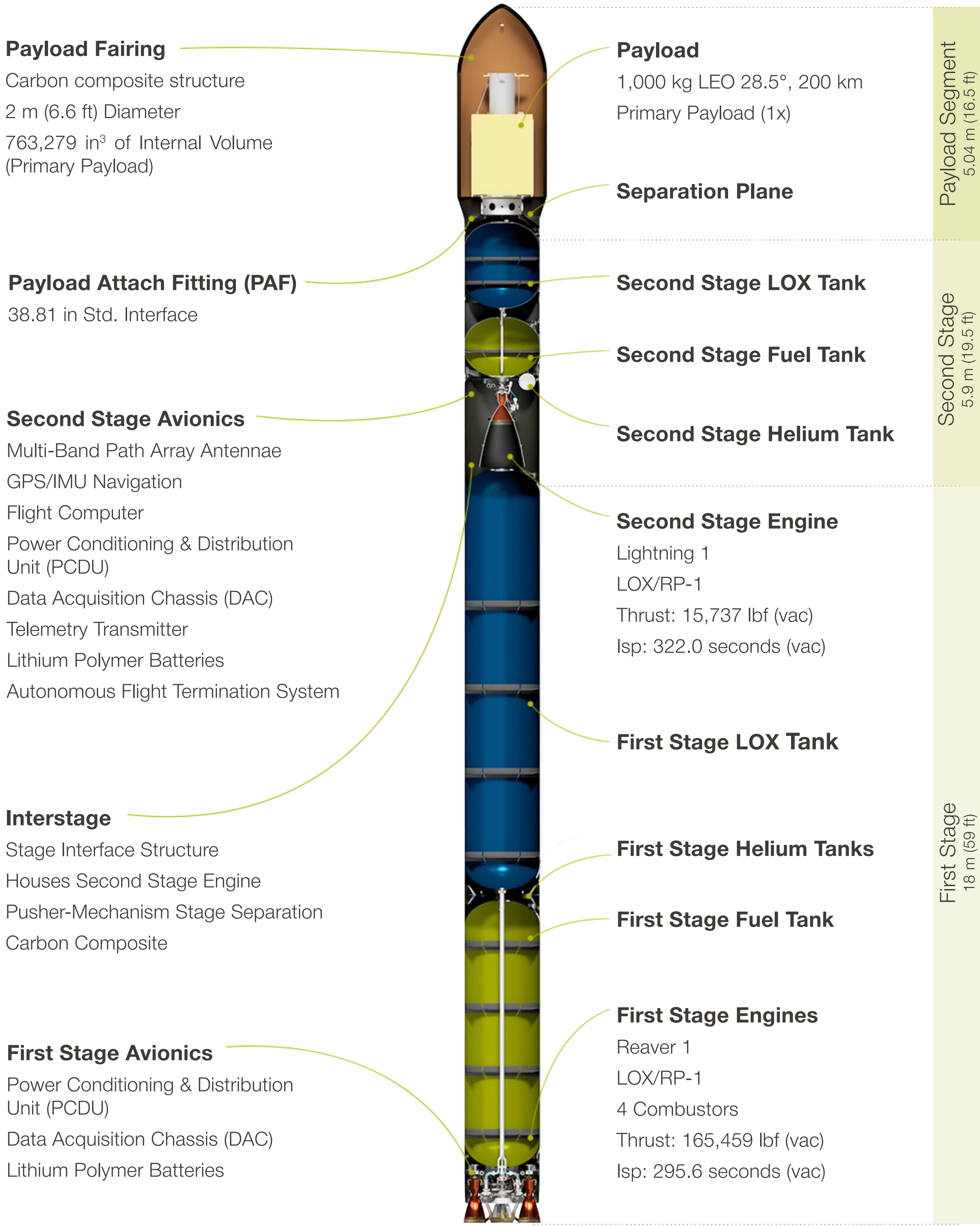

Figure 1: Alpha Overview

Figure 2 shows the definition of the axes for the Firefly Alpha vehicle. As is the case with most launch vehicles, the X-axis is the roll axis for the vehicle, and therefore the vertical axis for any vertically mounted satellite. The axes definitions in Figure 2 are used throughout this User's Guide to specify payload environments, loads and test requirements.

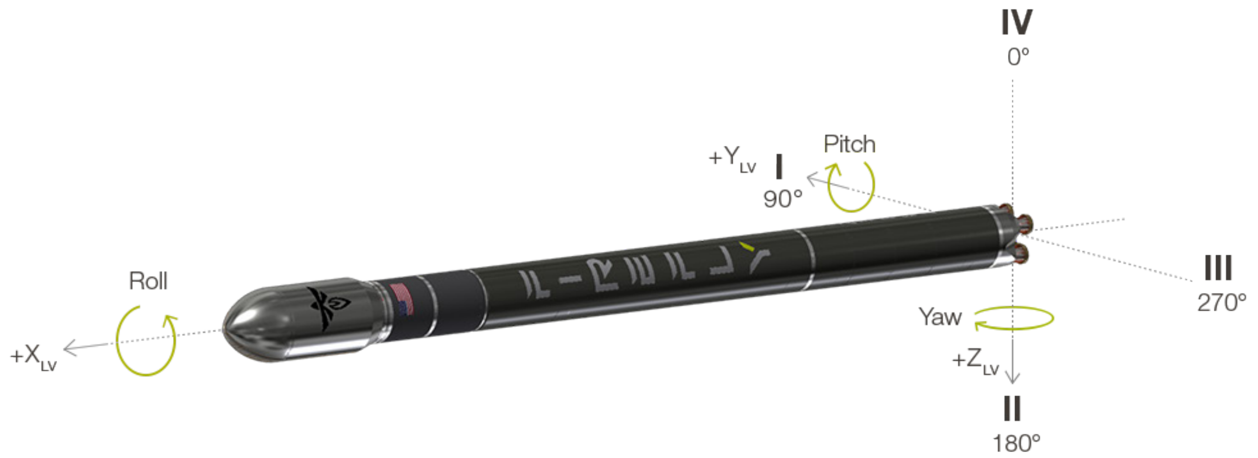

Figure 2: Alpha Vehicle Coordinate Frame

2.1.1 First Stage

First stage propulsion features four independent LOX/RP-1 engines. These pump-fed LOX/RP-1 engines yield 165,459 lbf (vac) thrust. This stage incorporates a carbon composite propellant tank with four helium pressurant tanks nested between the LOX and fuel tanks. Thrust vector control is provided by gimballing each thrust chamber using electrohydraulic actuators. Flight termination is ordnance-based termination for both stages for the first ten flights, with Autonomous Flight Termination Units located on Stage 2.

2.1.2 Second Stage

The second stage delivers the payload to orbit, and features a pump-fed stage with a bell nozzle engine. The LOX/RP-1 second stage provides 15,737 lbf (vac) thrust. The second stage features an all-composite structure including a 2 m payload fairing baseline accommodation. A single helium tank provides ullage pressurant, attitude control, roll control, and settling. The engine is gimbaled using electrohydraulic actuators for thrust vector control.

2.1.3 Payload Fairing

The payload fairing composite construction is 2 m (6.6 ft) in diameter by 5.04 m (16.5 ft) in height, developed by Firefly.

The fairing is separated into two equal halves as shown in Figure 3 by a mechanical separation device using a pyrophoric bladder.

Figure 3: Open Clamshell Fairing Concept

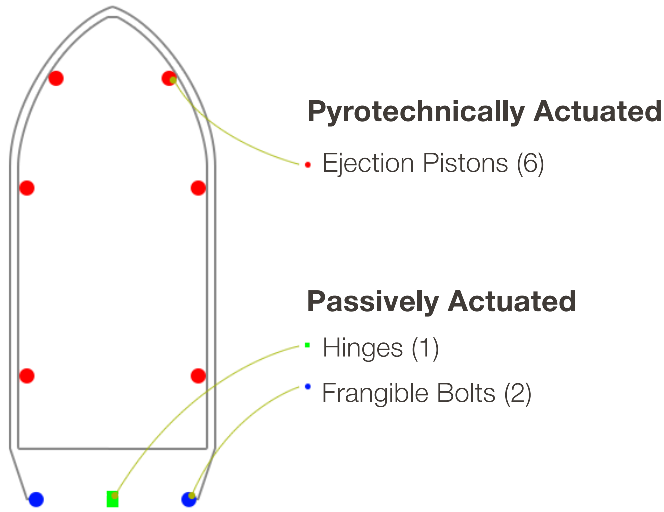

Figure 4: Baseline Fairing Separation Design

Firefly separation occurs as the timed event referring to the exposure of the payload and departure of its encapsulation during second stage flight. Firefly initiates this event by using pyrotechnically actuated pistons to eject the fairing. Successful fairing separation is achieved through Firefly's split clamshell design and by managing key fairing kinematic parameters and design features.

The ultimate deployment of payload is called payload separation, which occurs after second stage burn and vehicle stabilization. This event involves the deployment of the satellite from the Payload Attach Fitting (PAF).

2.2 Performance

The performance capabilities of the Firefly Alpha vehicle are detailed in this section. Alpha can accommodate a wide range of payload requirements and our team can provide performance trades to meet our Customers' needs. Figure 5 shows orbit delivery performance for inclinations typical of a launch from the East Coast of the United States. Figure 6 shows orbit delivery performance for inclinations typical of a launch from the West Coast of the United States. These plots currently reflect two-burn profiles, and will be refined as additional analysis is performed.

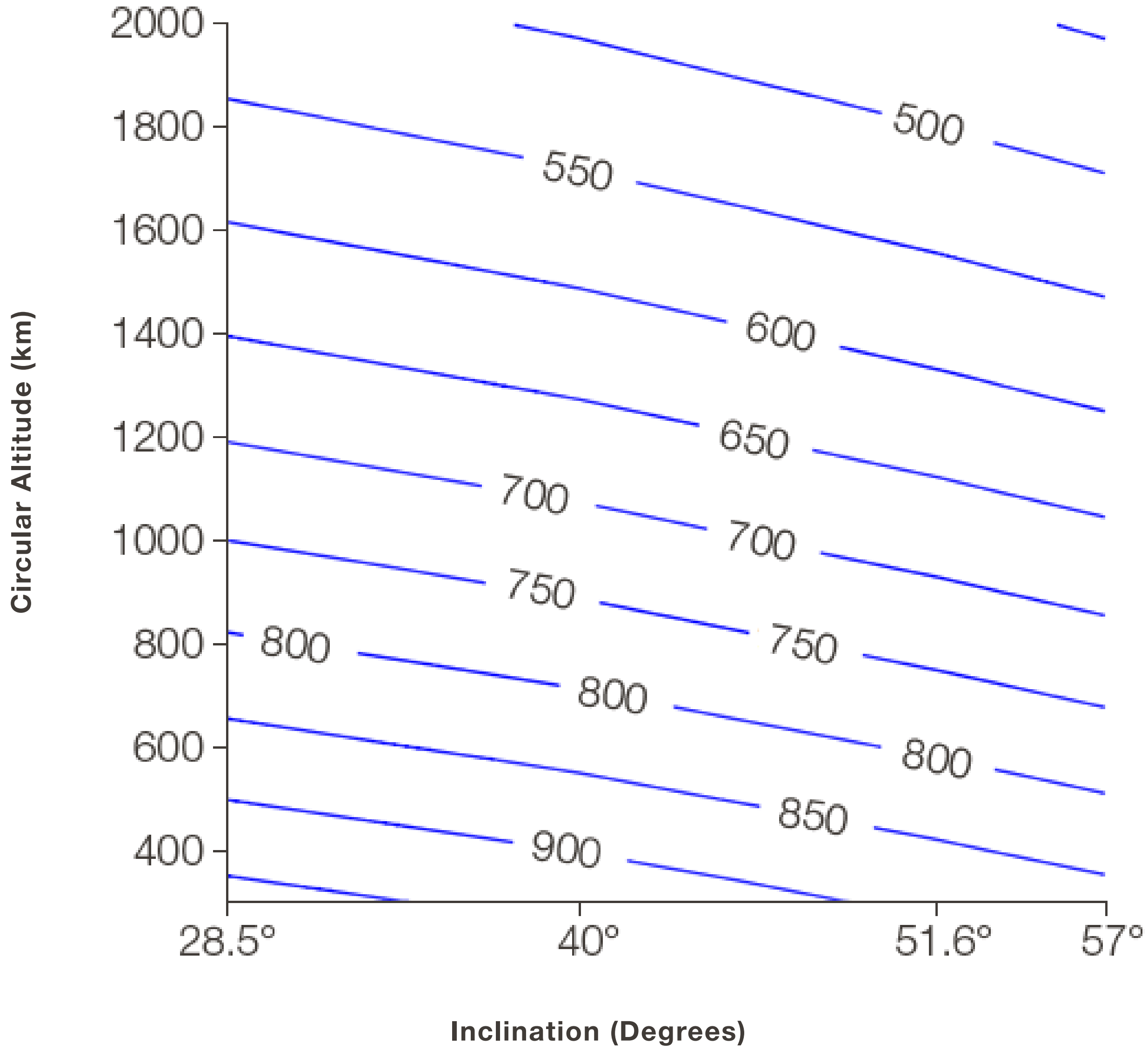

Figure 5: Alpha Performance, East Coast Launch

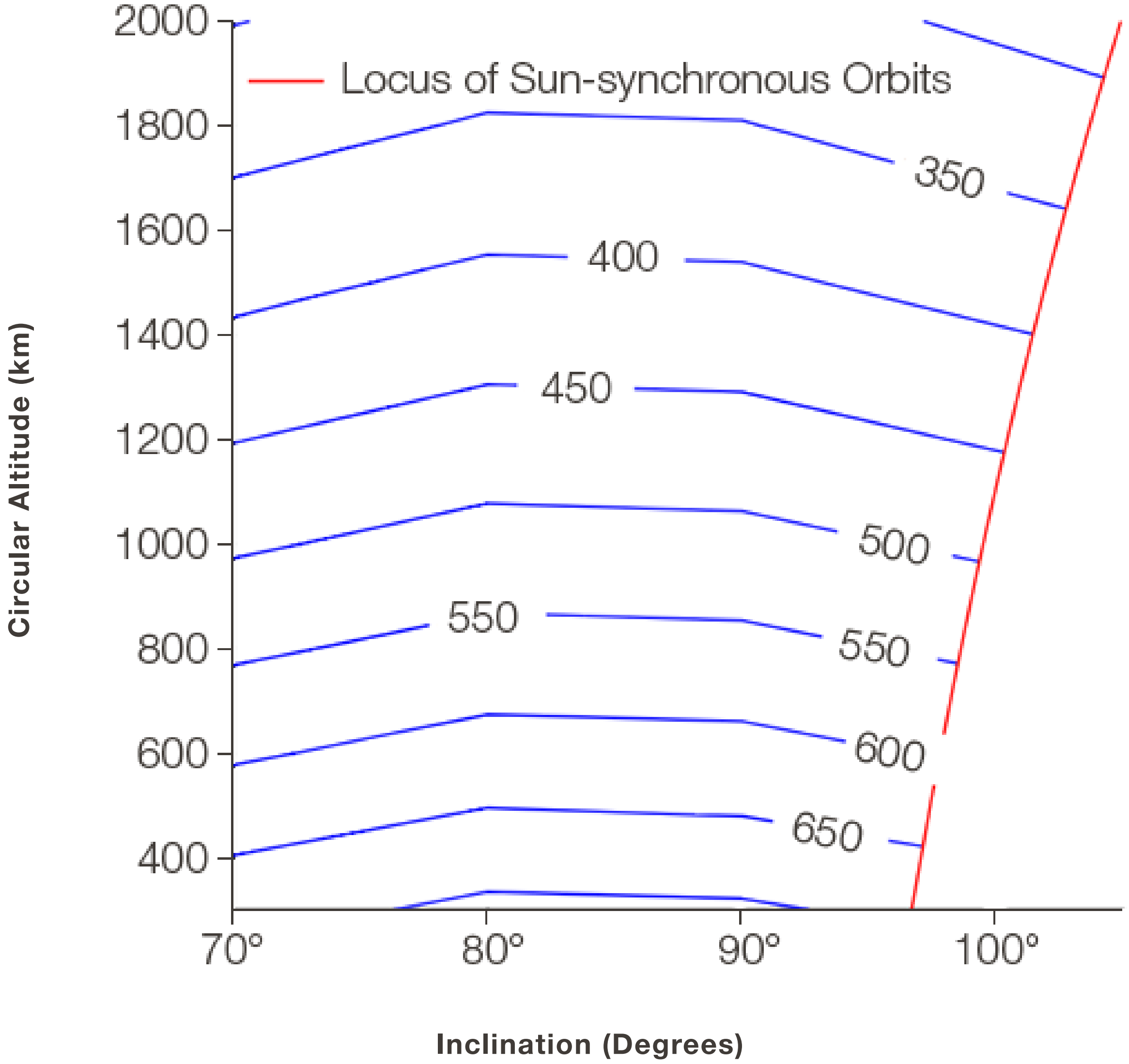

Figure 6: Alpha Performance, West Coast Launch

An example flight profile of the Firefly Alpha launch vehicle is depicted in Figure 7. Most missions will follow a similar profile, although the times and altitudes at which key events occur may vary slightly. For the direct insertion missions depicted, payload deployment will occur approximately 500 seconds after liftoff. For multi-manifested missions and/or those requiring higher orbits, the Alpha second stage will first insert into a low elliptical transfer orbit, coast to apogee, and then initiate a second burn to circularize into the final orbit.

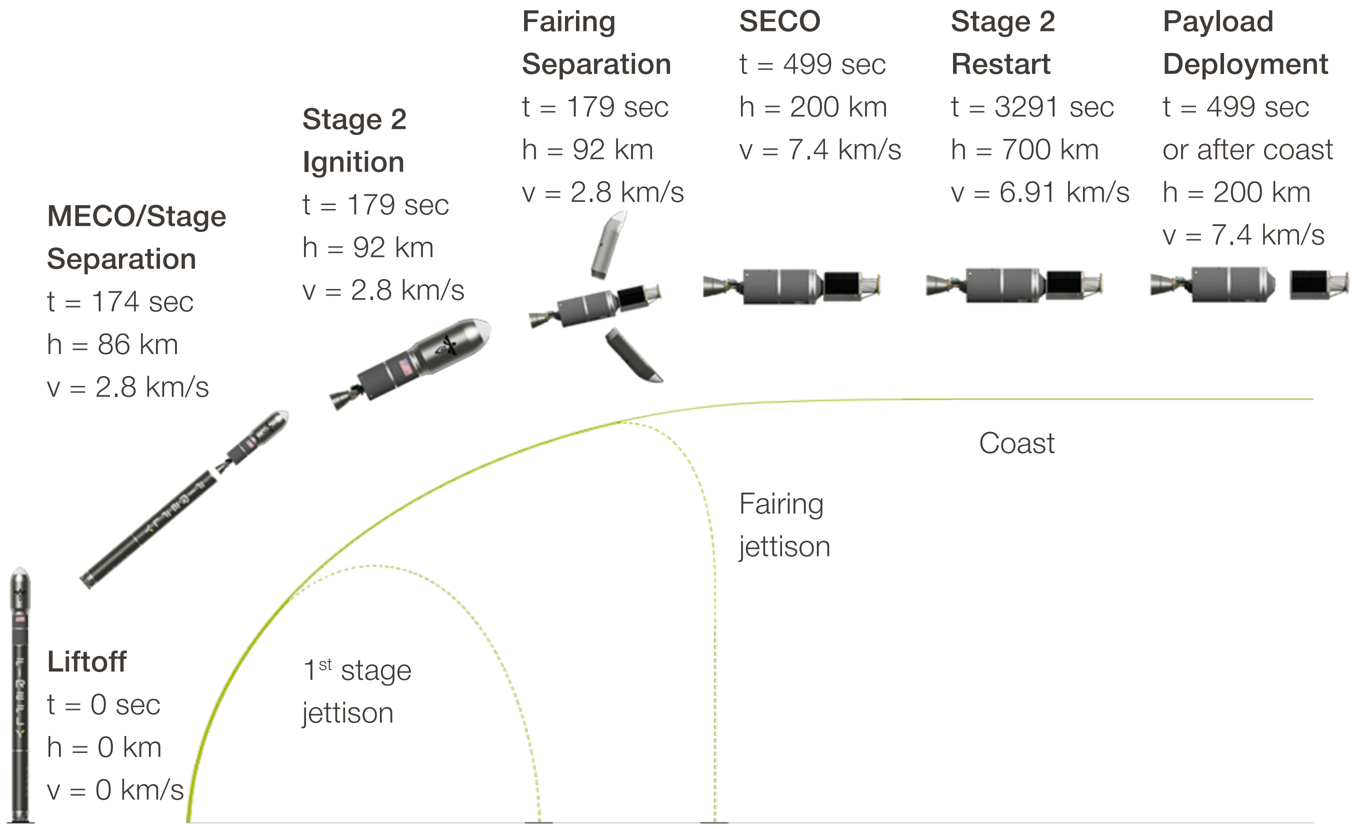

Figure 7: Example Alpha Flight Profile

2.2.1 Payload Insertion Accuracy

The second stage of the Alpha vehicle incorporates an inertial navigation control module consisting of an IMU and GPS receiver, to provide precise pointing and orbit insertion. For a second-stage probability of command shutdown (PCS) of 99.7%, the following values represent the three-sigma (3σ) dispersions for a two-stage mission to low-earth orbit. Continued analysis may yield tighter tolerances as performance is refined.

- Perigee altitude: ± 5km
- Apogee altitude: ± 15 km
- Orbit inclination: ± 0.1°

2.2.2 Launch Services

Firefly aims to offer the lowest price, best value launch service to its Customers. A list of standard services and provisions are included in the basic Firefly offering and price. Firefly also anticipates requests for non-standard services during early mission planning and will accommodate the services and provisions listed below:

Table 2: Launch services

STANDARD SERVICES	NON-STANDARD SERVICES
• Payload access prior to fairing closure • Launch of the payload into the desired orbit • Customer support from the Payload Mission Manager, Ground support and Launch Operations resources and personnel needed to support Mission planning, integration and launch • ISO 8 (same as 100K) clean room payload and PAF integration space • Payload processing, integration and encapsulation within the fairing • Testing of payload interfaces at the launch site • Environmental conditions per contract agreement and payload health and monitoring requirements • Provisions for safety interfaces and protocols, pursuant to range regulations • Acquisition and maintenance of mission-required licensing for launch vehicle, including US FAA and State Department • Mission Simulation Test exercising operational readiness, vehicle resources and equipment and ground system support • Mission Dress Rehearsal for key launch team members • Post-flight launch services, including delivery of the Post-Flight Data Package, including payload separation confirmation, payload environment report and final orbit configuration • Separation system provided by Customer	• Payload power during launch • Payload access after fairing closure • Payload heating and/or dedicated thermal control during cruise phase (prior to payload separation) • Additional planning meetings • Additional Customer offices and payload checkout space • Increased cleanliness levels in payload checkout areas • Additional fueling services and provisions • Additional launch documentation • Hypergolic fueling of payload • RF transmission after encapsulation and before payload separation • Separation system provided by Firefly

2.3 The Firefly Advantage

Firefly is enthusiastic about the opportunity to discuss how Alpha might accommodate your mission. Select advantages of Firefly's Alpha space launch vehicle include:

Availability
Firefly launch vehicles will be mass produced to the highest quality standards. Mass production enables the ability to change the industry through regularly scheduled launches.

Reliability
Firefly launch vehicles are designed and built for reliability. Separation events are kept to a minimum in that there are just three: stage, fairing, and payload separation. Each launch vehicle will run through a regime of tests, starting at the component level, up to a full stage test prior to transportation to the launch site. Specific design choices have been made to ensure that reliability is not compromised, beginning at the architectural level. Firefly has made the following design decisions for improved reliability:

Table 3: Design choices for increased reliability

DESIGN CHOICE	DESCRIPTION
Environmental Qualification	Environmental qualification is performed on all Firefly-designed avionics with SMC-S-016 (Space and Missile Systems Center Standard – Test Requirements for Launch, Upper-Stage and Space Vehicles) as a baseline
Parts, Materials and Processes Plan	The Firefly-developed Parts, Materials and Processes Plan is used to standardize and establish reliability for Firefly designed hardware; The EEE parts baseline is Automotive Grade with extended temperature ranges
Pump-Fed Engine	Pump-fed engine enables tank design pressures for low operating strain
CLA	Coupled Loads Analysis with Vibroacoustic analysis ensures that the Alpha launch environment will not exceed the vibration requirements of the payload
Safety Margins	Robust structural margins of safety

DESIGN CHOICE	DESCRIPTION
Composite Materials	Composite materials enable monolithic parts with fewer structural joints, which leads to fewer failure points and leak paths
COTS hardware	With space launch vehicle heritage, COTS hardware is employed for many Avionics and Fluid System components, as well as prepreg carbon fiber to ensure consistent quality and robust material for Structures components
Autonomous Flight Termination	The Autonomous Flight Termination Unit (AFTU) is procured from a RCC-319-14/AFSPCMAN qualified manufacturer
Engine Material Selection	Engine Material Selection based on 50 years of US rocket heritage

3 Mission Management

3.1 Mission Planning & Preparation

Firefly will provide a single point of contact to help guide every Customer through the entire mission planning and execution process. Assigned as the Payload Mission Manager, this Firefly point of contact will remain the primary liaison for the entirety of the Firefly-Customer relationship. Customers can expect transparency and open communication throughout the entire process, with regular status reports. One fit check meeting is foreseen during the mission preparation phase, typically to take place at Firefly's integration facilities per convenience of the Customer. This will be combined with a meeting to finalize the payload to launch vehicle Interface Control Document (ICD). Activities and objectives of the Fit Check include

- Assemble a comprehensive mass and volume representative model of the entire payload segment, including all payloads (in the event of multi-manifested launch configurations) and separation systems and adapters
- Validate the mechanical and electrical interfaces
- Where possible, validate the operation of all separation systems

3.2 Launch Campaign Timeline

Each Firefly mission will follow a standard timeline, starting with the initial Customer contact and finishing with the successful completion of the mission. A typical timeline with key milestones is depicted in Figure 8. All timings and milestones are counted before (-) or after (+) the Launch Date. Insertion data will be provided as early as possible, with the final confirmation of launch performance and parameters delivered no later than three hours after launch. Please note that all dates in the figure should be seen as guidelines, and not as firm constraints; faster timelines may be possible depending on Customer circumstances.

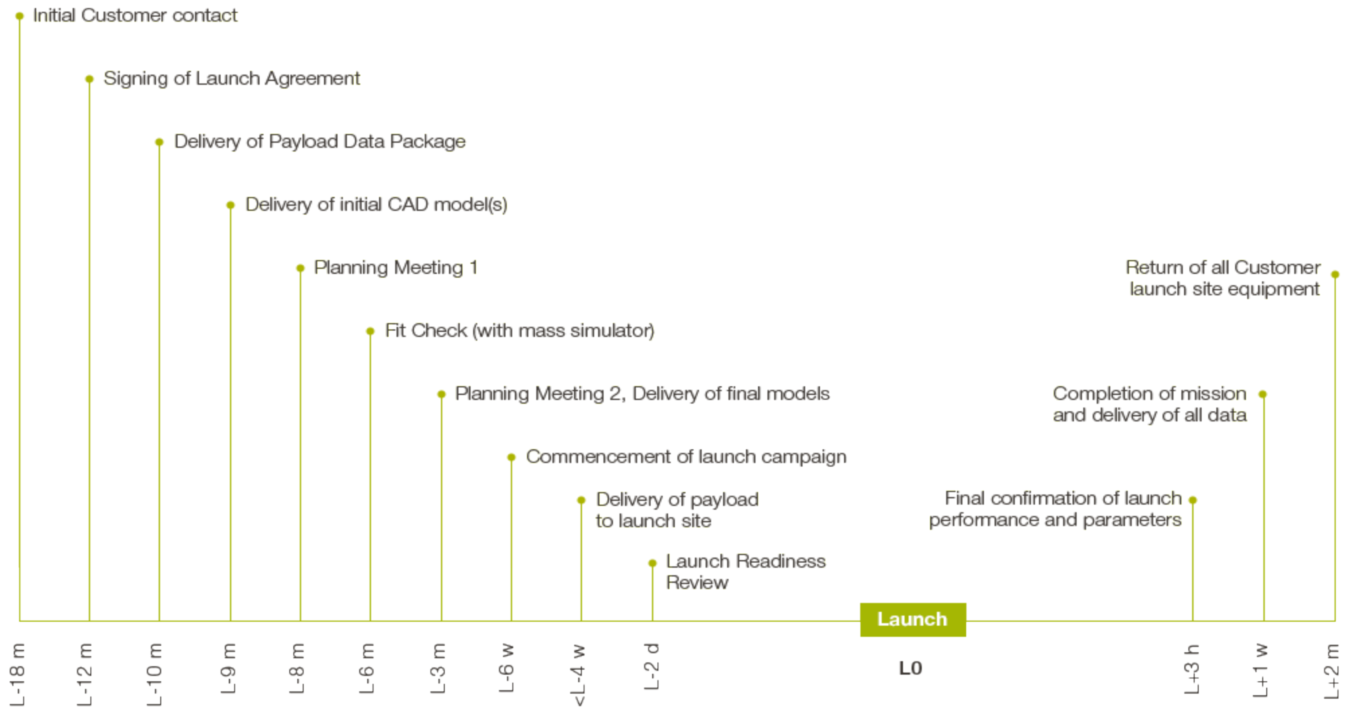

Figure 8: Typical Launch Event Timing

Figure 9 depicts a notional launch timeline as the launch date nears, and Firefly welcomes the opportunity to discuss adjustments for Customer needs. Additional or fewer days can be supported for payload operations depending on Customer needs; the current schedule carries two margin days post-payload mate to the launch vehicle. The Mission Readiness Review evaluates the status of the facilities, the launch vehicle, ground support and payload en route to mission success. This review is the final review of the launch vehicle configuration and all hardware and software modifications needed to support spacecraft mission requirement. It is conducted before shipment of launch vehicle hardware to the launch site. The Flight Readiness Review (FRR) ensures that safety systems and procedures are enabled and readied for mission success. The FRR examines tests, demonstrations, analyses, and audits that determine the overall system readiness for a safe and successful flight/launch and for subsequent flight operations. It also ensures that all flight and ground hardware, software, personnel and procedures are operationally ready. The Flight Safety Review will be incorporated into the FRR. The review shall include vehicle hazards, the status of any applicable waivers and any other issues that contribute to the risk of the flight. The Launch Readiness Review (LRR) is the final prelaunch assessment of the integrated launch vehicle/payload system and launch facility readiness for launch and is considered the last critical review before launch.

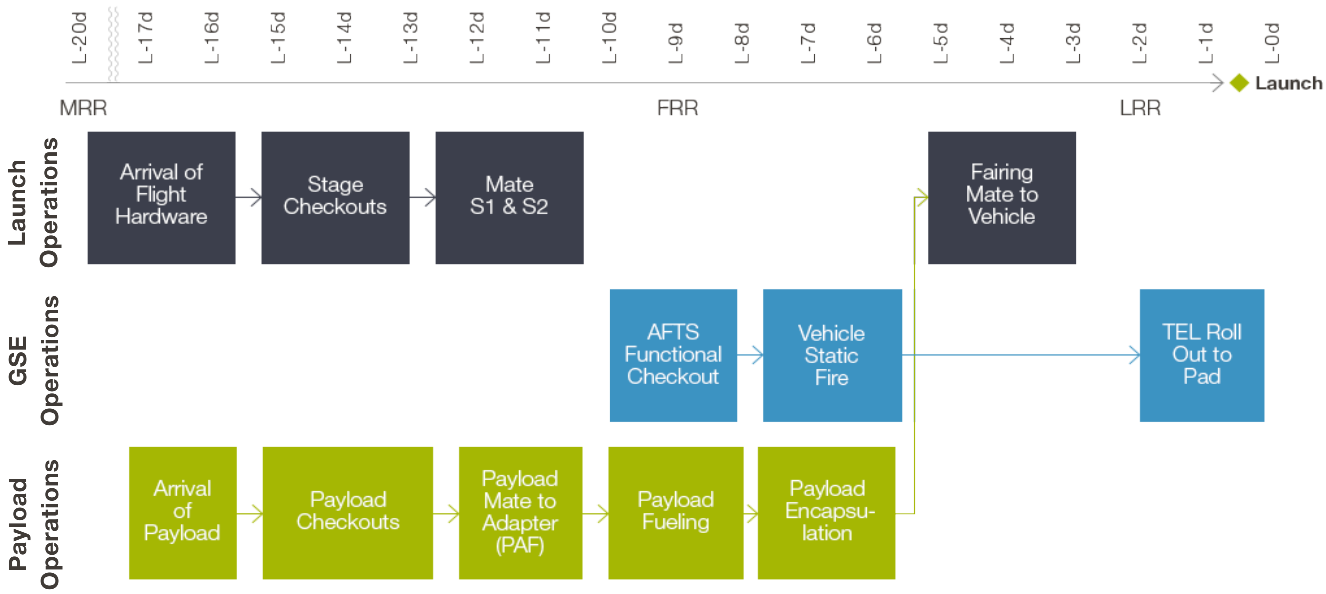

Figure 9: Notional Launch Campaign Timeline

An expected overall launch campaign duration is three weeks, with seven to ten days typically assigned to payload checkout and miscellaneous autonomous payload operations, and an additional seven to ten days typically required for payload to launch vehicle integration activities and final launch vehicle preparation activities (including fairing closure, transport to launch pad, and launcher erection). The Firefly point of contact will work with Ground Support to facilitate clear communication and coordinate launch site activities. Firefly aims to exceed Customer expectations during all phases of launch preparation.

3.3 Payload Integration Operations

Payloads interface with the launch vehicle by means of a structure called the Payload Attach Fitting (PAF) and are encapsulated by the payload fairing in the vertical position. The encapsulated payload will then be rotated to a horizontal orientation by means of a break-over fixture. The payload segment is then mated to the launch vehicle in the horizontal position. The payload will be in a horizontal, cantilevered position until the launch vehicle is rolled out to the pad and raised to the vertical position.

4 Ground and Launch Operations

4.1 Launch Control Organization

Figure 10 shows the expected launch control organization and associated roles, and is representative of the organization after the test flight phase is complete. The primary interface for the Customer is a dedicated Payload Mission Manager, who reports to the Launch Director at the Range.

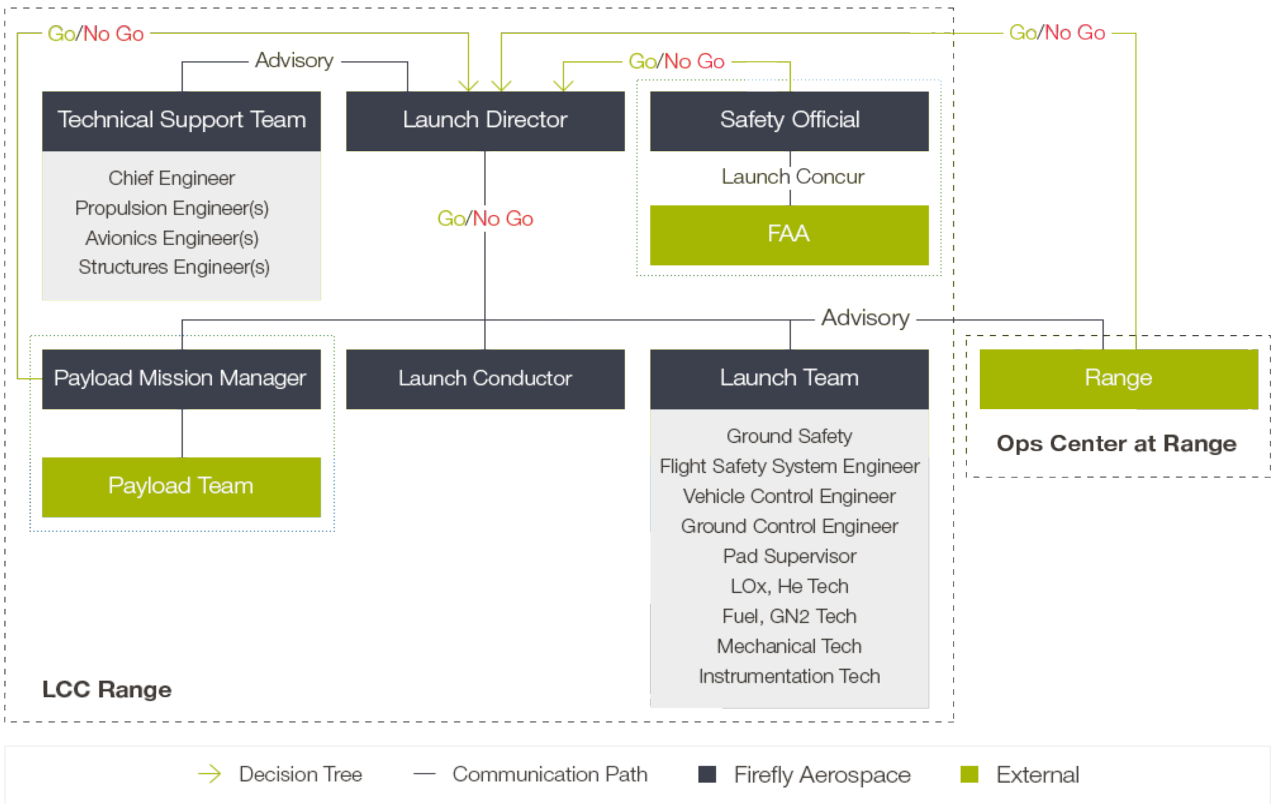

Figure 10: Launch Control Organization

4.2 Payload Processing

4.2.1 Payload Transport to Launch Site

The Firefly Payload Mission Manager will work with Customers to coordinate transportation of payloads from the pickup location (Customer facility, airport, railway station, etc.) to the Firefly Payload Processing Facility (PPF). Please see Section 6.3.2 for more details of this facility. If accommodations are desired beyond the PPF, Firefly can work with Customers to process the payload elsewhere with advanced discussion.

The payload arrives at the Firefly PPF and is lifted from the transportation carrier by fork truck or overhead crane located within the airlock. The satellite shipping container is wiped down prior to being relocated into the clean room area, which will provide a minimum processing area of 500ft^2. The satellite will be removed from the shipping container with an overhead crane and mated to the PAF. Once the payload is fully assembled, checked out, and (if required) fueled, it will be encapsulated by the fairing.

4.2.2 Encapsulation

After the payload is mated to the PAF and checkouts are complete, all contamination-critical hardware will be inspected and if necessary cleaned prior to encapsulation. The payload will be enclosed by the fairing in the vertical position. Upon payload encapsulation, a continuous supply of clean air is provided at a typical environment range as stated in Table 8. The air is supplied to the encapsulated payload through the air-distribution access door. A deflector can be installed within the fairing at the inlet to direct any airflow from sensitive payload components. The payload fairing with enclosed payload will be rotated to a horizontal orientation by means of a break-over fixture. The PAF will be mated to the launch vehicle in the horizontal position. The payload will be in a horizontal, cantilevered position until the launch vehicle is rolled to the pad and raised to the vertical position. The air distribution access door is closed during the roll out to the launch pad with no climate control provided until arrival at the pad.

4.2.3 Fueling

Gaseous helium and nitrogen fluid panels will be available in the Payload Processing Facility and main vehicle integration hangar. Nitrogen will be 99.99% pure per MIL-PRF-27401F, Grade B. Helium will be 99.995% pure per MIL-PRF-27407D, Grade A. Higher purities can be provided upon request.

Hypergolic fueling can be completed as a non-standard option and Firefly welcomes the discussion at initial mission planning meetings. Early missions that require fueling may take place at a third party facility and then be transported to the launch site.

4.2.4 Cleanliness of Facilities

The Horizontal Integration Facility is maintained as a visibly clean, climate controlled space at all times. As a standard service, the PPF clean room area will be certified and operated at ISO 8 (Class 100K FED-STD-209E) for payload encapsulation.

4.2.5 Customer Team Accommodation & Offices

Office type accommodation will be provided for Customer teams. This will typically consist of:

- Office desks and chairs
- A meeting area with a small meeting table and chairs
- IT equipment is not provided as a standard service although adequate power and network/internet connections will be provided. Additional Customer office accommodations can be provided as desired.

4.2.6 Infrastructure

4.2.6.1 Power

Firefly accommodations for payload EGSE at the PPF and launch equipment building provide the following power sources: 120V/240V single phase, and 208V three phase, 60 Hz. 50 Hz accommodations could be made via frequency converters and should be included within the ICD requirements and discussed during initial meetings.

4.2.6.2 Internet

High-speed, broadband internet access (both Ethernet and WiFi) will be available to Customers both in the offices provided and the payload processing cleanroom facilities. A single connection in each office/area will be provided. This is not part of the mission network and can only be used as general use – if local networks are required it is expected that the Customers bring their own equipment to set up local networks.

4.2.7 Launch Vehicle Customer Access

Customer access to Alpha will be restricted to the combined payload/launch vehicle processing operations and activities. Customers will be allowed to view the launch vehicle during agreed upon times, arranged in advance. Non-US Customers or personnel may not be able to view the launcher while it is in its processing and assembly facility due to ITAR restrictions.

4.2.8 Launch Pad Access and Viewing

Pre-arranged escorted access will be granted to Customers for viewing and access to the launch pad as agreed-upon by all parties. Customers will be invited to view the launch from an official viewing point which will be a safe distance from the launch pad. Non-US Customers will be allowed to view the launch vehicle only during agreed-upon times, arranged in advance, and only with U.S. Government authorization in compliance with the International Traffic in Arms Regulations and the Export Administration Regulations.

4.2.9 Visitors & VIPs

It is understood and expected that Customers may want to invite VIPs and other visitors to view the launch. Firefly will endeavor to accommodate these individuals at the launch viewing sites. Hospitality services may gladly be arranged as a non-standard service offering.

4.2.10 Fluid Checkout Panels

Gaseous helium and nitrogen fluid panels will be available in the Payload Processing Facility and main vehicle integration hangar. Nitrogen will be 99.99% pure per MIL-PRF-27401F, Grade B. Helium will be 99.995% pure per MIL-PRF-27407D, Grade A.
Higher purities can be provided upon request.

4.2.11 Post Launch

Firefly will provide all Customers with preliminary and final orbit details for the launch vehicle at the time of payload deployment. This will occur as soon as is feasible, following the final separation of all payloads. Information on the overall achieved payload delivery, including separation times and any anomalies seen, will also be provided as soon as available. During launch, a video of the payload deployment process will be captured and made available to the Customer post-deployment for analysis and marketing purposes.

5 Payload Accommodations & Requirements

5.1 Payload Envelope

The payload is protected by a fairing that shields it from aerodynamic buffeting and heating while in the lower atmosphere. The fairing is a carbon fiber composite structure with a nominal inner diameter of 2 m (6.6 ft). The maximum usable internal volume is shown in Figure 11, with two payload accommodation scenarios available:

- Single (Primary Only) payload, and
- Primary Payload plus Secondary Payloads (including CubeSats)

Baseline accommodations for Secondary Payloads are presented in Section 5.5, with a secondary payload configuration depicted in Figure 12.

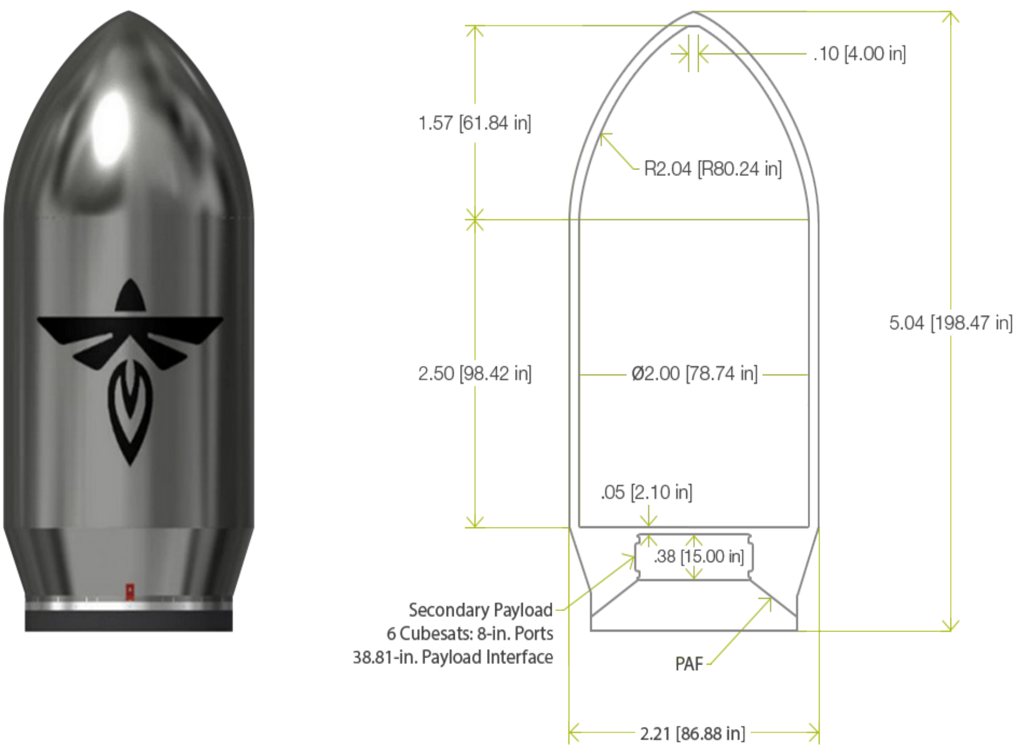

Figure 11: Firefly Alpha Standard Fairing

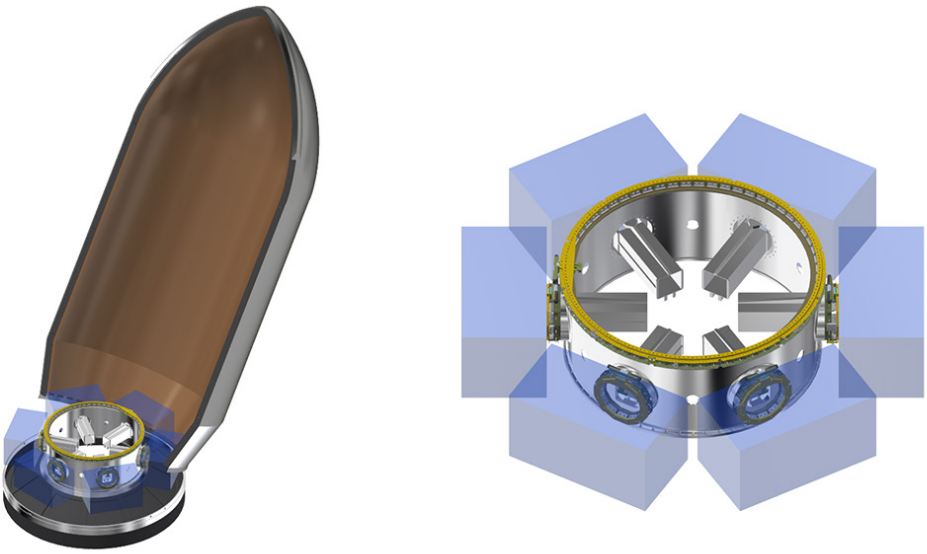

Figure 12: Secondary Payload Configuration

5.2 Payload Interfaces

The Firefly Alpha vehicle features an adaptable standardized attachment pattern, and multiple options for electrical interfaces to accommodate typical small satellite interfacing requirements and characteristics. The emphasis is on interface simplicity and robustness, in line with the overall Firefly approach.

5.2.1 Mechanical Interfaces & Separation Systems

Firefly Alpha may provide a separation system as a non-standard service. Standard services assume a customer-provided payload separation system that interfaces directly to the Firefly-provided PAF. The PAF is designed to interface with a 38.81 inch standard or clamp band separation system, using 60 evenly spaced fasteners. The most commonly-used small satellite separation systems are all accommodated, including:

- Dassault ASAP 5
- Planetary Systems Lightband
- Ruag Clamp Band Separation Systems
- ISIPOD CubeSat Deployer

Per Customer request, the PAF design can be modified to accommodate satellite separation systems of diameters ranging from 8 inches up to 38.81 inches. Requests for accommodation of any non-standard payload interface should be discussed early in the mission planning process.

5.2.2 Electrical Interface

The Alpha Launch Vehicle provides a set of standard payload electrical interfaces in addition to a set of optional but prequalified interfaces. Other custom configurations can be accommodated but may require development NRE and qualification cost and schedule. Connector type and pinouts for the payload will be specified during the payload integration process.

All payload interfaces to the Alpha PAF must be electrically conductive with sheet resistance less than 0.1 Ω per unit area. This interface will be auto verified during payload integration. It is the Customer's responsibility to ensure this requirement is met prior to shipment of the payload to the launch site.

5.2.2.1 Standard Payload Configuration

In the standard payload configuration, the payload is provided access to a current-limited 28V DC supply through Alpha's second stage umbilical connection when on the ground. This supply is monitored and controlled by Alpha's support equipment depicted in Figure 13. Upon launch, payload power must come from satellite battery power and is no longer reliant on vehicle power.

Additionally, the payload is provided with a Category-5e cable connection through Alpha's second stage umbilical providing the operator access to telemetry during pre-flight operations. In this configuration, the payload will be completely isolated from all Alpha vehicle systems and should stay in a powered-off state until deployed.

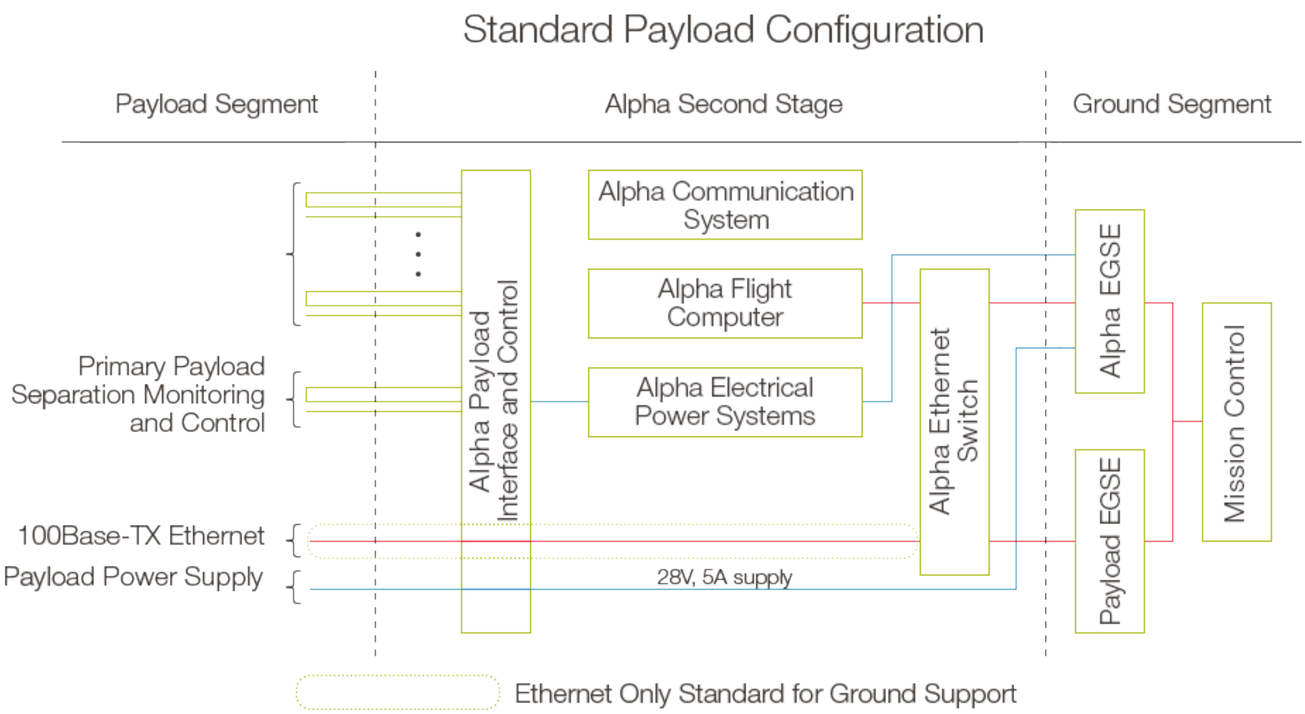

Figure 13: Payload Wiring Diagram – Standard Configuration

5.2.2.2 Optional Configurations

Several optional configurations are available given sufficient notice. All features of the standard configuration are still present with the optional features.

The Customer may request one or both of two forms of digital communication during flight. If desired, the Customer may interface with Alpha's avionics through a 100Base-TX link during flight. This switchover will be performed prior to launch and verified. This data will be sent directly through Alpha's communication system and will not be processed by any Alpha computers with the exception of bandwidth monitoring. Customers should contact Firefly early to determine network compatibility and bandwidth limitations to ensure that Alpha is well-equipped to handle the format and size of the desired data. Additional integration time might be required to ensure compatibility.

Alternatively, an RS-422 connection can be provided to the payload for simple signaling of events including stage separation, fairing deployment and payload separation at no greater than 115200bps. The optional payload configuration is depicted in Figure 14.

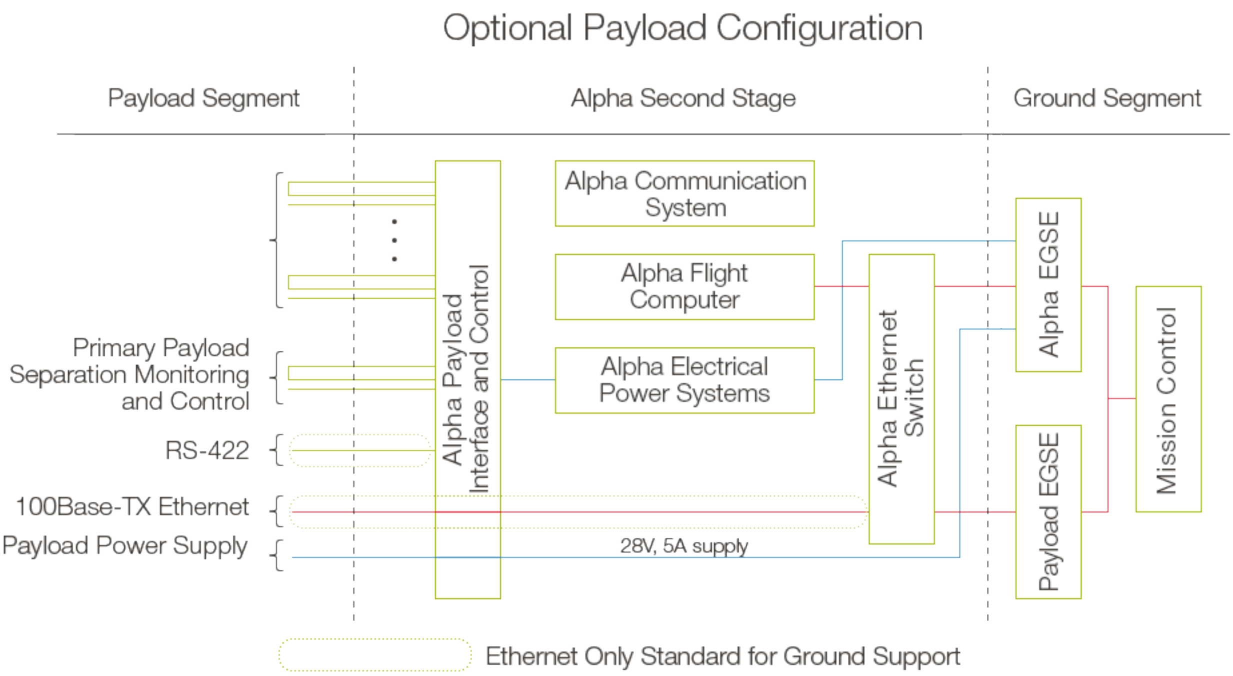

Figure 14: Payload Wiring Diagram – Optional Configuration

5.3 Payload Environments

This section describes the mechanical, atmospheric, and radiation conditions during an Alpha launch.

Table 4: Transportation & Handling Loads

Event	Axial Load (x), g	Lateral Load (y), g	Vertical Load (z), g
Slow-Moving Dolly, TEL Rollout	± 1.0	± 0.75	± 2.0
Launch Site Ground Handling	± 1.0	± 0.75	± 2.0

5.3.1 Mechanical

5.3.1.1 Transportation and Handling Loads

Table 4 shows the maximum transportation and handling loads anticipated during payload accommodations. The ground handling refers to transport down a standard highway, which is not currently provided as a service to the Customer. A slow-moving dolly will be used for any service to be provided to the Customer, which will have the same loading capacity as the Transport Erector Rollout (TEL). The following values reflect the concept of operations that assume an integrated launch vehicle is rolled to the pad horizontally.

5.3.1.2 Flight Loads – Quasi-Static

The payload will experience a range of axial, lateral and vertical loads during flight. Table 5 shows the maximum quasi-static loads to be expected at the payload/launch vehicle interface during flight, with an example axial acceleration for a direct insertion mission depicted in Figure 15. Please note that accelerations are trajectory dependent and will vary.

Table 5: Quasi-static Flight Loads at Payload/launch Vehicle Interface

Event	Axial Load (x), g	Lateral Load (y,z), g
Liftoff	1.0	TBD
Max q α	1.9	- 0.35
Stage 1 Engine Cutoff (MECO)	5.1	± 0.00
Stage 2 Startup (SES)	0.8	± 0.00
Stage 2 Engine Cutoff (SECO)	4.5	± 0.00

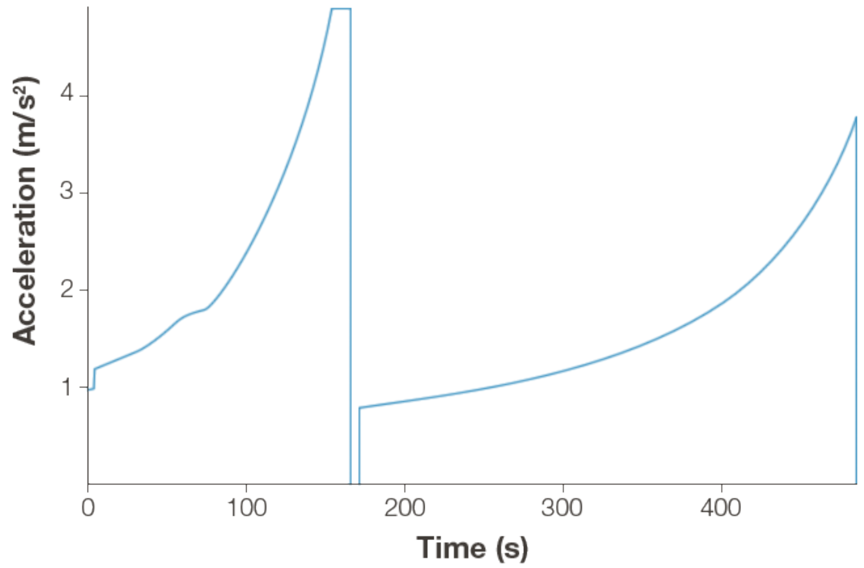

Figure 15: Example Steady State Axial Acceleration For Alpha

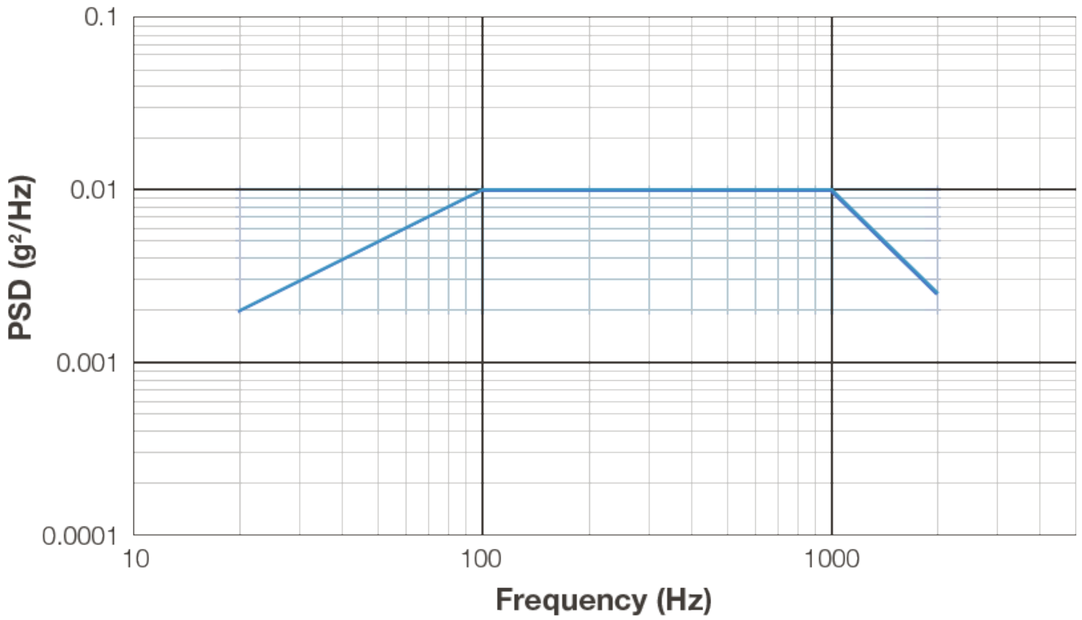

Figure 16: Payload Interface Random Vibration Test Levels [Ref 4]

5.3.1.3 Flight Loads - Random Vibration

During launch, payloads are subjected to a random vibration environment due to a combination of engine vibrations, vehicle structural modes, and aerodynamic buffeting. The intensity of these vibrations is highly dependent on payload mass and the interface between the payload and the launch vehicle.
It is possible to represent random vibrations in the frequency domain by a power spectral density (PSD) function. Results from PSD calculations may be depicted in the form of a line graph, where the overall GRMS value is obtained by integrating the area under the PSD curve, where the GRMS value is then equal to the square root of the area.

PSD levels as determined for Alpha by Firefly will be updated as data from further analysis and testing of the launch vehicle becomes available. Figure 16 shows representative values for launch vehicles of similar size and classification. The PSD values are dependent on mass, with the corner values and slopes of Figure 16 summarized in Table 6. The MIL-STD-1540E example values yield a root mean square acceleration (G_{RMS}) of 3.8.

Individual payloads may use values such as those listed in Table 6 to create a random vibration response of PSD versus frequency, in-line with actual levels experienced during flight based on the NASA General Environmental Verification Standard (GEVS) GSFC-7000A (See Reference 2).

Table 6: Alpha Random Vibration Maximum Predicted Values

Frequency (Hz)	PSD Level		
	MIL-STD-1540E	GSFC-7000A (<50 lbs)	Alpha
20	0.002	0.013	Alpha random vibration analysis in work
20 - 100	+3 *dB* per octave slope		
100 –1000	0.01	0.08	
1000 –2000	-6 *dB* per octave slope		
2000	0.0025	0.013	
G_{RMS}	3.8		

Analysis will be performed to predict random vibrations of the vehicle, but the preliminary Alpha environment is presented based on data from vehicles of similar size. The NASA GEVS levels are designed to encompass most of the common launch vehicles used. For this reason, Firefly uses NASA GEVS vibration testing levels when the launch vehicle environment is unknown, though it is expected that the results of Alpha analysis will be bound by the values in Figure 17.

5.3.1.4 Flight Loads – Acoustic

Analysis of the vibroacoustic environment inside the payload fairing during flight is ongoing. Acoustic protection will be provided to ensure that the Overall Sound Pressure Level (OASPL) does not exceed 135*dB*.

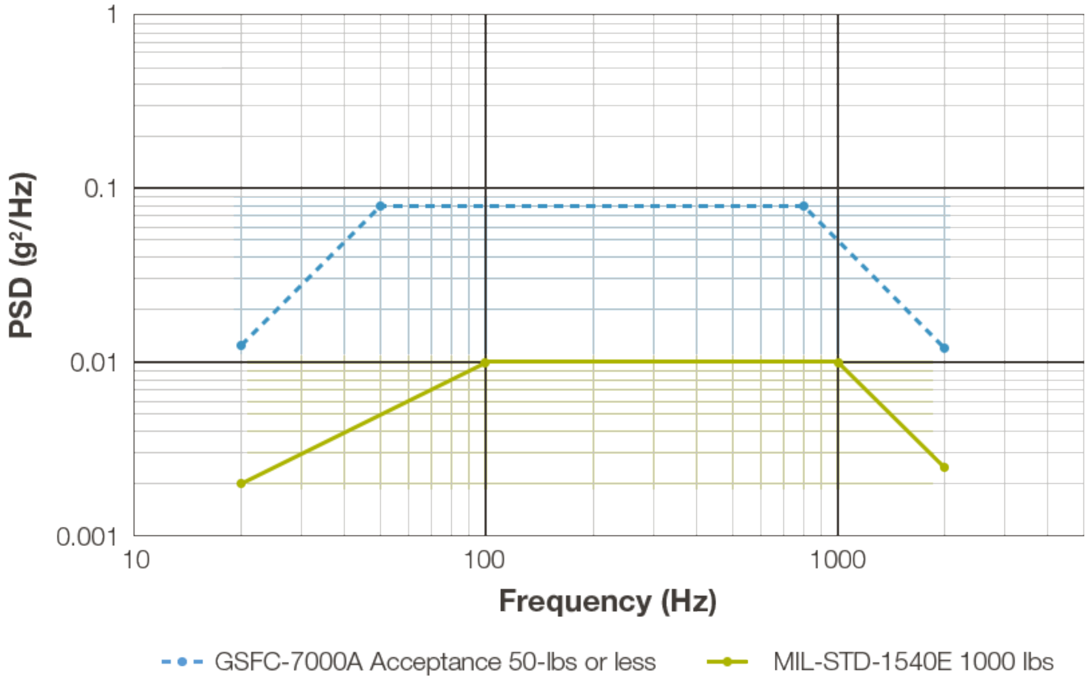

Figure 17: Bounding Random Vibration Test Levels [Ref 2,4]

Table 7: Expected Shock Values

Frequency	SRS (g-peak)
10 Hz	20
10-1,000 Hz	+3.99 dB/oct
1,000-10,000 Hz	100

5.3.1.5 Shock Loads

The maximum shock environment at the payload interface occurs during payload separation from the second stage and is dependent on the PAF/Payload separation system configuration. Shock levels at the payload separation interface due to other flight events – such as stage separation, fairing separation, and engine ignition/shutdown –are not significant compared to the shock caused by payload separation. Figure 18 illustrates the maximum expected shock environment. Representative values corresponding to the Shock Response Spectrum (SRS) are presented in Table 7.

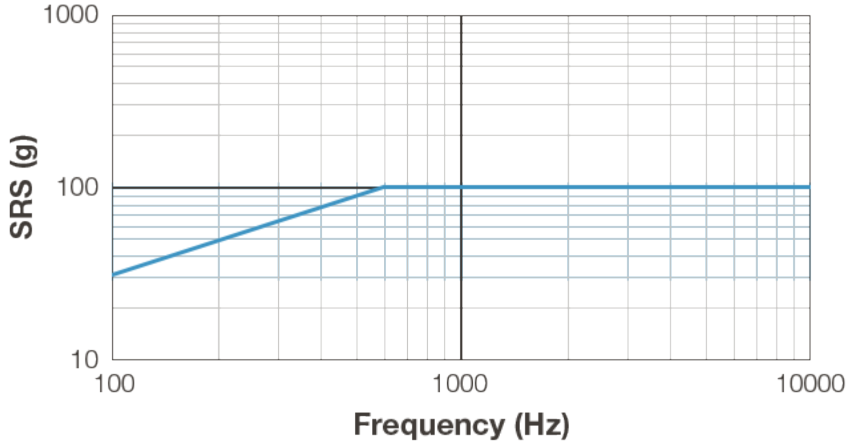

Figure 18: Representative Expected Shock Levels During Payload Separation [Ref 4]

5.3.2 Thermal & Atmospheric

5.3.2.1 Payload Conditioning

A trickle nitrogen (MIL-PRF-27401F, Type 1, Grade B purge) can be provided for specific bagged sensors while inside the processing facility prior to and after encapsulation. After encapsulation, a trickle purge line to a sensor bag can be accommodated through a strategically placed fairing access panel opening. Both of these trickle purges will be controlled by Customer supplied equipment. Source nitrogen can be provided by facility systems or K-bottles. After roll-out, a continuous supply of clean air is provided at a typical environment range as stated in the table below. After roll-out and prior to the vertical position movement, the bag would be removed from the sensor and the flight access panel installed on the fairing. A nitrogen purge can be provided through the payload air-distribution umbilical ducting while at the launch pad. The air distribution umbilical is attached to the fairing by means of locking mechanism that is pulled away by a lanyard at lift off. As the umbilical is pulled away from the fairing the spring-loaded access door automatically closes.

Table 8: Payload Environmental Conditioning

Location & Duration	Phase	Temp.	Relative Humidity	Flow Rate	Cleanliness	Hydrocarbon
Firefly PPF	Payload Processing; Non-Encapsulated	75F ± 10F 23.89C ±5.6C	50% ± 15%	N/A	Class 100,000	15ppm max

Location & Duration	Phase	Temp.	Relative Humidity	Flow Rate	Cleanliness	Hydrocarbon
Appx. Duration 1-2 Weeks	Payload Processing; Encapsulated	75F ± 5F 23.89C ± 2.78C	50% ± 15%	120-200 CFM	Class 10,000	15ppm max
Firefly HIF Appx. Duration 3-4 Days	Integrated Operations; Encapsulated Payload	75F ± 10F 23.89C ± 5.6C	50% ± 15%	120-200 CFM	Class 10,000	15ppm max
Rollout from HIF to Pad Appx. Duration <30 Minutes	Pre-Launch Operations; Encapsulated Payload	N/A	N/A	N/A	Class 10,000	15ppm max
LV on Pad Appx. Duration 1-2 Days	Launch Operations; Encapsulated Payload	75F ± 15F 23.89C ± 8.3C	(Customer TBD) 0% - 75%	120-200 CFM	Class 10,000	15ppm max

5.3.2.2 Fairing Thermal Environment

Upon payload encapsulation, air-conditioning is provided at a typical temperature range as stated in Section 5.3.2.1, depending on mission requirements.

The Alpha fairing is made up of carbon composite with a hemispherical total emissivity of 0.8. Acoustic foam can provide a relatively cool radiation environment by effectively shielding the payload from ascent heating in blanketed areas. Continued analysis on the payload and fairing will detail the radiative environment means by which Firefly will shield the payload from hazardous heating.

5.3.2.3 On Orbit Thermal Environment

As most Firefly missions are expected to be of short durations (for delivery into Low-Earth orbits), active thermal control or heating of payloads is not foreseen. Active thermal control and payload heating may be able to be accommodated as an optional service.

5.3.2.4 Fairing Internal Pressure

As the Alpha vehicle ascends through the atmosphere, the fairing will be vented through one-way vents at the bottom of the fairing. The maximum expected pressure decay rate inside the fairing compartment is -0.24 psi/second. The internal pressure and depressurization rates are illustrated as functions of time in Figure 19.

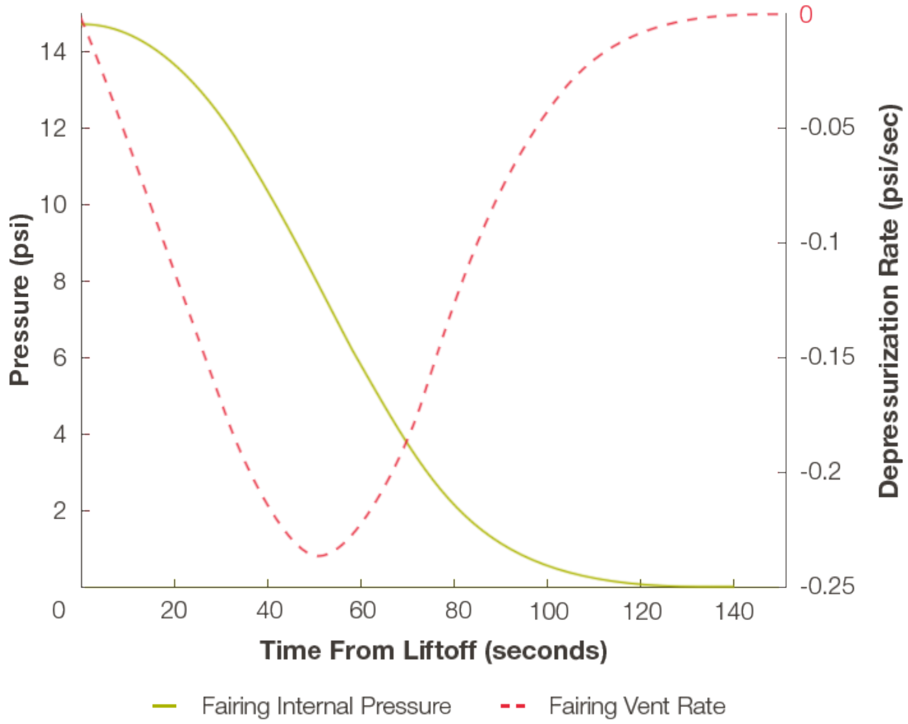

Figure 19: Example of Fairing Internal Pressure Profile [Reference 4]

5.3.3 Payload Environment – RF & EMC

5.3.3.1 Radio Frequency Environment

Alpha RF system characteristics are detailed in Table 9. All payloads are expected to pass testing to MIL-STD-461 for radiated emissions and susceptibility. For payloads that are connected to the Alpha avionics system, all connections must pass conducted emissions and susceptibility testing per MIL-STD-461. The Alpha RF system is particularly sensitive to payload RF emissions in the L-band GPS frequencies. It is recommended that payloads are powered off during launch to reduce the risk of damage caused by RF interference. Additionally, Customers must ensure that any payload component or material constituents that are sensitive to RF transmissions are compatible with the electromagnetic environment provided in Table 9.

Table 9: Alpha RF System Characteristics

Function	Stage 2 TLM	GPS
Role	Transmit	Receive
Band	S-Band	L-Band
Frequency	2.2-2.4 GHz	L1: 1575.42 MHz L2: 1227.60 MHz

5.4 Payload Requirements

5.4.1 Primary Payload Customer Requirements

1	**Resonances and First Natural Frequency**	The Primary Payload Customer shall provide evidence of the 1st lateral resonant frequency being above 6 Hz at Max Q [Ref 2]. Please refer to the Firefly Alpha vehicle axis definitions as shown in Section 2.1. Firefly will complete a Coupled Loads Analysis (CLA) as early as possible to identify any issues associated with dynamic coupling. The threshold given in this requirement is a representative value of a similar vehicle and will be re-evaluated upon completion of the CLA.
		The Primary Payload Customer shall provide evidence of the 1st axial resonant frequency being above 25 Hz at Max Q. Please refer to the Firefly Alpha vehicle axis definitions as shown in Section 2.1
2	**Quasi-static and/or Sine Vibration Loading**	The Primary Payload Customer shall provide evidence that the payload is robust and will not suffer mechanical failure under the loadings specified in Table 5, with positive margin.

3	**Random Vibration**	The Primary Payload Customer shall provide evidence that the payload is robust and will not suffer mechanical failure under the loadings specified in Table 6, with +3 dB margin. Test duration shall be 2 minutes, per Reference 2.
4	**Acoustic Vibration**	Should the Primary Payload Customer choose to design and qualify/accept theirdesign against the acoustic load environment (as may be expected for larger satellites), the Customer shall provide evidence that the payload is robust and will not suffer mechanical failure under the loadings specified in Section 5.3.1.4, with positive margin.
5	**Notching**	Reduction of the vibration input amplitude at certain resonance frequencies (i.e. notching) may be possible for the Primary Payload Customer, but cannot be guaranteed. Any notching requirements or preferences should be communicated to Firefly as early as possible in the mission planning process.
6	**Mass Properties**	The required position of the payload's Center of Gravity (CoG), relative to the plane of separation, is defined below. This assumes that the Primary Payload Customer is mounted centrally, i.e. with its vertical axis aligned with the launch vehicle roll (X) axis. • Offset of CoG from Y & Z axis: < 2 in (50mm)
7	**Grounding, EMC and RF Transmissions**	It is assumed that all payloads will be powered off during launch (in line with the Firefly baseline launch offering), and therefore will not be emitting any signals or radio frequency noise during the launch phase. Payloads that request to be powered on during launch will be required to provide evidence of a payload level EMC test which shows EM compatibility with the Firefly vehicle assuring that any payload operations during launch cannot interfere with Firefly's Avionics & Flight Systems. All payloads (including those which will be powered off) are required to show compliance to the Firefly EMC specification to ensure that post-separation operations of the launch vehicle upper stage are not compromised by the payload(s).

		All payload interfaces to the Alpha PAF must be electrically conductive to less than 0.1 Ω per unit area. This interface will be auto verified during payload integration. It is the Customer's responsibility to ensure this requirement is met prior to shipment of the payload to the launch site.
8	**Primary Payload Data Package**	In order for Firefly to carry out its mission design, analysis, and verification for the Primary Payload Customer, the following numerical/computer models and reports for the Primary Payload will be required, in addition to the general requirements of the Payload Data Package found in Table 10: • A computer aided design (CAD) model, in STEP (*.stp or *.step) or Parasolid (*.x_t) or Inventor format: The CAD model supplied should include accurate representations of the external characteristics and features of the payload, including all appendages, and the separation system. • A Finite Element (FE) model of the payload, in ANSYS Workbench Project Archive (*.wbpz), Femap Neutral (*.neu, version 11.1 or older) or NASTRAN input (*.nas or *.bdf) format: The FE model should accurately represent the payload's stiffness and mass properties, contain all relevant material/connection property definitions, and should ideally be simplified. • Mass properties report: The report shall include total mass, center of mass location in body coordinates, and moment of inertia properties about the center of mass. Analysis and Test report: The report shall include information regarding the first six modes of the payload, and evidence that the payload has been analyzed and/or tested to withstand the quasi-static and random vibration loads stated in Section 5.3.1.2 in each of the three orthogonal body axes. The report shall also include compliance evidence for atmospheric, thermal, and EMI/EMC requirements.

9	**Mass Simulators**	A mass representative model of the Primary payload will be required for the fit check. This mass simulator should ideally be mass and volume representative and should have a representative launch vehicle interfaces.

5.5 Secondary Payload Accommodations

With the approval of the Primary Payload Customer, Secondary Payloads may also be accommodated on Alpha. For Customers with 3U CubeSats, a CubeSat Deployment Canister will be sent to the Customer for convenient loading and shipment back to the Firefly facility. Customers may also complete this portion of the integration process at the Firefly facility in a shared-use Secondary Payload clean room (ISO 8 / Class 100K FED-STD-209E). To maximize Secondary Payload capacity, 1U and 2U CubeSats from multiple Customers may be integrated into a single 3U CubeSat Deployment Canister.

Customers with CubeSat payloads will have the opportunity to manually check battery voltage and charge if needed prior to integration with the CubeSat dispenser. By default, charging or other diagnostic checks will not be available once the dispenser is mated to the vehicle.Customers who opt to integrate their CubeSat with the dispenser at their own facility and ship the integrated assembly to Firefly will not have the opportunity to check battery state before the dispenser is mated to the vehicle.

Please contact Firefly early in the mission planning process if your Secondary Payload requires data or power accommodations similar to those mentioned in Section 5.2.2.1 or Section 5.2.2.2.

5.5.1 Secondary Payload Customer Requirements

Requirements for Secondary Payloads may vary slightly from those for Primary Payloads. In general, all Secondary Payloads shall comply with, and provide evidence for, all requirements stated in the CubeSat Design Specification document. For individual CubeSats, Firefly will provide the dispenser, and Customers planning to supply their own deployment canisters are requested to contact Firefly as early as possible in the mission planning process.

1	**Resonances and First Natural Frequency**	Secondary Payload Customers shall provide evidence of the 1st resonant frequency being above 100 Hz.
2	**Quasi-static and/or Sine Vibration Loading**	Secondary Payloads shall withstand structural integrity under the loading of ±10g with positive margin.
3	**Random Vibration**	Secondary Payload Customers shall provide evidence that the payload is robust and will not suffer mechanical failure

		under the loadings specified in Table 6, with +3 dB margin. Test duration shall be 2 minutes, per Reference 2.
4	**Notching**	Reduction of the vibration input amplitude at certain resonance frequencies (i.e. notching) will not be possible for Secondary Customers.
5	**Mass Properties**	Secondary Payloads shall adhere to the following mass limits. Larger CubeSat masses may be evaluated on a mission by mission basis. • 1U CubeSats shall not exceed a mass of 1.33 kg • 3U CubeSats shall not exceed a mass of 4.0 kg • 6U CubeSats shall not exceed a mass of 12.0 kg
		There are no strict requirements for CoG positioning on the Secondary Payloads, as they are expected to be arranged as a whole within the payload space by Firefly to achieve optimal mass distribution. Measured mass properties of all payloads must be communicated to Firefly.
7	**Grounding, EMC and RF Transmissions**	It is assumed that all payloads will be powered off during launch (in line with the Firefly baseline launch offering), and therefore will not be emitting any signals or radio frequency noise during the launch phase. Secondary Payloads cannot be powered on during launch.Secondary Payloads are required to follow the same grounding and EMC compliance as Primary Payloads.
8	**Secondary Payload Data Package**	The Secondary Payload Data Package is the same as the requested Primary Payload Data Package, sans Finite Element Analysis.
9	**Mass Simulators**	A mass representative model of each payload shall be provided by each Customer. For Secondary Payload Customers, this model will be retained until after launch, and will be returned by Firefly within 3 months of launch. Firefly reserves the right to launch mass simulators of Secondary Payloads if delivery of flight model payloads is delayed for periods in excess of those compatible with Primary Payload timelines.

5.6 Evidence of Qualification & Acceptance

The following Payload Data Package is requested by Firefly to comprehensively understand the Customer payload and interface; The package includes, but may not be limited to the following items:

Table 10: Requested Payload Data Package

Item	Description
Payload Questionnaire	The Payload Questionnaire is soon to be provided on the Firefly website with the purpose of introducing the objectives and requirements of the Customer.
Payload Flight Mode	Data outputs from qualification model mechanical tests or payload flight models to inform Firefly of the specific path of the payload once deployed, which may affect the trajectory and launch window of the vehicle.
RF Data Sheet	Test results of RF transmissions are requested so that Firefly may prepare ground support for specific frequencies and expected durations.
EMC Data Sheet	Response traces and results from an EMC test must be provided, showing that payload emissions are within acceptable ranges. Electromagnetic compatibility test results ensure that the provided payload or its elements do not generate interference that can adversely affects its own subsystems and components, or other payloads, or the safety and operation of the launch vehicle and launch site.
Payload Model	CAD and a finite element model are required for Coupled Loads Analysis (CLA) so Firefly can assess payload dynamics. Requirements, tools, and formats can be provided by Firefly.
Mass Properties	The following must be provided as part of a report or in the form of raw data: • Measurement/test data from mass properties measurements of the flight model payload or

Item	Description
	• Output data from a sufficiently representative simulation or CAD/FE model of the payload
Media Package	When appropriate and desired, Firefly intends to help socialize the launch of specific payloads through the use of Payload Customer logos, insignias, graphics, video files, solid models and drawings. The earlier this package, or components of this package arrive, the more comprehensive the branding effort may be. In the case of mission-specific insignias to be positioned on the launch vehicle, Firefly requests the proposed design submission no later than 4 months before the launch date.
Safety Package	The following shall be provided as part of a report or in the form of raw data: • Relevant certificates and certifications relating to the safety requirements • Any exemptions or associated justifications
Representative volume	Representative volume and mass dummy of payload including the expected mechanical and electrical interfaces.
Loads Compatibility	Demonstrated (test) evidence of compatibility with the loads and environments generated by the Firefly Alpha vehicle.
Comm. Compatibility	Demonstrated (test) evidence of compatibility with the Firefly vehicle's electrical and communications systems.
Mechanical Compatibility	Documentary evidence of compatibility of mechanical and electrical interfaces.

6 Facilities

6.1 Headquarters & Mission Control Center

The Mission Control Center (MCC) will be located at Firefly headquarters in Cedar Park, TX. The MCC will contain seating for up to fifteen personnel and include GUI displays and voice communication systems. The MCC will allow personnel to view ground systems data, as well as monitor the data from the LV prior to and after launch. This area will be utilized for the engineering backroom personnel on launch day.

A separate viewing area for the Customer can also be provided. The data and communication to this area will be limited to a payload GUI and the countdown net.

6.2 Test Site

Both propulsion and structural tests are conducted at the 200-acre Firefly Test Facility located just north of Headquarters. With full utilities, the site contains two operational test stands, helping to orchestrate engine and component testing, as well as integrated stage testing. Conveniently located less than an hour from downtown Austin, the site is fully staffed and hosts several facilities including a 10,000 square foot Test Control and Fabrication building, a 2,500 square foot surface finish shop and a 30,000 square foot production shop.

Figure 20: Lightning Heatsink in Testing at Firefly's Test Facility

6.3 Launch Site

Firefly is currently in the process of securing a site at Vandenberg Air Force Base (VAFB), as this location is expected to support the initial test flights of Alpha and a substantial number of future Customers; This process is currently underway with documentation submitted to Air Force Space Command and VAFB 30th Space Wing. Vandenberg Air Force Base (VAFB) is the launch site considered to be Firefly's Primary domestic site. This operational launch site services multiple inclinations, with typical orbits being Polar (90°) and SSO up to 2,000 km (104.89°). The Alpha launch vehicle will be compatible with mission infrastructure and operations at launch sites defined by the ConOps and a conceptualized layout of the infrastructure needed as the launch site is depicted in Figure 21.

In the future, Firefly may offer additional launch sites and will soon begin the process to secure a site on the east coast with potential locations being KSC, CCAFS or the Mid-Atlantic Regional Spaceport (MARS). Once an east coast location is determined, Firefly can establish a site within 24 months or less to include approvals and necessary construction.

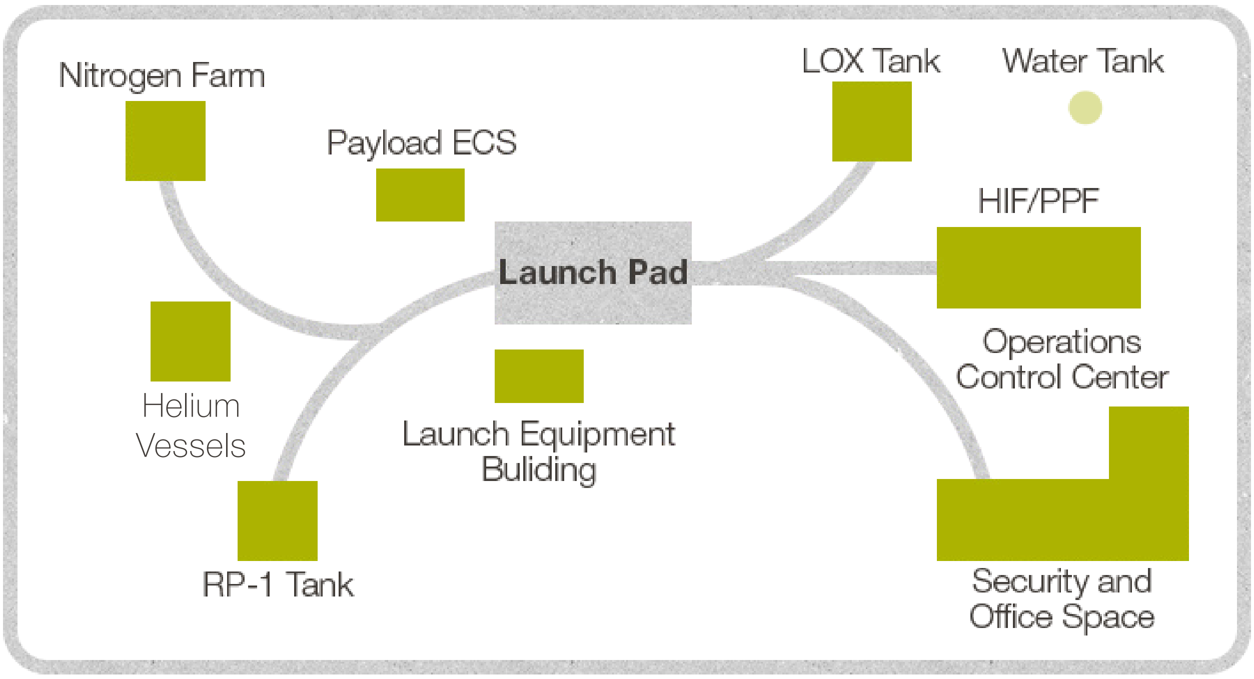

Figure 21: Firefly Launch Site Concept

6.3.1 Horizontal Integration Facility

A Horizontal Integration Facility (HIF) will be utilized for processing and integration of Alpha. The HIF will be climate controlled. 120/240V single phase 60Hz, 208V three phrase 60Hz, and 240/480V three phase 60Hz power will be available for processing. The HIF will consist of a five thousand square foot open high bay with an eave height of twenty-five feet. The high bay will have two overhead bridge cranes to support shipping and processing efforts. This eave height allows for the removal of Alpha components from their shipping fixtures located on flatbed transportation trailers with deck heights up to 58 inches. Within this area there will be space for engineering work stations and consumable storage. The high bay and ancillary rooms will be operated as visibly clean, air conditioned, humidity controlled work spaces. Climate will be maintained to a temperature of 75F ± 10F (23.89C ± 5.55C) and a relative humidity between 30% and 75%.

The HIF provides short-term storage of Alpha launch vehicle assemblies prior to shipping to a storage site. Several Alpha vehicles may be stored at each site, with the details of the storage yet to be defined. The ultimate intent is to maintain an inventory of Alpha vehicles to support near-term flight rates with possible market surges and commercial missions.

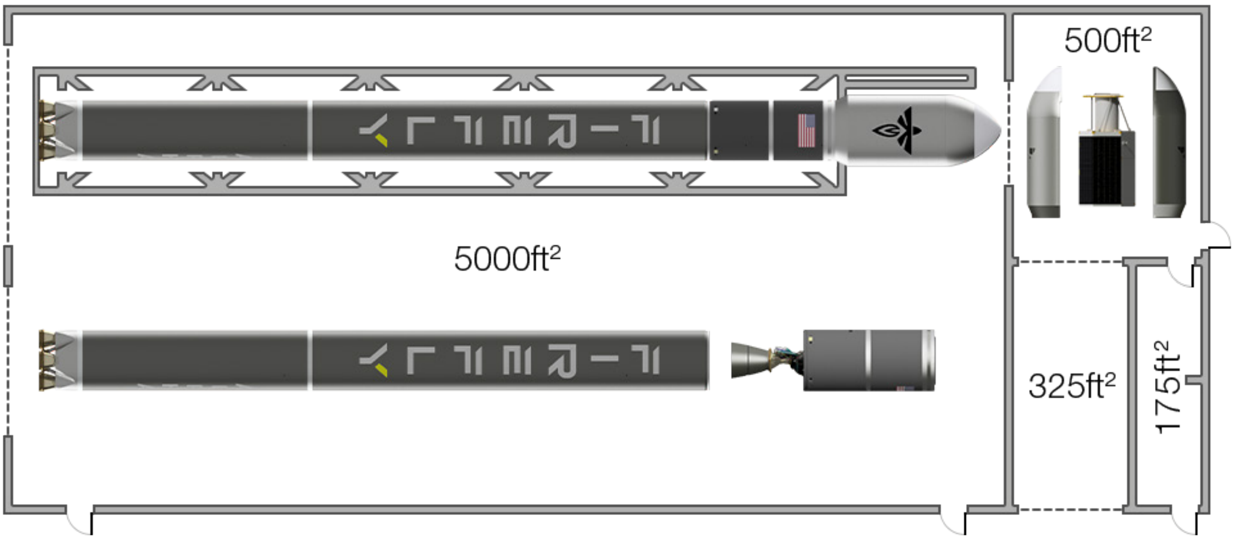

Figure 22: Horizontal Integration Facility Layout

6.3.2 Payload Processing Facility

A Payload Processing Facility (PPF) will be utilized for processing and encapsulation. The PPF will be climate controlled and cleanliness will be maintained as required for the specific payload. 120/240V single phase 60Hz, 208V three phrase 60Hz, and 240/480V three phase 60Hz power will be available for processing. 230V 50Hz power can be made available in a few key locations within the PPF. The PPF will consist of a high bay that has five hundred square feet of processing space, and a three hundred twenty-five square foot airlock, as well as a one hundred seventy-five square foot garment room.

The high bay is planned as an ISO 8 (Class 100K) cleanroom. Climate will be maintained to a temperature of 75F ± 10F (23.89C ± 5.6C) and a relative humidity of 50% ± 15%. Ancillary rooms will be considered visibly clean, air conditioned, humidity controlled work space. Additional payloads will be processed in modular soft-walled cleanrooms operated at ISO 8 (Class 100K) within the Alpha processing area.

6.3.3 Launch Control Center

A LCC will be located at the launch location. This may be a mobile solution or may be built into space within a facility. Personnel at this location will serve as the Primary controllers. The LCC will contain seating for up to twelve personnel and include a GUI and voice communication systems. LCC will allow personnel to control ground and LV systems that are not automated during launch as well as continue to monitor the data from the LV prior to and after launch.

A separate viewing area for any remaining payload members can be provided. The data and communication to this area will be limited to a payload GUI and the countdown net. Engineering support will also be housed in office space, approximately 3,000 square feet located near the launch site; A GSE shop area and storage space will also be located in close proximity to the launch site.

7 Safety

7.1 Safety Requirements

Pending a final decision on a launch site location, Customers must meet the requirements in AFSPCMAN 91-710, Range Safety User Requirements (see Reference 3) when designing flight and ground systems. 91-710 contains requirements for mechanical, electrical, fluid system, ordnance and RF design along with requirements for ground handling and lifting hardware. Firefly would be happy to assist Customers in determining if their current designs meet such requirements.

1	**Payload Batteries**	Payload batteries must not be allowed to overcharge excessively to the point where an explosion risk arises.
2	**Pressure Vessels**	Payloads containing pressure vessels shall comply with the safety standards specified in ATR-2005(5128)-1, Operational Guidelines for Spaceflight Pressure Vessels.
3	**Pyrotechnic and Explosive Devices**	The standard baseline launch services assume that no pyrotechnic devices are present on the payload(s). Customers planning to include pyrotechnic devices should contact Firefly as early as possible in the mission planning process.
4	**Ground Support Equipment**	All ground support equipment (GSE) shall be safety tested with test reports available for review upon request. Electrical GSE should include safety measures which allow payload power to be cut in case of emergency, and to prevent overcharging of payload batteries. Lifting fixtures should be clearly marked with proof load limits. Propulsion system GSE should include vent valves that will automatically activate to prevent over pressurization.

Payload Questionnaire

The Payload Questionnaire is intended to inform Firefly of payload system requirements for preliminary feasibility and compatibility assessments. If you are considering using Alpha for your mission needs, please complete and return the requested information to Firefly within 12 months of the desired launch date.

Alternatively, this process will soon be made available on our website, at www.fireflyspace.com.

With a single point of contact, Firefly ensures a streamlined and secured process from initial contact through end of mission – we look forward to working with you!

Payload Questionaire

Available at www.fireflyspace.com

Payload Information

Payload Name/Acronym	
Payload Point(s) of Contact	
Name	
Email	
Phone	
Payload Contractor/Sponsor	
Payload Description	
Primary Objectives	
Maximum Expected Payload Mass	
Payload Height	
Payload Max. Diameter	
Desired Launch Date	

Payload Interface

Post-encapsulation access needed?	☐ Yes	☐ No
Describe desired door location with respect to payload		

If additional information is available, please continue to populate the following with your mission-specific data:

Payload Trajectory Parameters

Desired Orbit Apogee [km]	
Desired Orbit Perigee [km]	
Desired Right Ascension of Ascending Node (RAAN) [deg]	
Desired Orbit Inclination [deg]	

		Packaged Configuration		Tolerance
Center of Gravity [mm]	X		±	
	Y		±	
	Z		±	

Payload Environment

Thermal and Humidity

Pre-launch Temperature Range [°C]	
Pre-launch Vapor in Air [grains/lb of dry air]	

Contamination Control

Desired Cleanroom and Fairing Air [Class]	
Desired Fairing Air Cleanliness [Class]	

Dynamic Environment

Max Allowable Acoustic Sound Pressure Level [dB/OASPL]	
Maximum Allowable Sine Vibration [GRMS]	
Maximum Allowable Shock [g]	
Maximum Lateral Acceleration [g]	
Maximum Axial Acceleration [g]	
Fundamental Lateral Frequency [Hz]	
Fundamental Axial Frequency [Hz]	

Additional Payload Data

1. Please describe any known hazards or safety issues associated with the payload, and its interfacing processes (e.g. onboard propellants, hazardous chemicals, etc.).

2. Please indicate if testing is needed during ground support processing and any desired testing to be performed while encapsulated.

3. Please describe all power systems associated with the payload (e.g. energy storage devices, CMGs, catalyst beds, etc.).

4. Please describe the propulsion systems to be used on the payload, if applicable.

5. Please provide all drawings, schematics and 3-D Models of the payload.

6. Please describe any payload requirements that have not yet been addressed.

Supporting Documents

1. NASA Langley Research Center. NASA-SP-8077, Transportation and Handling Loads.
   http://ntrs.nasa.gov/search.jsp?R=197200052422.

2. NASA Goddard Space Flight Center. GSFC-STD-7000A, General Environmental Verification Standard.
   https://standards.nasa.gov/standard/gsfc/gsfc-std-70003.

3. United States Air Force Space Command. AFSPCMAN 91-710, Range Safety User Requirements.
   http://static.e-publishing.af.mil/production/1/afspc/publication/afspcman91-710v3/afspcman91-710v3.pdf4.

4. Test Requirements for Launch, Upper-Stage, and Space Vehicles. MIL-STD-1540E/TR-2004(583)
   http://everyspec.com/USAF/TORs/download.php?spec=TR2004-8583-1A.026768.pdf

Definitions and Acronyms

Common Definitions

The following definitions apply when referred to in this document:

Term	Definition
Ambient	The surrounding environmental conditions such as pressure or temperature

Acronyms

AFSPCMAN	Air Force Space Command Manual
AFTS	Autonomous Flight Termination System
AFTU	Autonomous Flight Termination Unit
C&DH	Command and Data Handling
CAD	Computer Aided Design
CFM	Cubic Feet per Minute
CLA	Coupled Loads Analysis
COTS	Commercial-Off-The-Shelf
EEE	Electrical, Electronic and Electromechanical
EGSE	Electrical Ground Support Equipment
EIRP	Effective Isotropic Radiated Power
EPS	Electric Power System
ESPA EELV	Secondary Payload Adapter
FAA	Federal Aviation Administration
FED-STD	Federal Standard
FF	Firefly
FRR	Flight Readiness Review
FPS	Frames Per Second GLOW Gross Lift-Off Weight
GN&C	Guidance Navigation and Control
GPS	Global Positioning System
GRMS	Root Mean Square Acceleration
GSE	Ground Support Equipment
GUI	Graphical User Interface

HIF	Horizontal Integration Facility
ICD	Interface Control Document
ISO	International Organization for Standardization
Isp	Specific Impulse
ITAR	International Traffic in Arms Regulations
LEO	Low-Earth Orbit
LRR	Launch Readiness Review
LOCC	Launch Operations Command Control
LOX	Liquid Oxygen
LV	Launch Vehicle
MCC	Mission Control
MCTU	Message Transfer and Control Unit
MECO	Main Engine Cut-off
MIL-STD	Military Standard
MRR	Mission Readiness Review
NRE	Non-Recurring Expense
OASPL	Overall Sound Pressure Level
OBC	Onboard Computer
PAF	Payload Attach Fitting
PPF	Payload Processing Facility
PSD	Power Spectral Density
QPSK	Quadrature Phase Shift Keying
RCC	Range Commander Council
RF	Radio Frequency
RP-1	Rocket Propellant
SECO	Second Engine Cut-off
SMC	Space and Missile Systems Center
SRS	Shock Response Spectrum
SSO	Sun-Synchronous Orbit
TBC	To be Confirmed
TBD	To be Determined
TLM	Transmission Line Matrix
TRL	Technology Readiness Level
VAFB	Vandenberg Air Force Base

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