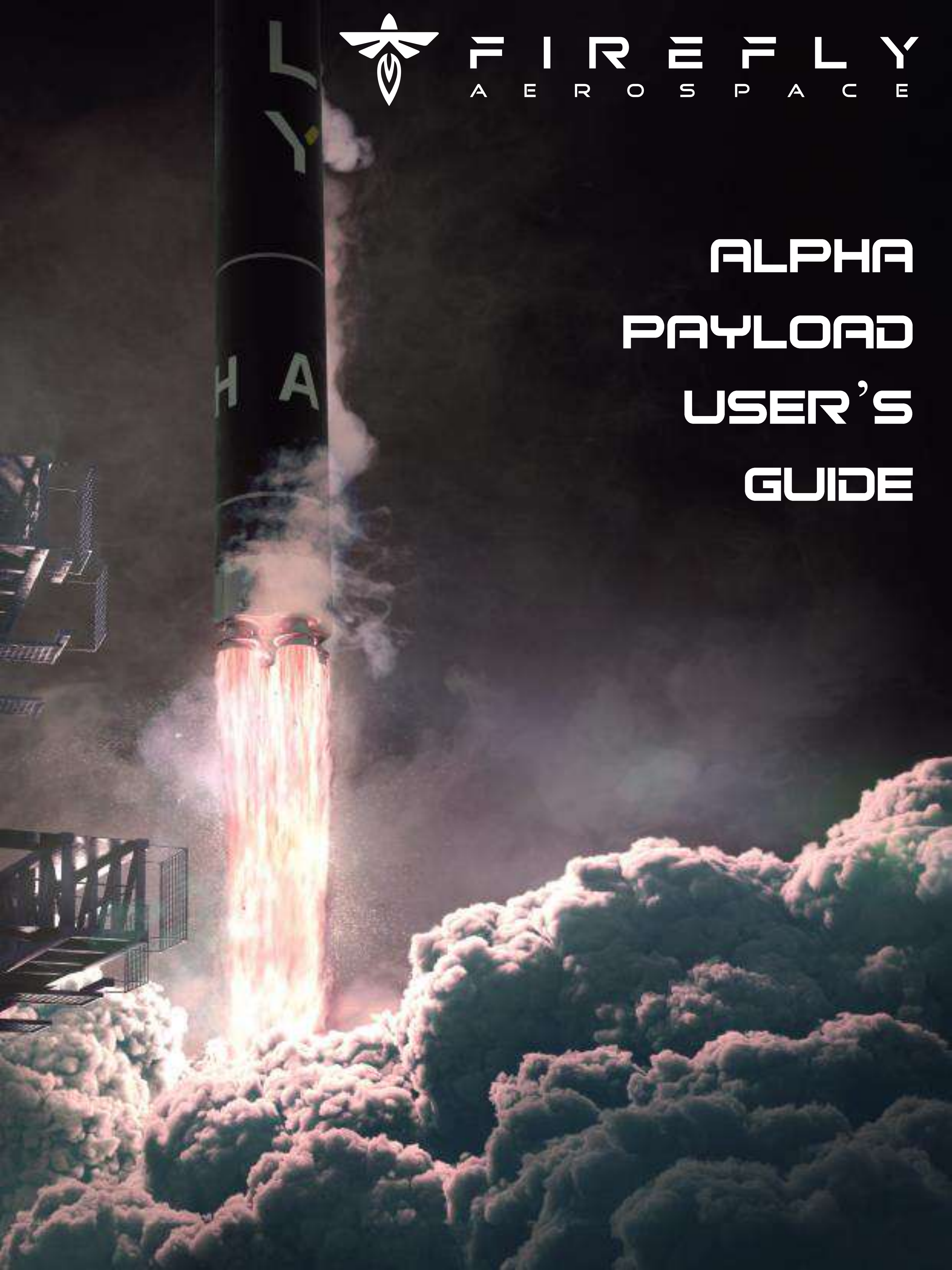
FIREFLY AEROSPACE

ALPHA PAYLOAD USER'S GUIDE



MAKING SPACE FOR EVERYONE

Firefly is dedicated to providing customers with economical, reliable, and convenient access to space. We accomplish this through the design, manufacture, and operation of launch vehicles incorporating the best of New Space practices and Heritage Space principles.

We employ a collaborative method to mission management and mission assurance. This means you will receive candid insight into key technical milestones and schedule status. Customers have the option of even greater insight into Firefly's engineering rigor for their most critical missions. Our launch vehicle designs, testing approach, and the quality systems supporting our engineering processes are robust and transparent to you.

As a customer, you will be provided a dedicated Mission Manager whose priority is ensuring excellent customer service and support throughout your mission's campaign. Our team possesses exemplary industry heritage and expertise, having several decades of experience in both government and commercial launch programs, At Firefly, we recognize the importance of delivering your spacecraft to orbit reliably, on time, and at the lowest possible cost. Whether your mission is for a commercial on-orbit capability, scientific Earth observation, interplanetary exploration, or National Security, we are committed to meeting your needs.

We welcome you to explore the capabilities of the Alpha launch vehicle within this Payload User's Guide. For questions regarding Firefly's other launch and in-space capabilities, please contact the Firefly Business Development team.

Sincerely,

Shea Ferring
Vice President of Mission Assurance

OVERVIEW

This user's guide provides a capability summary for preliminary mission planning. The contents are not mission specific and are intended to facilitate additional technical interchange between customers and Firefly mission management personnel. The information in this user's guide may be superseded by mission specific documentation provided by Firefly Aerospace, Inc ("Firefly"). Upon establishing a Launch Service Agreement, we encourage customers provide payload specific information.

REVISION HISTORY

DATE	VERSION	HISTORY
March 2018	1.0	First Release
August 2019	2.0	Updated Release

CONTACT FIREFLY

Please contact us with inquiries of Firefly and it's launch vehicles for your mission.

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VEHICLES

OVERVIEW

Firefly combines five decades of heritage space experience with the passion and innovativeness of the "New Space" industry. Our competitive, world-class organization is dedicated to serving customers with an unrivaled launch experience for their mission needs. Our vision is to pair innovative technologies with proven flight heritage aerospace applications, tailored to a customer responsive approach.

Though this guide is specific to the Alpha Launch Vehicle (LV), **Figure 1** highlights key characteristics of our family of LVs along with performance to Sun Synchronous Orbit (SSO), Low Earth Orbit (LEO) and Geo-Transfer Orbit (GTO).

PERFORMANCE	ALPHA	BETA	
Payload [SSO, 500km]	630	3,000	kg
Max Payload [LEO, 200km]	1,000	4,000	kg
Payload [GTO]	N/A	1,000	kg
ARCHITECTURE			
GLOW	54,120	149,000	kg
Number of Stages	2	2	
Total Length	29.75	31	m
Max Diameter	2.2	2.8	m
Structure	All Composite	All Composite	
PROPULSION			
Oxidizer	LOX	LOX	
Fuel	RP-1	RP-1	
Max Thrust [Stage 1]	736 / 165.5	2,208 / 496.4	kN / klbf
Max Thrust [Stage 2]	70 / 15.7	163 / 36.6	kN / klbf

FIGURE 1 Performance and Key Characteristics of the Alpha and Beta Launch Vehicles

Firefly's Alpha provides low-cost capabilities for small satellite customers at a price of $15M for standard commercial launch services. Firefly aspires to design and engineer the Alpha launch vehicle as the world's most reliable, responsive, and operationally capable launch option within the small launch vehicle class. Supported by Firefly's streamlined approach to mission planning, integration, and launch, Alpha is a well-rounded choice for commercial, civil, and demanding national security missions.

Figure 2 shows an Alpha long duration stage 2 test performed at Firefly's Briggs, Texas test facility. These tests confirm engineering analyses and ensure all components are properly validated while operating in a flight-like configuration.

FIGURE 2 Alpha Stage Test

Examples of increased efficiencies in our processes include:

- Streamlining Coupled Loads Analysis (CLA) and Interface Control Document/Drawings (ICD) to decrease completion times from months to weeks or days depending on payload complexity
- A "Test-What You-Fly" and "Test-As-You-Fly" approach to ensure mission success.
- Limited use of ordnance to minimize payload exposure to harsh environments
- A vertically integrated corporate and engineering structure to ensure control over key technologies and subsystems most impacting mission success, including propulsion, composites manufacturing and mechanisms

Figure 3 highlights the elements comprising the Alpha Launch Vehicle.

ARCHITECTURE

PAYLOAD
1,000 kg LEO 28.5º, 200 km
850 kg LEO 45º, 500 km
600 kg to 600 km SSO

PAYLOAD FAIRING
Carbon Composite Structure
2.2 m [7.2 ft] Diameter
12.5 m^3 [441.4 ft^3] of Internal Volume
All Pneumatic Low Shock Fairing Separation

STANDARDIZED SECONDARY PAYLOAD ADAPTER
6 Ports @ 15" bolt interface

PAYLOAD ATTACH FITTING (PAF)
38.81" bolt interface, compatible with 937 clamp-band

STAGE 2 LOX TANK
All Composite Construction
Design MEOP 80 psi

STAGE 2 AVIONICS
Flight Computer
Multi-Band Path Array Antennae
GPS/IMU Navigation
Power Conditioning & Distribution Unit (PCDU)
Solenoid Drive
Data Acquisition Chassis (DAC)
Telemetry Transmitter
Lithium Polymer Batteries
Flight Termination System

STAGE 2 FUEL TANK
All Composite Construction
Design MEOP 80 psi

STAGE 2 HELIUM TANK
Aluminum Liner
Design MEOP 5500 psi

STAGE 2 ENGINE
Lightning 1
Qty Engines: 1
Propellant: LOX/RP-1
Thrust: 70 kN [15.7 klb$_f$] (vac)
Isp: 322.0 seconds (vac)

INTERSTAGE
Houses Second Stage Engine
Hot Gas Stage Separation
Carbon Composite

STAGE 1 LOX TANK
All Composite Construction
Design MEOP 80 psi

STAGE 1 AVIONICS
Power Conditioning & Distribution Unit (PCDU)
Solenoid Drive
Data Acquisition Chassis (DAC)
Lithium Polymer Batteries

STAGE 1 HELIUM TANKS
Aluminum Liner
Design MEOP 5500 psi

STAGE 1 FUEL TANK
All Composite Construction
Design MEOP 80 psi

STAGE 1 ENGINE
Reaver 1
Qty Engines: 4
Propellant: LOX/RP-1
Thrust: 736 kN [165.5 klb$_f$] (vac)
Isp: 295.6 seconds (vac)

ALPHA LV
GLOW 54,120 kg [119,314 lbm]
Height 29.75 m [97.6 ft]
Stage 1 Dry Mass- 2,895 kg [6,382 lbm]
Stage 2 Dry Mass- 909 kg [2,006 lbm]

PAYLOAD SEGMENT 5.2 m [16.9 ft]
STAGE 2 5.75 m [18.6 ft]
STAGE 1 18.8 m [61.6.1 ft]

Alpha's general orbital performance from Space Launch Complex 2 (SLC-2) at Vandenberg Air Force Base (VAFB) is shown in **Figure 4**. **Figure 5** shows Alpha's performance from SLC-20 at Cape Canaveral Air Force Station (CCAFS). This performance is for dedicated missions, though Firefly welcomes rideshare missions and is capable of pairing payloads to allow customers with smaller satellites to receive an efficient launch experience as a secondary payload. Mass for payload-specific attachment accommodations must be subtracted from the performance shown for proper calculation of useable capacity. For additional payload performance or on-orbit capability, view our Firefly Orbital Transfer Vehicle (OTV) user's guide on our webpage.

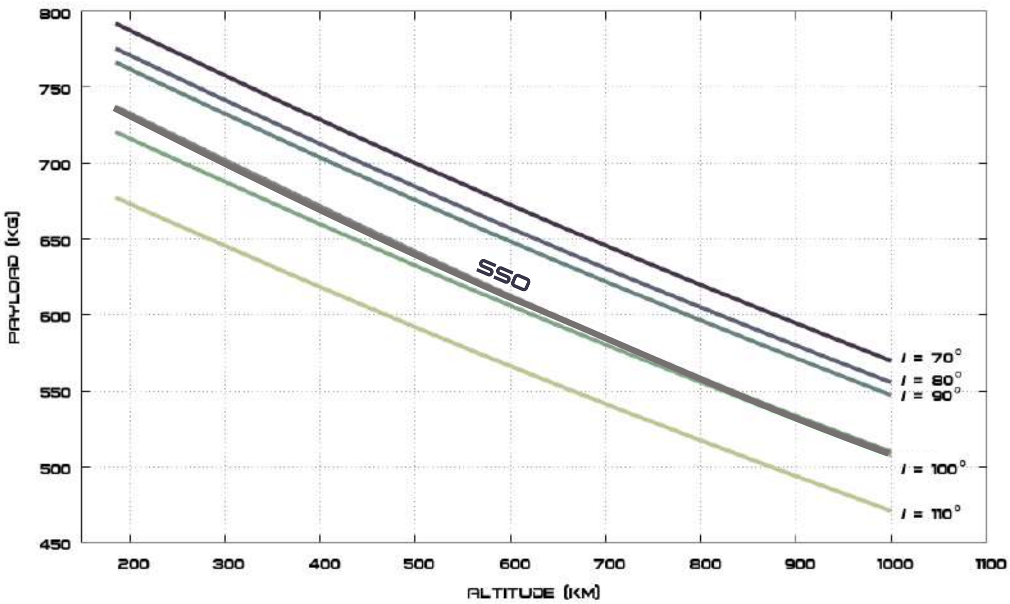

FIGURE 4 Alpha West Coast Performance Capability for Popular Inclinations

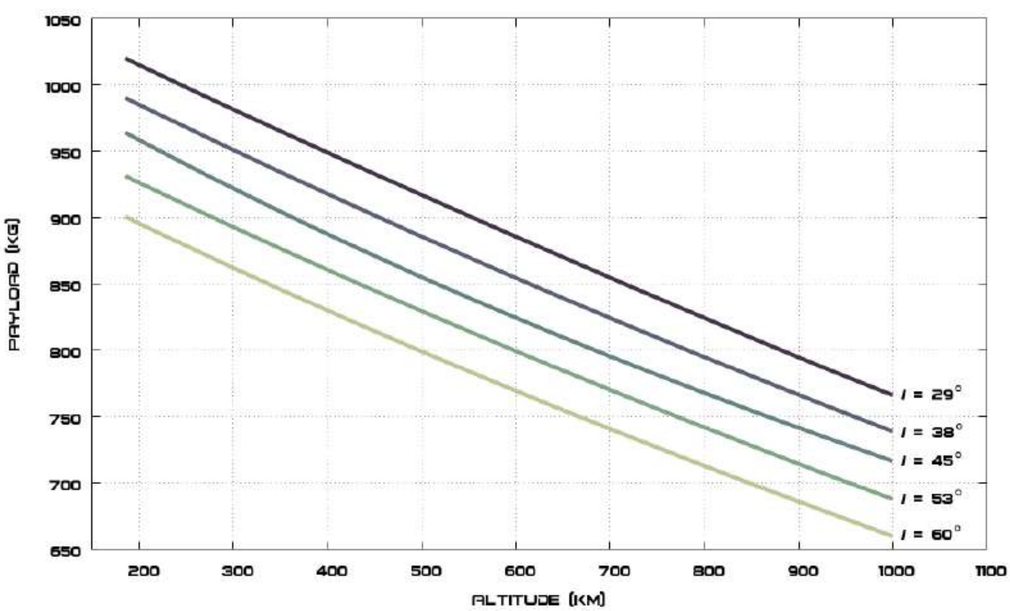

FIGURE 5 Alpha East Coast Performance Capability for Popular Inclinations

The Alpha launch vehicle coordinate frame is depicted in **Figure 6** below. The axes definitions are used throughout the remainder of this document to specify and reference payload environments, loads, flight, and test requirements. A representative flight profile of the Alpha launch vehicle is provided in **Figure 7**. Although missions follow a similar profile, timing and altitude for key events may vary per mission.

For missions requiring orbits above 400 km, Alpha's second stage inserts into a low elliptical transfer orbit, coasts to apogee, and then initiates a second burn maneuver to circularize into the final desired orbit.

FIGURE 6 Alpha Coordinate Frame

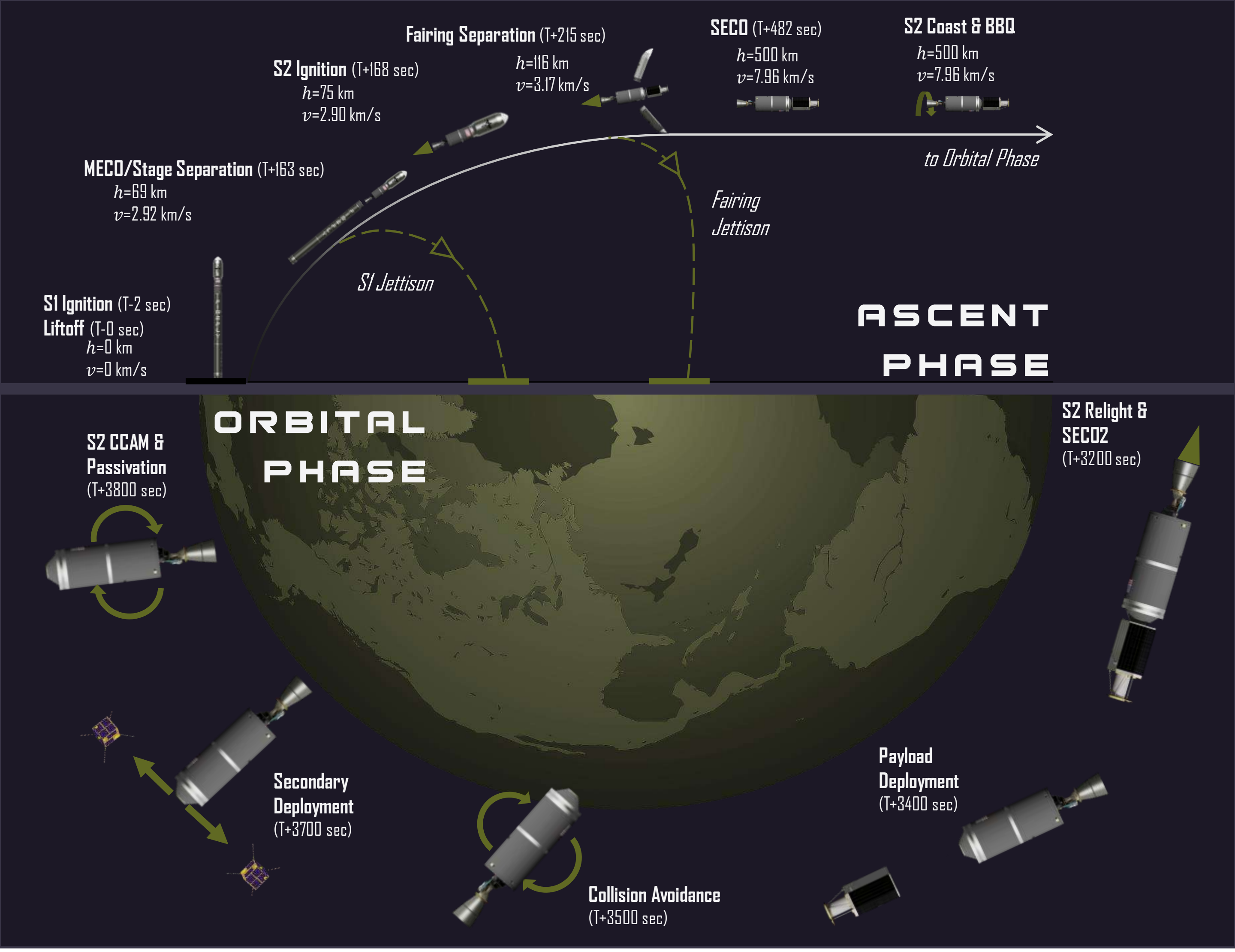

FIGURE 7 Alpha Direct Insert Flight Profile

PAYLOAD INJECTION & SEPARATION

Precise pointing and orbit insertion are provided by a navigation control module consisting of an Inertial Measurement Unit (IMU) and Global Positioning System (GPS) receiver on the upper stage of the launch vehicle. The values in Table 1 represent three-sigma (3σ) dispersions for a LEO mission with a second stage Probability of Command Shutdown (PCS) of 99.7%.

PAYLOAD INJECTION ACCURACY
± 5 km perigee altitude
± 15 km apogee altitude
± 0.1 deg inclination
PAYLOAD SEPARATION PARAMETERS
> 1 ft/sec separation velocity
< 1.4 deg pointing accuracy on each axis
< 1 deg/sec stability in pitch, yaw, and roll

TABLE 1 Payload Injection and Separation Accuracy

The Alpha payload fairing is a carbon composite structure developed, manufactured, and tested by Firefly, measuring 2.2 m (7.2 ft) in diameter, and 5 m (16.4 ft) in height. The fairing separation system employs a debris free, low-shock pneumatic separation method fully testable prior to flight. **Figure 8** illustrates the key payload fairing dimensions. The payload fairing remains in place until launch ascent free molecular heating is below 1,136 W/m^2. Immediately thereafter, Alpha initiates a low shock separation system to deploy the two fairing halves from the payload and LV upper stage.

The payload envelope accounts for dynamic movement of the fairing and payload relative to each other, acoustic isolation panels, thermal expansion, and manufacturing tolerances. To avoid coupling with low frequency LV modes and violating this envelope, the SC should be designed to fundamental frequencies of greater than 8 Hz lateral and 25 Hz axial.

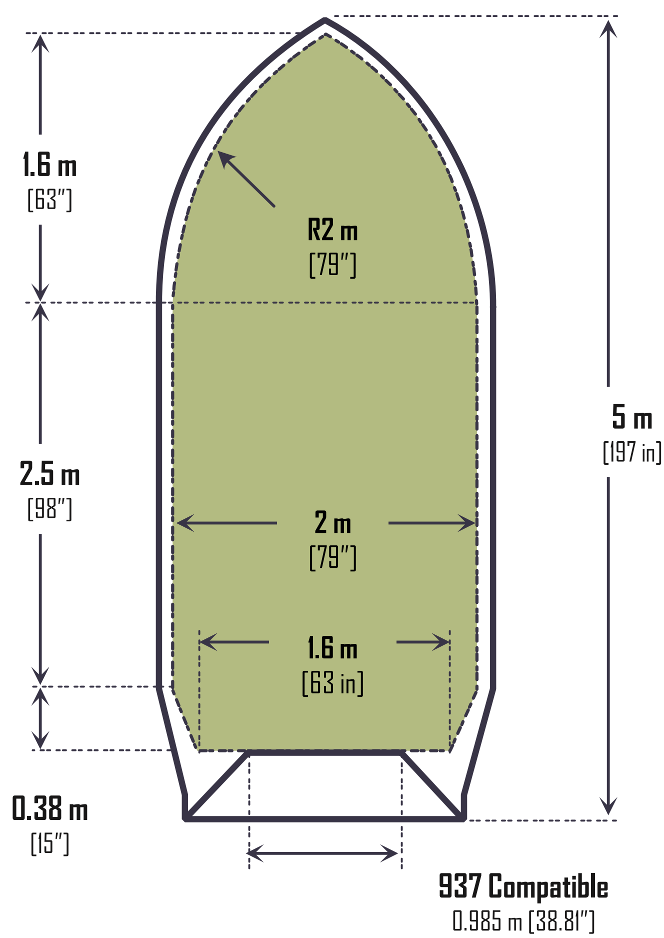

FIGURE 8 Alpha Payload Fairing Configuration

The Alpha vehicle features a standardized 38.81" circular bolt pattern interface which is compatible with the industry standard 937 adapter and other Firefly-specific dispenser structures. Firefly can accommodate all industry standard interfaces and separation systems currently flight proven, depending on customer needs. Accommodations outside the standard bolt pattern may be negotiated and should be discussed early in the mission planning process. At customer request, Firefly may procure the separation system desired. **Figure 9** illustrates primary payload interface dimensions within the launch vehicle coordinate frame. Also depicted are allowable payload mass and CG in relation to the standard interface.

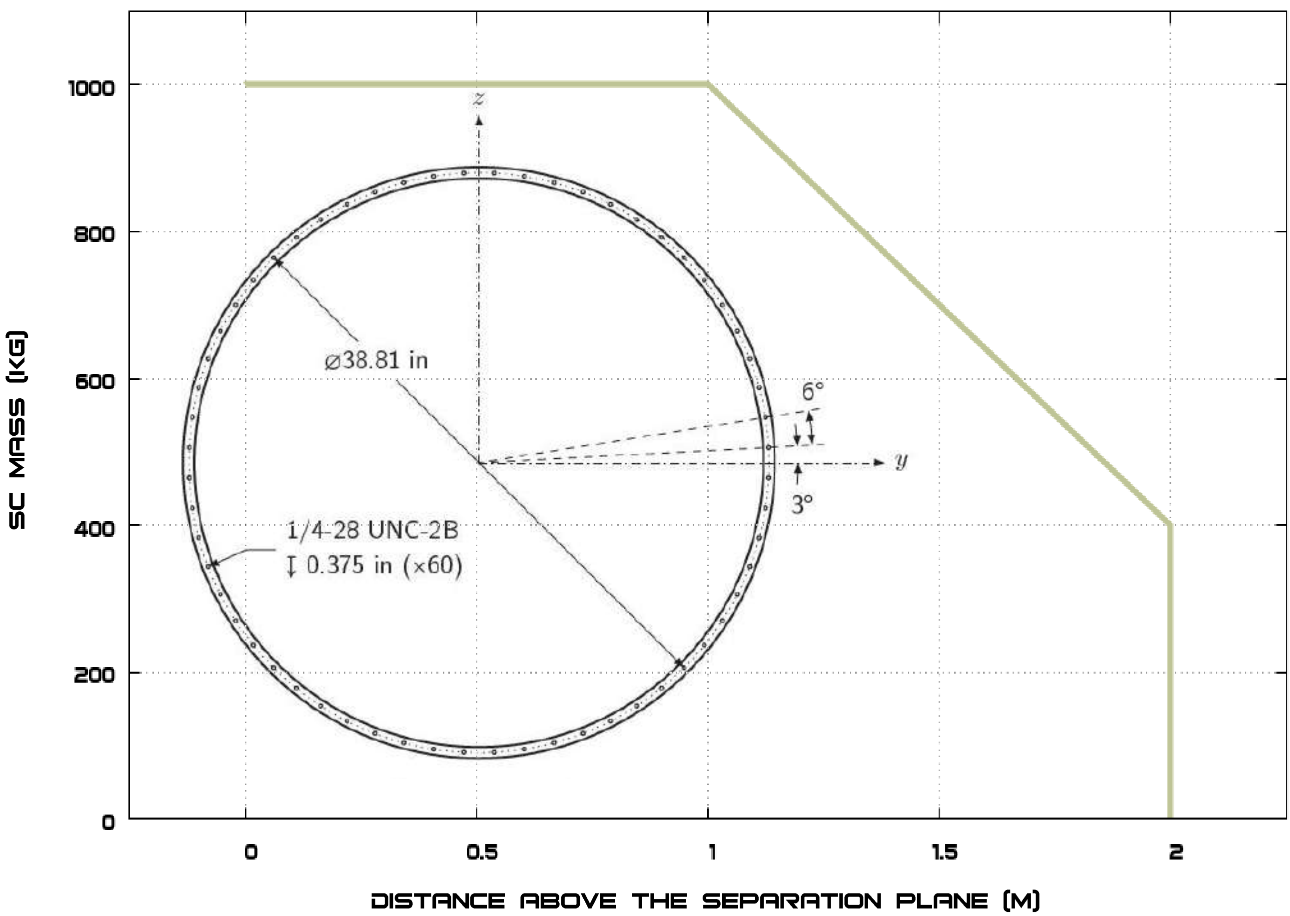

FIGURE 9 Payload Interface Dimensions in Launch Vehicle Coordinate Frame and Allowable CG Height

Firefly is developing several standardized in-house payload dispensers to accommodate the full array of small satellites from cube-sats to micro-sats, to ESPA class satellites and larger. Although each dispenser is compatible with industry standard separation systems, Firefly maintains the capability to design customized adapters to support unique mission needs. **Figure 10** illustrates some of the common payload configurations and dispensers for the Alpha launch vehicle. Please contact Firefly for additional information regarding customized payload accommodations.

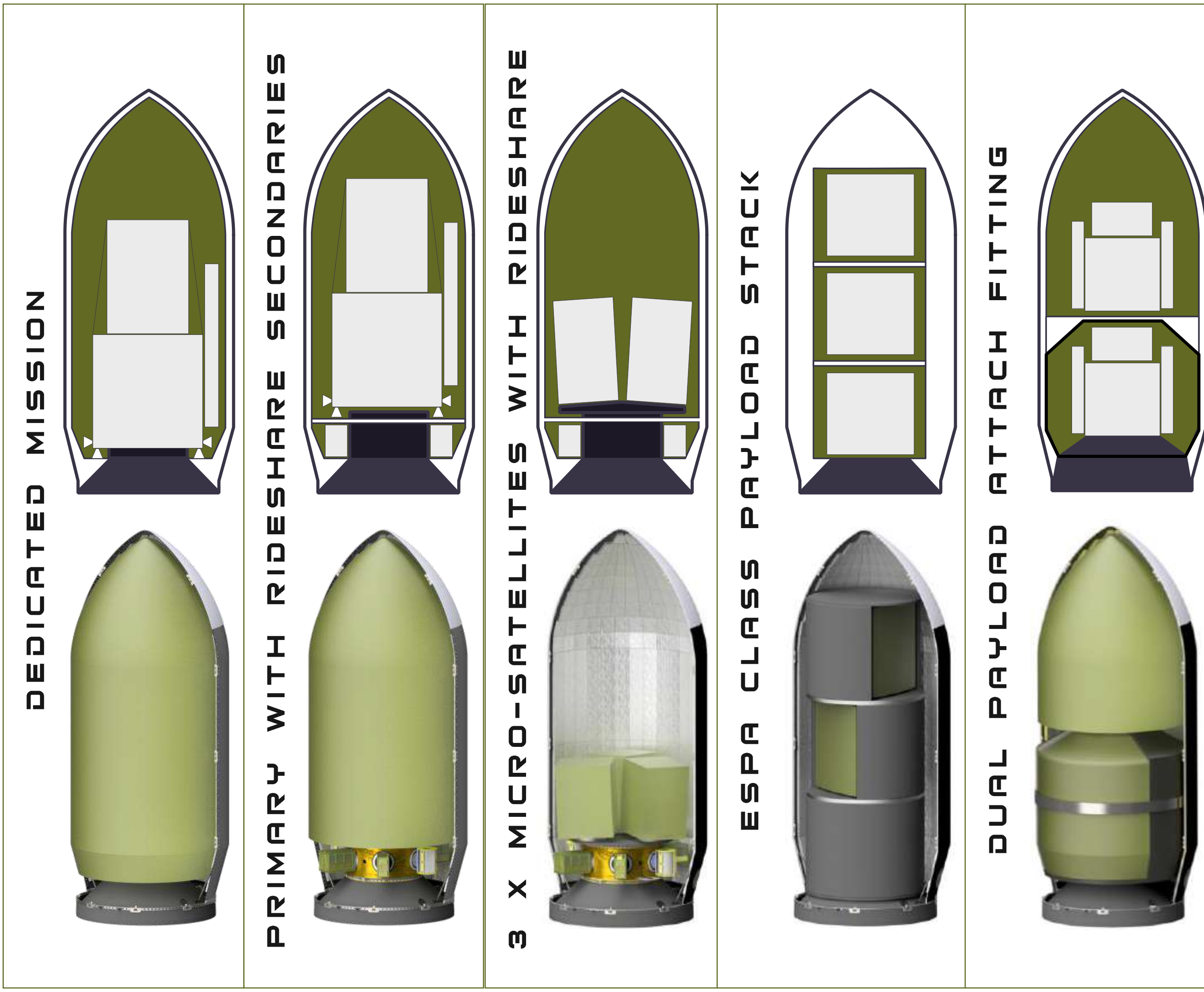

FIGURE 10 Payload Attach Fitting Configurations

ALPHA ELECTRICAL INTERFACES

Figure 11 depicts Alpha's standard electrical interface for the primary payload. This interface is compatible with all industry standard separation systems and most spacecraft customer needs. Additional electrical interface options are available based on customer mission unique needs.

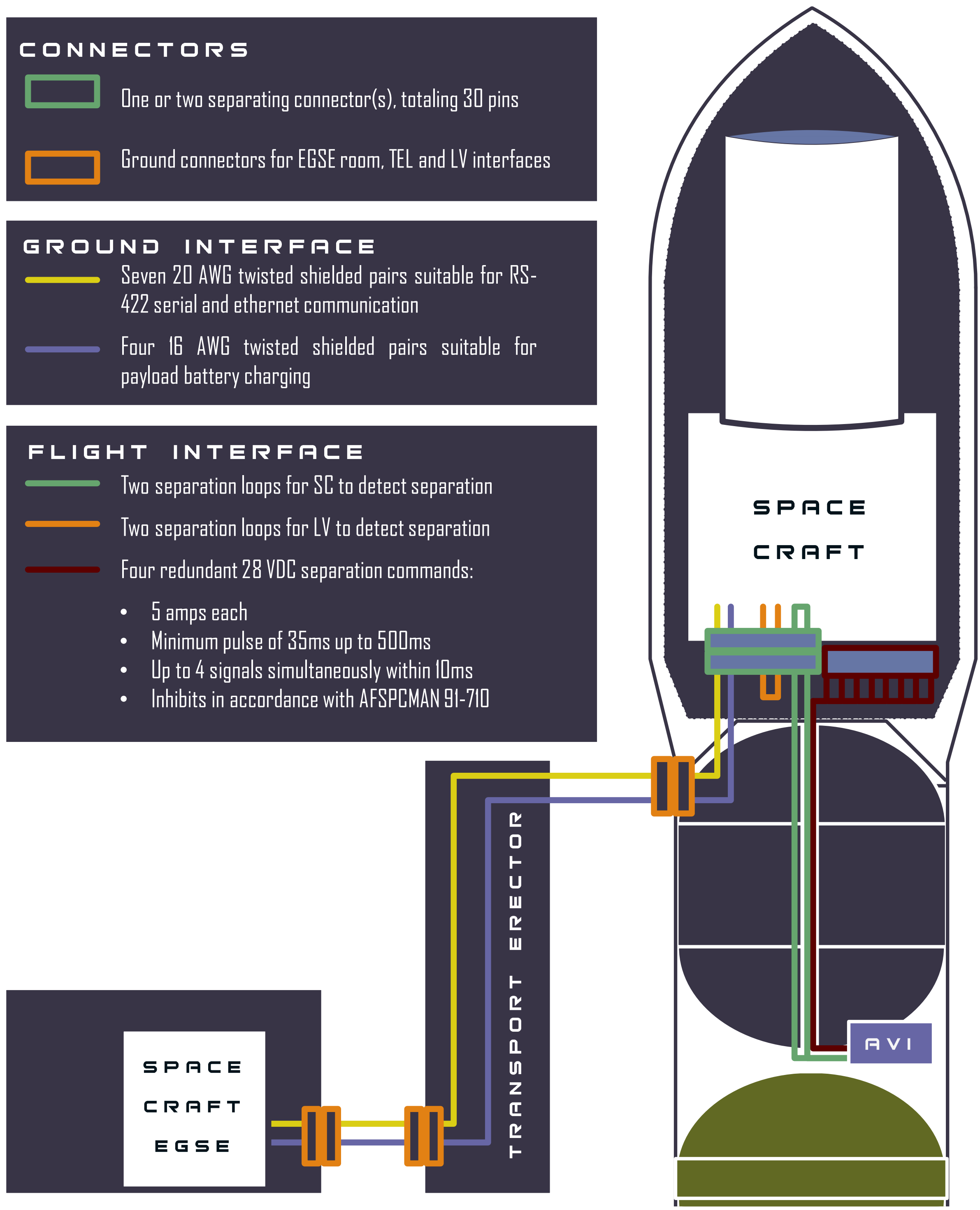

FIGURE 11 Alpha Standard Electrical Interface for Primary Payloads

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ENVIRONMENTS

LOADS AND ENVIRONMENTS

Alpha launch vehicle loads and environments are less than those historically produced by small to medium class launch vehicles, limiting the need for payloads to use critical resources for additional isolation systems or other mitigation techniques.

Key design elements to reduce environmental levels include eliminating the use of pyrotechnic devices near the payload, near full coverage (5 cm, 2" thick) acoustic panels in the fairing, pad-based water suppression, and advanced composite structures that mitigate transmission of LV produced loads and environments. Additionally, precise sizing and design of each launch vehicle stage, paired with exceptional engine performance, significantly limits exposure of the payload to excessive loads.

Coupled Loads Analysis (CLA) and integrated thermal analysis models are used to ensure full compatibility with each SC design. All payloads shall be qualified to these minimum levels prior to launch.

QUASI-STATIC ACCELERATION LOADS

Figure 12 illustrates the maximum predicted axial and lateral quasi-static loads induced to the payload during launch. Payloads desiring launch on Alpha should account for these worst-case loads. These loads originate from a complex mix of vehicle accelerations, pitch maneuvers, aerodynamic buffeting, and coupling of loads. The completion of the mission specific CLA analyses will confirm if potential loads can be reduced for a specific mission.

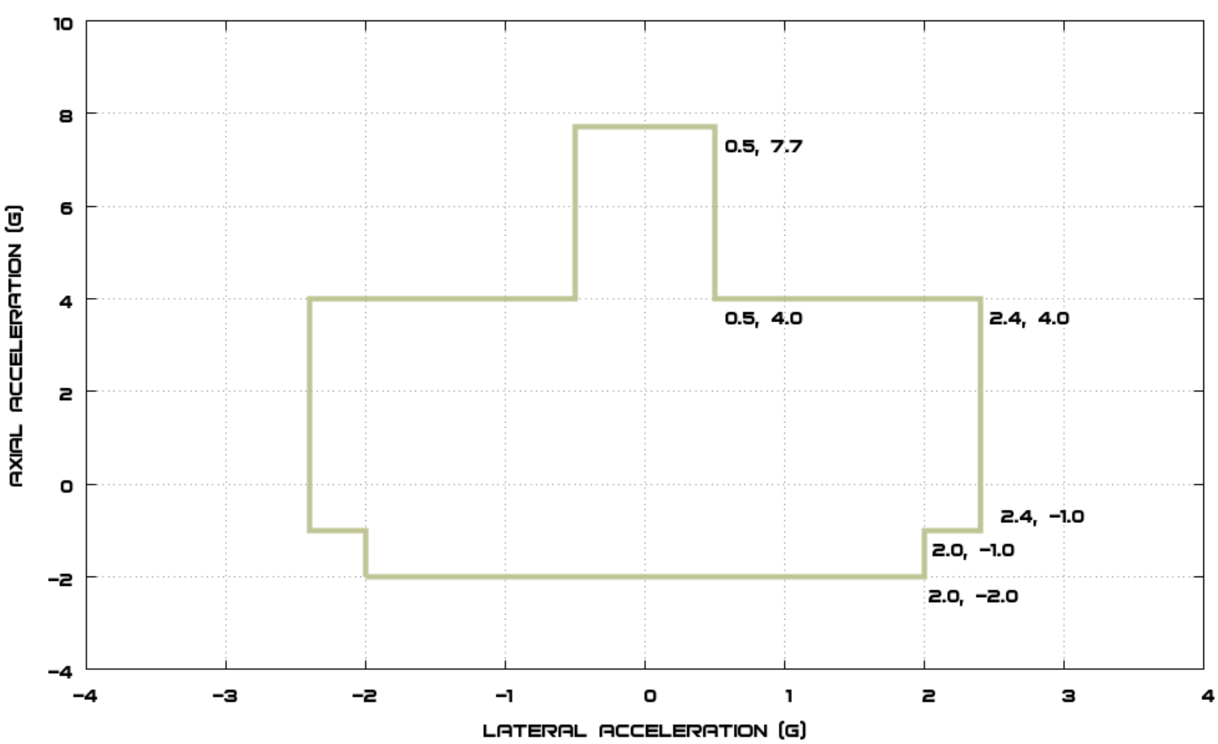

FIGURE 12 Alpha Maximum Quasi-Static Load Factors Airplane Plot

Figure 13 illustrates maximum predicted axial steady state loads induced on the payload during launch. Currently, Alpha does not require engine throttling to maintain these acceleration levels. It is anticipated that future variants of Alpha with higher performing engines will require throttling.

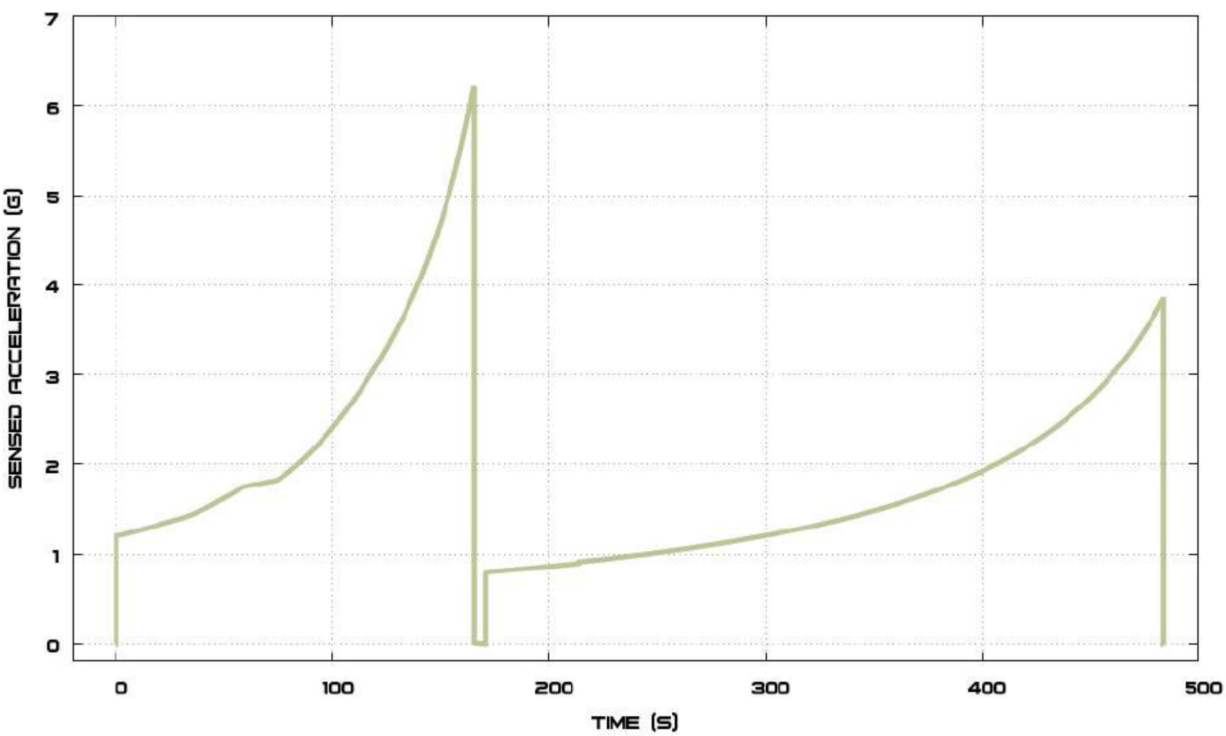

FIGURE 13 Alpha Maximum Axial Steady State Accelerations

Alpha launch vehicle acoustic protection is intended to provide an Overall Sound Pressure Level (OASPL) well below 139 dB. Currently predicted sound pressure levels within the Payload Fairing (PLF) and insulative foam are well below this value without the use of water deluge. VAFB's SLC-2 deluge system will further reduce predicted values. **Figure 14** depicts the maximum predicted acoustic environment of the Alpha launch vehicle without water suppression.

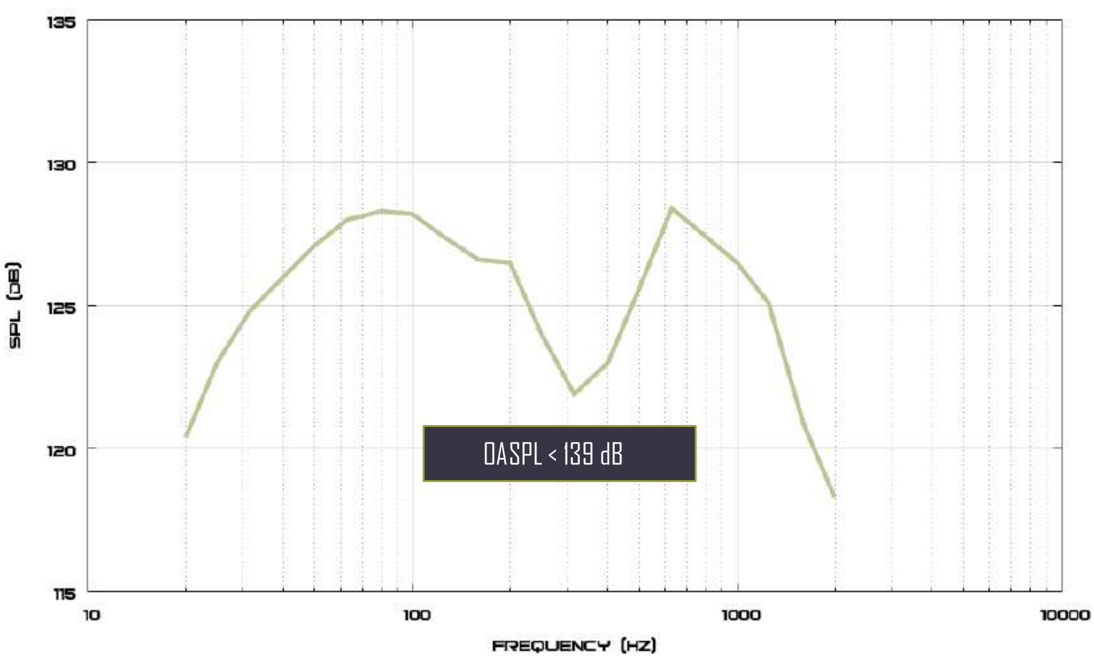

FIGURE 14 Alpha Maximum Predicted Acoustic Environment

The maximum shock environment at the payload interface occurs during payload separation from the vehicle's second stage and is dependent on the PAF/Payload Separation System configuration. Shock levels at the payload separation interface due to stage separation, engine ignition and cutoff, and payload fairing separation are all maintained below a maximum acceleration of 1,000 g's at 1000 Hz. **Figure 15** and **Table 2** below depict the Alpha launch vehicle shock environment, but do not include the mission specific payload separation system.

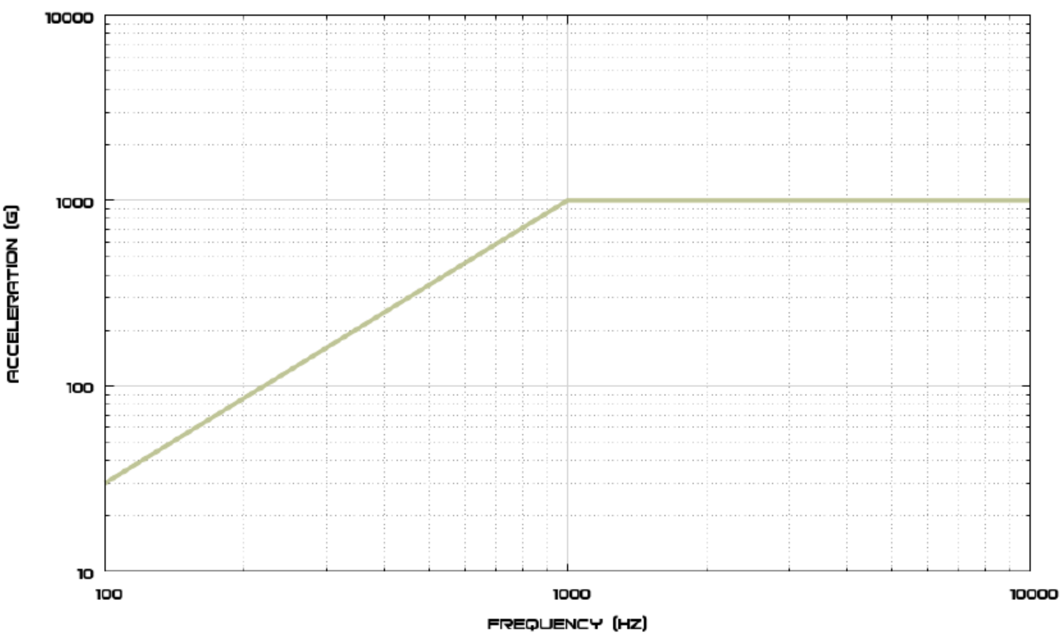

FIGURE 15 Alpha Maximum Predicted Shock Environment

FREQUENCY	ACCELERATION
100 HZ	30
100 - 1,000 HZ	SEE FIGURE
1,000-10,000 HZ	1,000

TABLE 2 Alpha Frequency and Acceleration Levels

Payloads are subjected to a combination of engine vibrations, vehicle structural modes, acoustics, and aerodynamic forces transmitted through the launch vehicle and into the spacecraft interface. The intensity of these vibrations is highly dependent on the payload mass, stiffness, and the interface between the payload and the launch vehicle. The predicted maximum random vibration PSD for a payload mass of 90 kg or greater, is shown in **Figure 16** and **Table 3**. Test levels per the GSFC-STD-7000A General Environmental Verification Standard (GEVS) are additionally displayed for comparison.

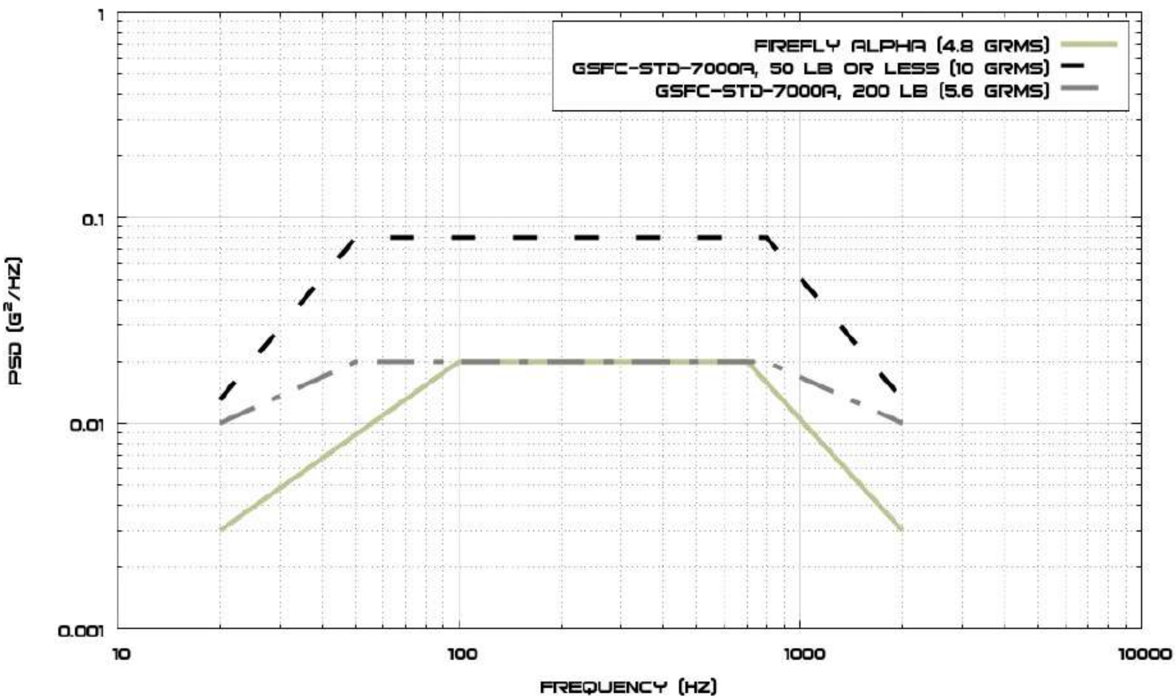

FIGURE 16 Alpha Random Vibration Environment Plot

FREQUENCY	ALPHA PSD LEVEL
20 HZ	0.003
20 – 100 HZ	SEE FIGURE
100 – 700 HZ	0.02
700 – 2,000 HZ	SEE FIGURE
2,000 HZ	0.003
GRMS	4.9 G

TABLE 3 Alpha Random Vibration Frequency and PSD Levels

PRESSURE AND VENTING

The Alpha launch vehicle is designed to minimize rapid pressure drops within the payload fairing during ascent. During ascent, the fairing will relieve internal pressure through one-way vents located at the aft end of the payload fairing. The pressure decay rate will not exceed -0.3 psi/second, except for a brief period during transonic flight, when the decay rate is not expected to exceed -0.9 psi/second (not depicted in the plot). **Figure 17** depicts a typical payload pressure and venting environment for the Alpha launch vehicle.

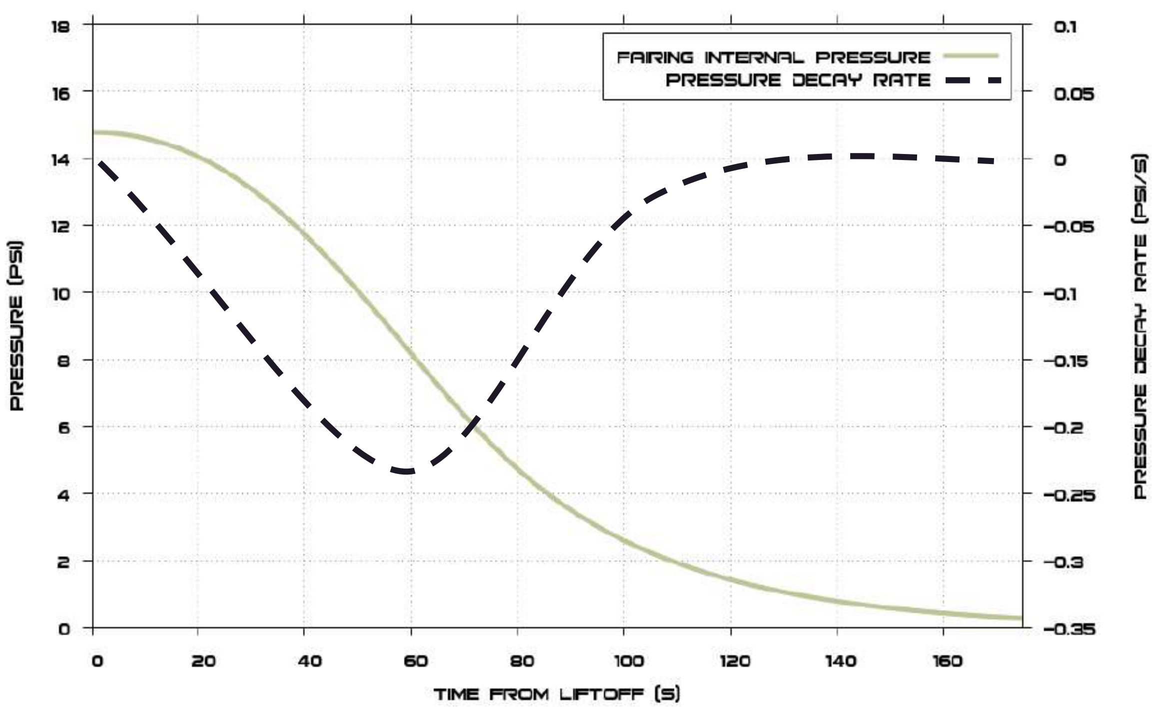

FIGURE 17 Alpha Payload Fairing Venting Environment

The Alpha launch vehicle provides the payload with standard thermal, humidity, and High Efficiency Particulate Air (HEPA) clean controlled environments from encapsulation through liftoff. The payload protection encompasses liftoff until an adequate free molecular heating (FMH) rate is achieved for fairing separation. Figure 18 outlines the Alpha vehicle's thermal and cleanliness environments.

Alpha is designed to accommodate contamination-sensitive payloads from integration in the PPF, roll-out to the launch pad, and through launch. Alpha's standard service will accommodate most payload cleanliness requirements. For payloads requiring extensive cleanliness environments, Firefly can provide additional cleaning, filtration, contamination mitigation protocol, and verification services.

CLEANING AND MATERIALS

- All major surfaces including the PLF, Acoustic Blankets, and PAF are Visibly Cleaned to NASA SN-C-0005
- Major materials within line of sight of the payload comply to 1% TML 0.1% CVCM
- Mission specific cleaning down to 500A available

AIR CLEANLINESS

- ISO 8 (Class 100K) HEPA air in PPF and PLF during transport, and while on the launch pad
- GN2 available as an upgrade
- Air diffuser preventing high velocity air impingement directly onto the payload
- Air ventilates out through ports on the PLF
- Mission specific ISO 7 (Class 10k) available

TEMPERATURE

- Temperature controlled air 10-21 deg C [50-70 deg F]
- Relative air humidity controlled from 20-60%
- Maximum FMH < 1,136 W/m^2 [0.1 BTU/ ft^2 /s]
- PLF internal surface temperature < 93 deg C [200 deg F]

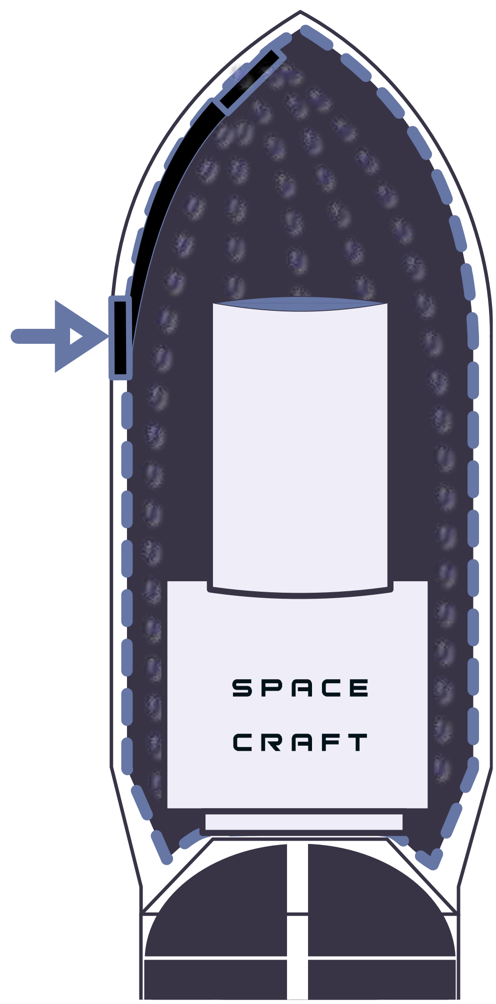

FIGURE 18 Alpha Thermal and Cleanliness Environment

RADIO FREQUENCY AND EMI/EMC

Alpha can accommodate payloads which are powered on during launch, but for standard operations it is recommended payloads be powered off during launch to reduce the potential for interference or damage caused by RF or Electro Magnetic Interference (EMI). Customers must ensure payload components or material constituents sensitive to RF transmissions are compatible with the radio frequency and EMI/EMC environment provided in **Table 4** below.

FUNCTION	FREQUENCY
S-BAND TRANSMITTER	2.2 - 2.4 GHZ
AVIONICS POWER SWITCHING	100 KHZ - 400 KHZ, 440KHZ, 660 KHZ, 960 KHZ
GPS L-BAND RECEIVER	L1: 1575.42 MHZ L2: 1227.60 MHZ
UHF RECEIVER	421 MHZ

TABLE 4 Alpha Radio Frequency and EMI/EMC Environment

3

OPERATIONS

STANDARD AND NON-STANDARD SERVICES

Firefly employs a customer-oriented mission management approach by simplifying launch planning and integration processes. By understanding both the payload and the launch vehicle boundaries, Firefly can operate in a quick and agile manner, making customer interactions as streamlined as possible.

Should non-standard services be required, the customer is encouraged to specify these items during completion of the Payload Questionnaire. This will enable the Mission Manager to deliver prompt information regarding payload accommodation, as well as adjustments to launch schedule or cost. Standard and non-standard services offered by Firefly are described below.

STANDARD SERVICES

- Dedicated Firefly Mission Manager
- Development of a mission-specific Interface Control Document (ICD)
- Launch vehicle licensing, including FAA and Range Safety Documentation
- Preliminary and final modeling and analysis of the integrated mission, including performance analysis, CLA, and thermal modeling
- Fit Check Verification of the Payload to the PAF
- Certified ISO 8 (Class 100K) cleanroom for payload to PAF integration areas, encapsulation, and through launch
- Two working group meetings, one at Firefly facilities, and the second at the launch site
- Mission dress rehearsal for key launch personnel
- Payload access prior to payload fairing closure
- Delivery of the payload into requested orbit
- Access to all other standard features presented in the guide like the electrical interface and fairing volume
- Post-flight launch services, including payload separation confirmation, delivery of the Post-Flight Data Package, Payload Environment Report, and final orbit configuration

NON-STANDARD SERVICES

- Separation system provided by Firefly
- Extensive insight into mission assurance processes, designs, test results, and hardware pedigree
- Customized or multi-payload dispenser
- Payload qualification support for regulatory compliance
- Increased cleanliness levels to ISO 7 (Class 10K) cleanroom facilities for the payload and PLF integration spaces
- Additional mission analysis and modeling
- Contamination control analysis
- Payload non-hazardous and hazardous fueling and pressurization accommodations
- Payload access after payload fairing closure
- Dedicated payload GN2 purge, up to T-0
- RF Transmission after payload encapsulation, and before payload separation
- Additional services may be available upon request as coordinated during mission planning and mission contract negotiations.

PAYLOAD PROCESSING FLOW

PAYLOAD ARRIVAL

The payload arrives at the Payload Processing Facility (PPF) and is lifted from the transportation carrier by lift truck or overhead crane located within the airlock. The payload is removed from its shipping container using an overhead crane and readied for checkouts. Once checkouts are complete, combined SC and LV operations begin with mating of the SC to the Payload Attach Fitting (PAF). Once the payload is fully assembled onto the PAF and any additional services performed, it is then ready for PLF encapsulation.

PAYLOAD ENCAPSULATION

Payloads are encapsulated within the payload fairing in a vertical orientation. Once encapsulated, a continuous supply of HEPA filtered and temperature-controlled air is supplied to the PLF. A diffuser is installed within the payload fairing at the outlet, to minimize direct airflow impingement upon sensitive components. The encapsulated payload is then rotated to a horizontal orientation by means of a break-over fixture and mated to the LV. The encapsulated payload will remain in this horizontal, cantilevered position until the integrated vehicle is rolled to the launch pad and erected to vertical in advance of launch. Payload transportation and encapsulation processes are illustrated in **Figure 19**.

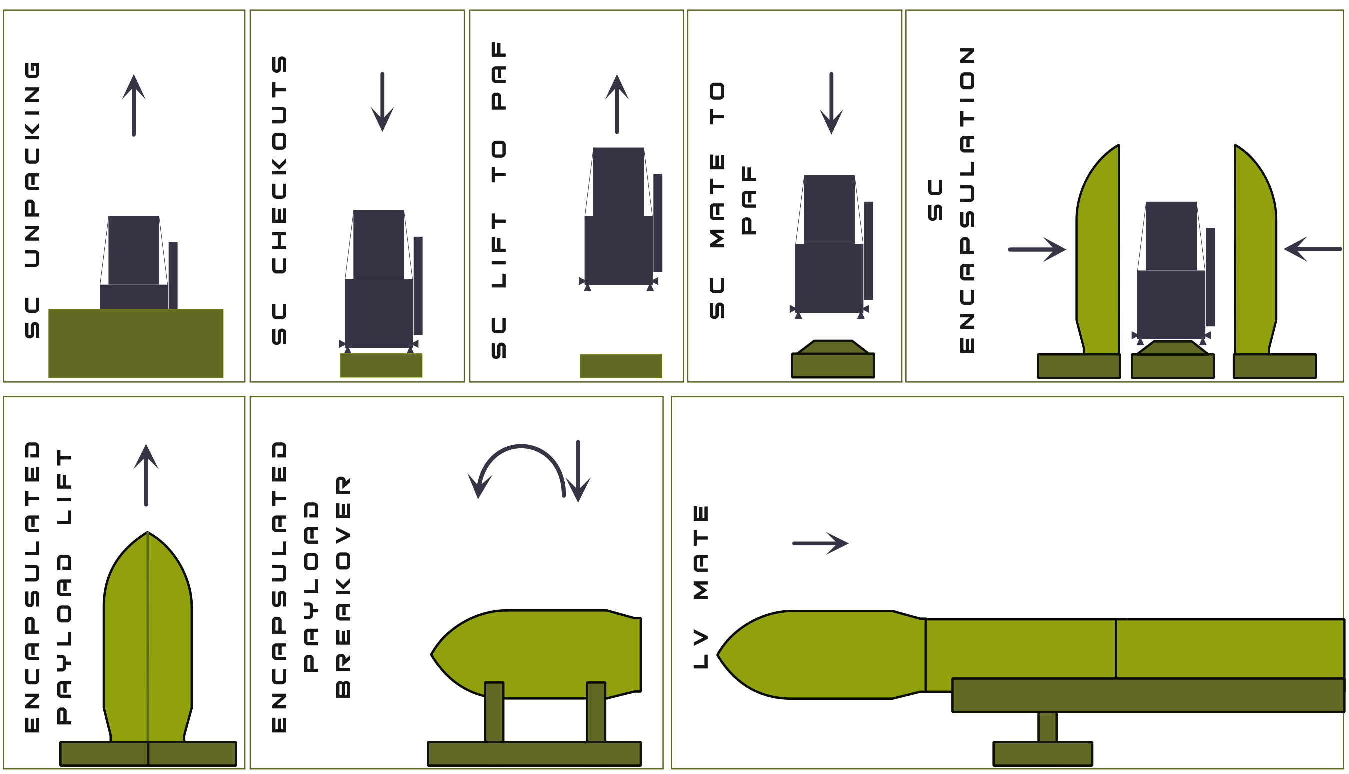

FIGURE 19 Payload Processing Flow

PAYLOAD FUELING AND CHECKOUT PANELS

As a non-standard option, hazardous, green, and other propellants and pressurization accommodations may be provided by Firefly. Depending on the type of propellant, these accommodations may take place at third-party facilities prior to transportation to the launch complex. Propellant loading details will be coordinated as part of tailored mission support to the payload.

LAUNCH CAMPAIGN TIMELINE

Each Firefly mission follows a standard timeline, beginning with initial customer contact, and ending with completion of mission delivery. Flexibility is offered for customers needing an expedited schedule and should be discussed early in the mission planning process to determine an adequate timeline. All dates provided in **Figure 20** below are intended as guidelines, and not firm constraints. **Figure 21** on the next page illustrates key final launch campaign events from vehicle integration through launch.

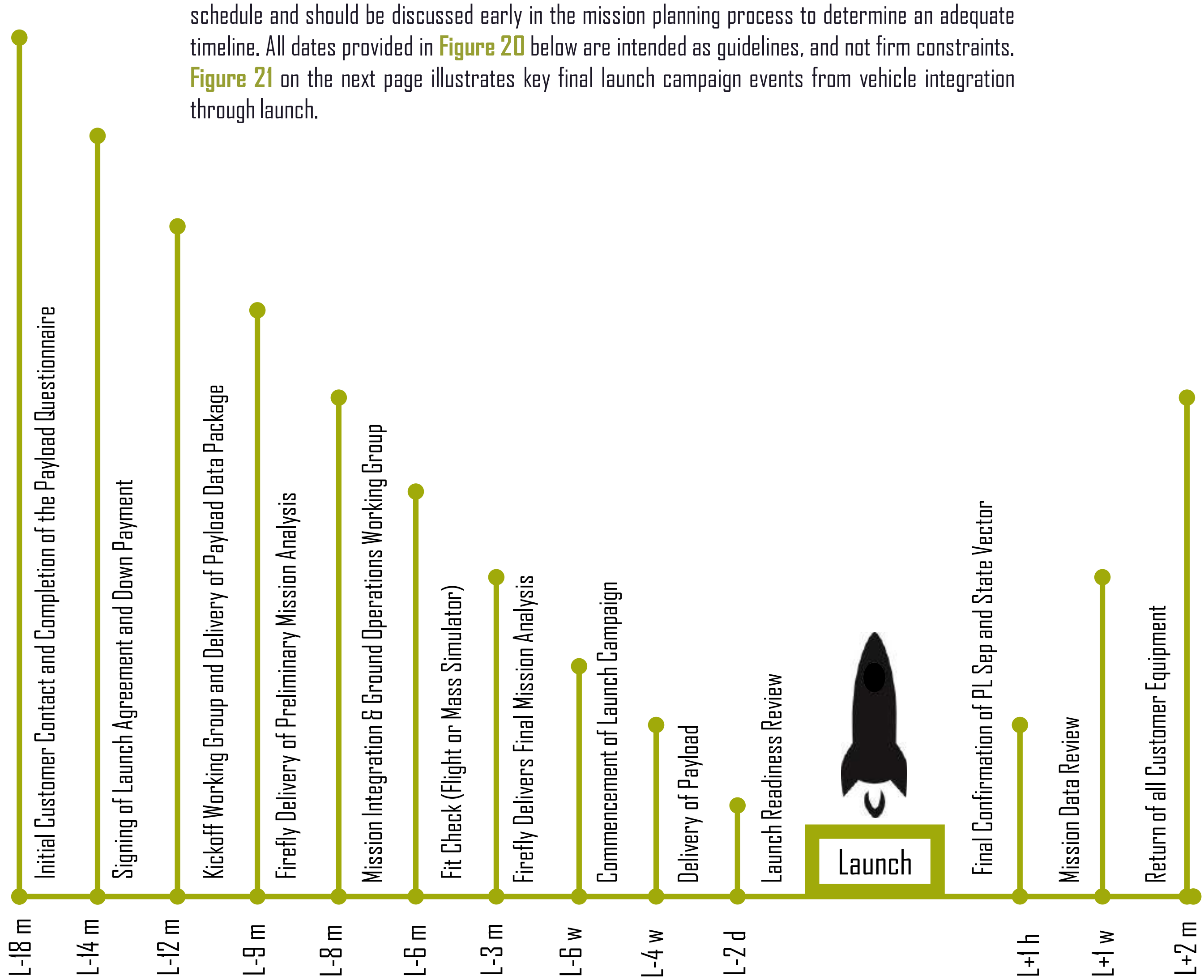

FIGURE 20 Notional Launch Campaign Timeline

FIGURE 21 Final Launch Campaign Events

INFRASTRUCTURE AVAILABLE FOR CUSTOMERS

Firefly offers standard infrastructure for customers in most of our facilities at each launch complex. In addition to office workspace, Firefly offers high-speed broadband internet access in our payload processing facilities. EGSE power sources for the payload at the PPF and at the launch equipment building are available as a standard service.

Customer access to the launch vehicle is restricted to payload/launch vehicle processing operations and activities. Customers may view the launch vehicle during precoordinated times. Escorted viewing of and access to the launch pad is granted to customers on a non-interference basis with launch vehicle operations. Due to U.S. Government International Traffic in Arms Regulations (ITAR), and Export Administration Regulations (EAR), non-US customers and personnel may view the vehicle while in its processing and assembly facility only if proper government approvals are in place.

Customers will be invited to view the launch from an official observation point, a safe distance from the launch site.

4

MISSION

CUSTOMER DELIVERABLES

Primary and secondary payload customers are expected to deliver required documentation pertaining to mission requirements, payload specifications, safety, and payload processing. These items include, but are not limited to, the deliverables shown in **Table 5**.

DELIVERABLE	DESCRIPTION
COMPLETED PAYLOAD QUESTIONNAIRE	An important first step for mission planning includes the completion of Firefly's Payload Questionnaire. This will be provided by your Mission Manager and gives necessary insight into your mission's requirements.
PAYLOAD SAFETY DATA PACKAGE	Safety documentation and data to support range safety operations and launch planning are requested early in the mission planning process. It is the customer's responsibility to supply all design, qualification, and acceptance test information for all hazardous and safety critical elements of payload subsystems and payload operations. Customers are expected to complete inputs to the Missile System Prelaunch Safety Package (MSPSP) using the template provided by Firefly. Your Firefly Mission Manager will integrate this information into both the Federal Aviation Administration (FAA) licensing application and the Range Safety Review Package.
ENGINEERING DATA PACKAGE	The Engineering Data Package includes, but is not limited to: • CAD (inclusive of separation systems and appendages) • FEA models and a Craig Bampton model for use in CLA • Mass Properties Report • Payload Analysis and Test Report Any requests to operate outside of standard environmental parameters specified herein must be included.
PAYLOAD PROCESSING PLAN	A detailed Payload Processing Plan including any requests for non-standard services pertaining to payload processing and launch operations.
MASS MODEL	A mass model of the payload is to be provided by the customer for fit checks. Mass models should show interfaces representative to flying on Alpha.

TABLE 5 Customer Deliverables

Each customer will be assigned a Firefly Mission Manager (FMM), who will remain the direct point-of-contact throughout the mission planning and launch process. The FMM works closely with their customer counterpart mission manager, ensuring all facets of the mission planning and integration process are completed in a timely manner. In addition to ensuring a seamless integration process to the launch vehicle, the FMM is also the key interface to both the Facility Manager and range safety. The Facility Manager interface is related to accommodating SC needs at launch site facilities. The Chief Range Safety Officer interface is for ensuring compliance to all ground and flight safety requirements. Customers can expect candid transparency and open communication from their FMM. Maintaining customer satisfaction and delivering an unrivaled customer experience is part of what sets Firefly apart in an evolving launch market. Figure 22 outlines Firefly's basic mission management interface structure.

FIGURE 22 Mission Services Organizational Structure

SAFETY REQUIREMENTS

Safety is paramount in the mission planning and launch process. The customer's Mission Manager, along with the Mission Assurance team, will ensure payloads meet all safety requirements throughout the design and launch planning process. Firefly will serve as a direct liaison between all customers and range safety officials.

It is mandatory for customers to be in compliance with applicable AFSPCMAN 91-710 requirements, as well as FAA 14 CFR, Part 400 for payload development, including the design of both flight and ground systems. Customers are responsible for providing inputs to the Firefly MSPSP during early stages of mission planning as part of Firefly's Safety Data Package.

HAZARDOUS SYSTEMS AND OPERATIONS

Payloads qualifying as a hazardous system or requiring hazardous operations outside of Firefly's Standard Service Package, will require both Firefly and range safety approval prior to performing the operation or conducting launch. The customer's payload classification will be determined early in the mission planning stages, to ensure proper permissions are granted.

WAIVERS

In the event systems or operations do not meet safety requirements but are believed to be acceptable for ground and launch operations, range safety officials may grant a waiver. It is the policy of both Firefly and range safety that waivers are used as a recourse and are not considered standard practice.

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FACILITIES

CORPORATE HEADQUARTERS

Firefly's Corporate Office is headquartered in Cedar Park, Texas. It is an open engineering environment to encourage collaboration. Headquarters also houses the main Mission Control Center (MCC) where major stage tests, operations, and launch can be monitored and supported.

FIGURE 23 Firefly Texas Production, Test, and Headquarters

PRODUCTION AND TEST FACILITIES

Propulsion and structural production and testing are conducted in Briggs, Texas, at a 200-acre test facility 30 minutes north of Firefly Headquarters. The test site is fully staffed and incorporates multiple facilities including a 10,000 ft^2 test control and fabrication building, a 2,500 ft^2 surface finish shop, and a 30,000 ft^2 production shop. The site includes several operational test stands for engine testing, component testing, and integrated stage testing.

Firefly launch sites provide customers with a wide range of orbit options to fit mission objectives. Each facility supports both dedicated and multiple manifest missions.

SLC-2, VANDENBERG AIR FORCE BASE

Firefly conducts Polar and SSO launches to high inclinations from SLC-2 at Vandenberg AFB, California. **Figure 25** shows typical orbit inclinations and launch azimuths from VAFB. Other orbit inclinations may be possible, inquire with Firefly for additional details.

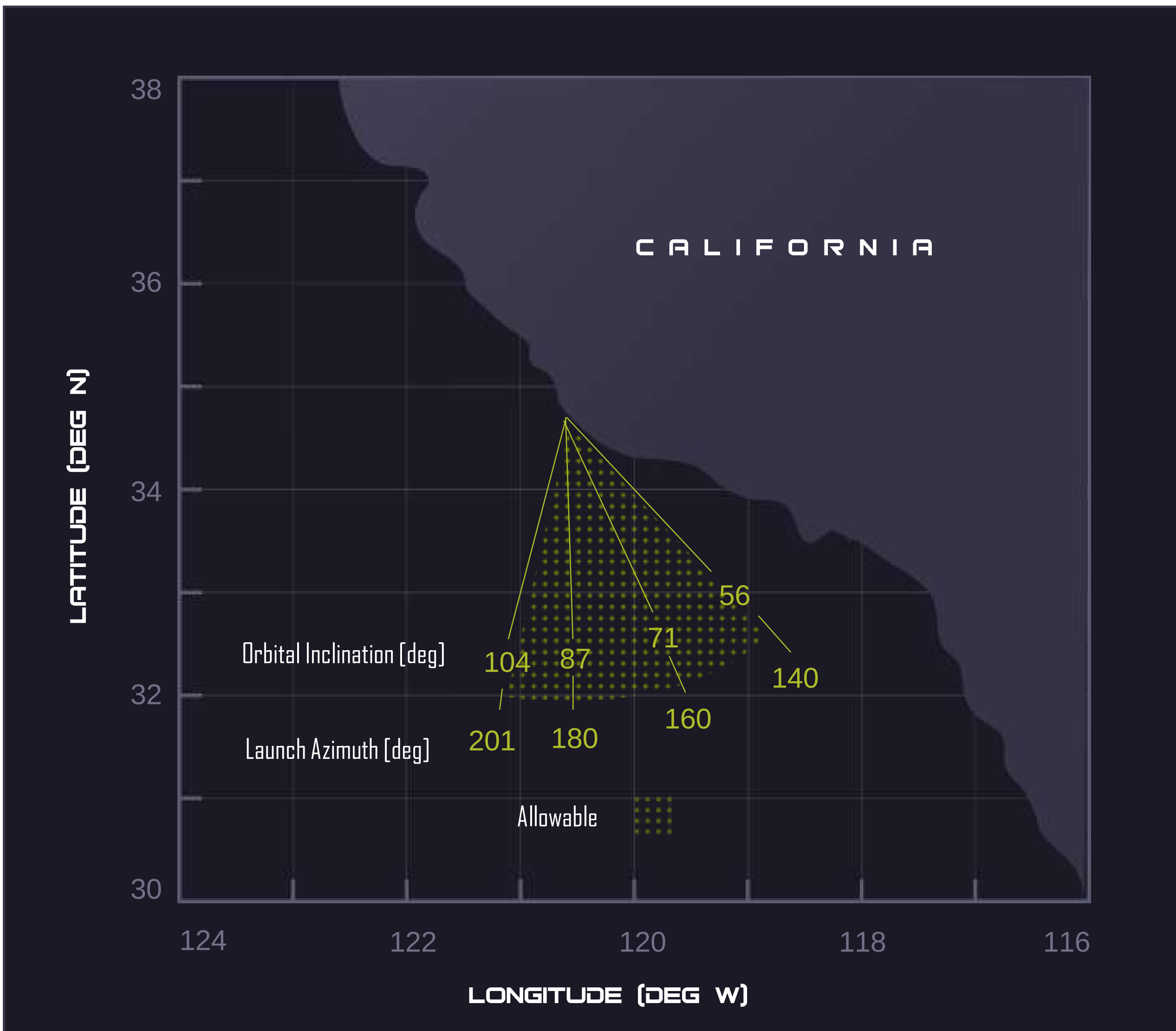

FIGURE 24 Vandenberg Air Force Base, SLC-2 Launch Inclinations and Azimuths

SLC-20 is an established launch complex located at Cape Canaveral Air Force Station (CCAFS) Florida. Launches capable of achieving inclinations from 29 deg to 57 deg are possible from this site. Figure 26 illustrates orbit inclinations and launch azimuths from CCAFS.

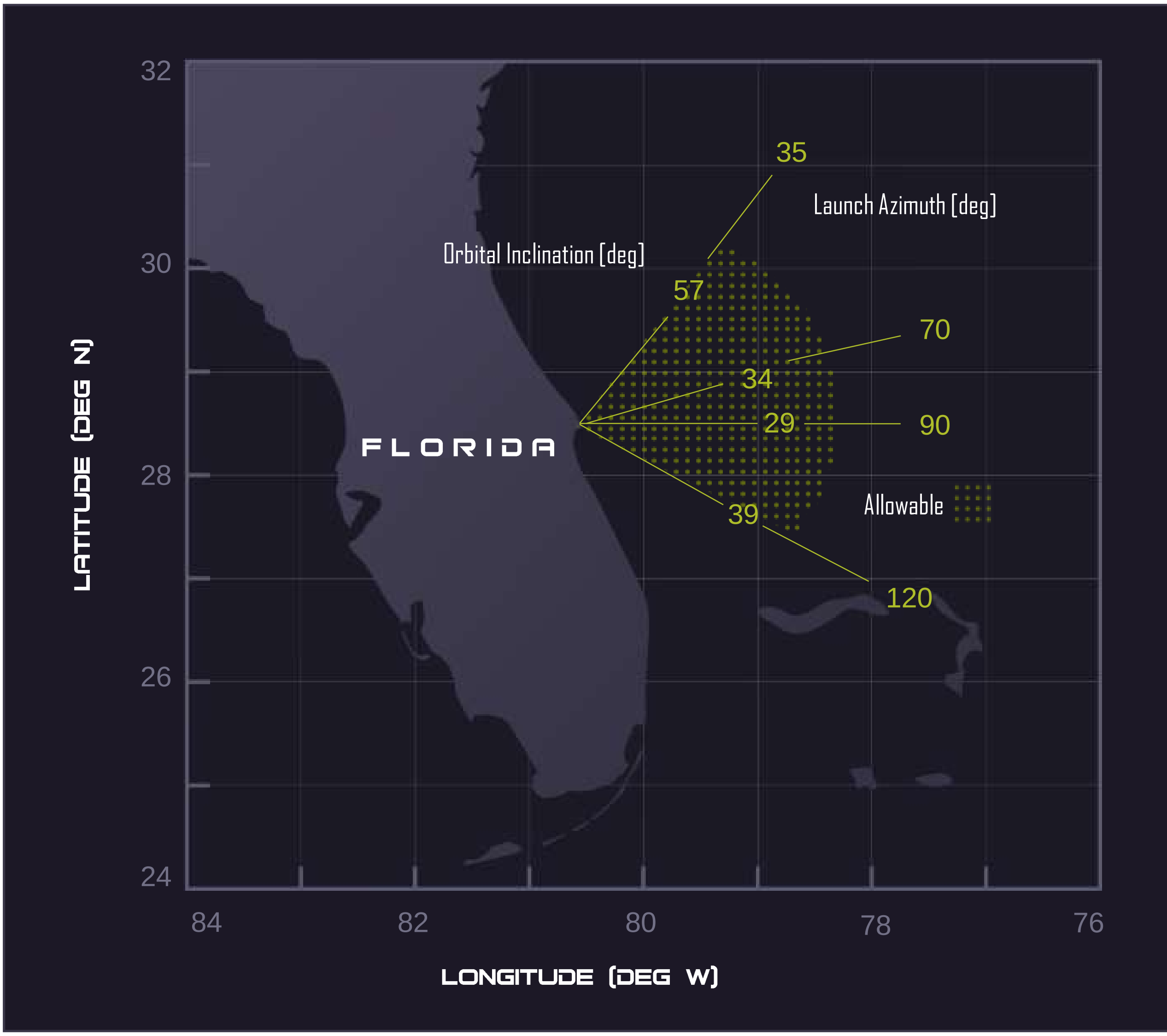

FIGURE 25 Cape Canaveral Air Force Station, SLC-20 Launch Inclinations and Azimuths

An on-site horizontal integration facility (HIF) is being utilized for processing and integration of Firefly launch vehicle stages. The HIF is also where the integrated PLF will be mated to the LV. The HIF is climate controlled and provides power and high-pressure gases used for processing Alpha LVs. The HIF is a 5,000 ft^2 open high bay, with an eave height of 25 feet, allowing for removal of Alpha components from shipping fixtures located on flatbed transportation trailers with deck heights up to 58". Two bridge cranes in the high bay support processing and operations. Multiple engineering workstations, administrative space, and communications equipment rooms are provided.

FIGURE 26 VAFB Horizontal Integration Facility

PAYLOAD PROCESSING FACILITY

The PPF provides controlled environmental space and equipment for payload processing and encapsulation with a high bay, an airlock, a garment room, and office space.

The PPF high bay is a climate-controlled ISO 8 (Class 100K) cleanroom. Ancillary rooms will be visibly clean, air conditioned, humidity-controlled workspaces.

Available power consists of 120/240 V single phase 60 Hz, 208 V three phase 60 Hz, and 240/480 V three phase 60 Hz for processing. Shop air is also available. Additional power and gasses can be made available on a mission unique basis.

FIGURE 27 VAFB Payload Processing Facility

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FIREFLY

ABOUT FIREFLY

Firefly was founded to provide economical and reliable access to space for small payloads through the design, manufacture, and operation of launch vehicles and spacecraft for the nation's small launch market.

To reduce risk and increase reliability, each vehicle is engineered with cross-industry design insights, leveraging high maturity COTS components. We use a highly vertically integrated manufacturing process. Propulsion, structures and avionics are designed, built, and tested in-house, integrating COTS components as required. The technologies employed in our Alpha flagship vehicle provide a clear pathway for future incremental improvements in capability.

FIGURE 28 Some of The Firefly Team Enjoying an Engine Test!

ABOUT THE TEAM

Our engineering team is comprised of established industry leaders with experience in building launch vehicles, spacecraft, and successful technology organizations, augmented by a passionate team from the country's top engineering universities.

With over 230 aerospace professionals on staff, we have a highly technical and capable workforce, providing Firefly with a balanced culture that blends the best elements of New Space passion, with heritage space rigor.

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REFERENCES

ACRONYMS

AFSPCMAN	Air Force Space Command Manual
AFTS	Autonomous Flight Termination System
AFTU	Autonomous Flight Termination Unit
AVI	Avionics
AWG	American Wire Gauge
C&DH	Command and Data Handling
CAD	Computer Aided Design
CCFAS	Cape Canaveral Air Force Station
CFM	Cubic Feet per Minute
CLA	Coupled Loads Analysis
COTS	Commercial-Off-The-Shelf
CG	Center of Gravity
CVCM	Collected Volatile Condensable Materials
EAR	Export Administration Regulations
EEE	Electrical, Electronic and Electromechanical
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPS	Electrical Power System
EELV	Evolved Expendable Launch Vehicle
ESPA	(EELV) Secondary Payload Adapter
FAA	Federal Aviation Administration
FEA	Finite Element Analysis
FED-STD	Federal Standard
FRR	Flight Readiness Review
FPS	Frames Per Second
GLOW	Gross Lift-Off Weight
GN2	Gaseous Nitrogen
GN&C	Guidance, Navigation and Control
GPS	Global Positioning System
GRMS	Gravity Root Mean Square Acceleration
GSE	Ground Support Equipment
GUI	Graphical User Interface
HEPA	High Efficiency Particulate Air
HIF	Horizontal Integration Facility
ICD	Interface Control Document
ISO	International Organization for Standardization
I_{SP}	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 Center
MECO	Main Engine Cut-Off
MIL-STD	Military Standard
MLB	Motorized Lightband
MRR	Mission Readiness Review
MSPSP	Missile System Prelaunch Safety Package
OASPL	Overall Sound Pressure Level
PAF	Payload Attach Fitting
PCS	Probability of Command Shutdown
PLF	Payload Fairing
PPF	Payload Processing Facility
PS	Payload Segment
PSD	Power Spectral Density
QPSK	Quadrature Phase Shift Keying
RCC	Range Commander Council
RF	Radio Frequency
RP-1	Kerosene
SC	Spacecraft
SECO	Second Engine Cut-Off
SLC-2	Space Launch Complex 2
SLC-20	Space Launch Complex 20
SMC	Space and Missile Systems Center
SRS	Shock Response System
SSO	Sun-Synchronous Orbit
TBC	To Be Confirmed
TBD	To Be Determined
TML	Total Mass Loss
TRL	Technology Readiness Level
VAFB	Vandenberg Air Force Base

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