
FIREFLY
AEROSPACE
ALPHA
PAYLOAD USER'S GUIDE

Contents

Revision History

Version	Date	History
1.0	March 2018	First Release
2.0	August 2019	Updated Release
3.0	March 2022	Updated Release
3.1	April 2022	Improved Release
4.0	July 2023	Orbital Launch Release
5.0	October 2024	Updated Flight Environments, Launch Services, and Facilities

The Alpha Payload User's Guide - Version 5.0 has been cleared for open publication by the Defense Office of Prepublication and Security Review, Department of Defense, as stated in letter 24-T-2754, dated October 22, 2024.

1. FIREFLY OVERVIEW

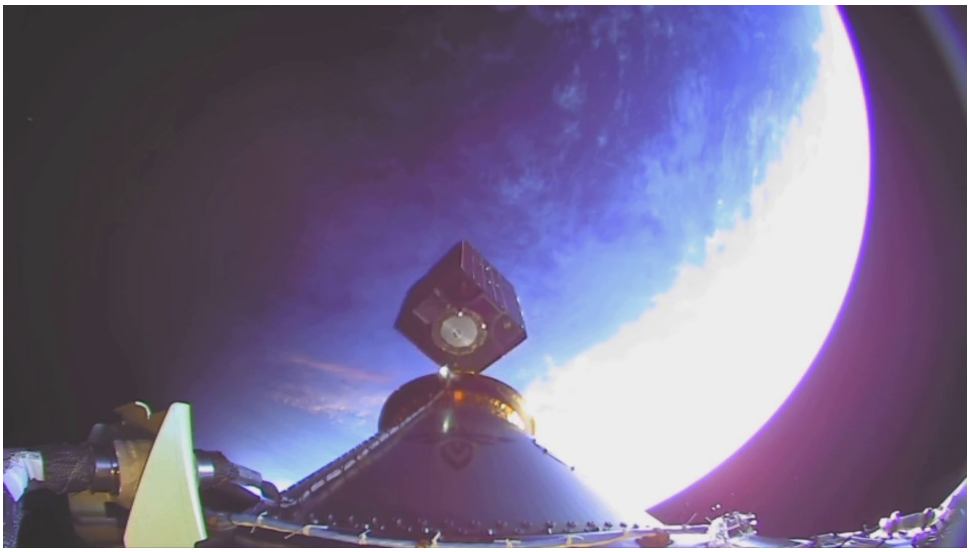

Figure 1. Firefly's Successful VICTUS NOX Mission Deploying the Payload in Orbit

Firefly is an end-to-end space transportation company offering launch, in-space, and lunar services. The company is focused on delivering responsive, reliable, and affordable space access for government and commercial customers. Firefly's small to medium lift launch vehicles, Elytra orbital vehicles, and Blue Ghost lunar landers provide the industry with a single source for missions from LEO to the surface of the Moon and beyond.

As an all-American company headquartered in central Texas, Firefly's vehicles share common components, teams, and facilities to scale efficiency and increase reliability. Firefly is established as a world leader in rocket propulsion and carbon composite structures, allowing us to lift heaver payloads at a much lower cost. The company's rapid-assembly manufacturing capabilities deployed across the organization further allow Firefly to accelerate production time and support rapid mission schedules.

Though this guide is specific to the Alpha Launch Vehicle (LV), Firefly offers a family of other space transportation services. The company's Elytra spacecraft offers additional opportunities for in-space mobility, logistics, and surveillance. Firefly's Blue Ghost lander further providers opportunities for lunar delivery and operations.

The technologies employed in the flagship Alpha vehicle provide a clear pathway for future incremental improvements in capability and expansion of Firefly's launch services, including a Medium Launch Vehicle.

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2. ALPHA LAUNCH VEHICLE

Alpha provides low-cost launch capabilities for customers at a price of $15M for a dedicated commercial launch service. Alpha is designed to be the most reliable and responsive 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 national security missions.

Table 1. Alpha Launch Vehicle Specifications

Performance	
Payload [SSO, 500km]	630 kg
Payload [LEO, 300km]	1,030 kg
Architecture	
Gross Lift-Off Weight (GLOW)	54,120 kg
Number of Stages	2
Total Length	29.48 m [96.7 ft]
Max Diameter	2.2 m
Structure	All Composite
Propulsion	
Oxidizer	LOX
Fuel	RP-1
Max Thrust [Stage 1]	836.3 kN [188 klbf]
Max Thrust [Stage 2]	73.0 kN [16.4 klbf]

Alpha is manufactured with a 100% carbon composite airframe including state-of-the-art linerless, cryogenic propellant tanks to enable a strong, lightweight vehicle.

Firefly's propulsion technology further simplifies and reduces weight in the flight-proven rocket engines. Alpha's four Stage 1 Reaver engines and one Stage 2 Lightning engine run with a patented tap-off cycle that removes the need for heavy pre-burners and excess engine components. The reduced engine mass directly correlates to additional mass to orbit.

Alpha's Mission Management utilizes Streamlined Coupled Loads Analysis (CLA) and Interface Control Documents (ICD) to decrease mission analysis completion times from months to weeks or days, depending on payload complexity. Every payload, whether dedicated or Rideshare, is treated with tremendous care to ensure mission success. Along with launch services, Firefly provides world class customer support in spacecraft and mission development.

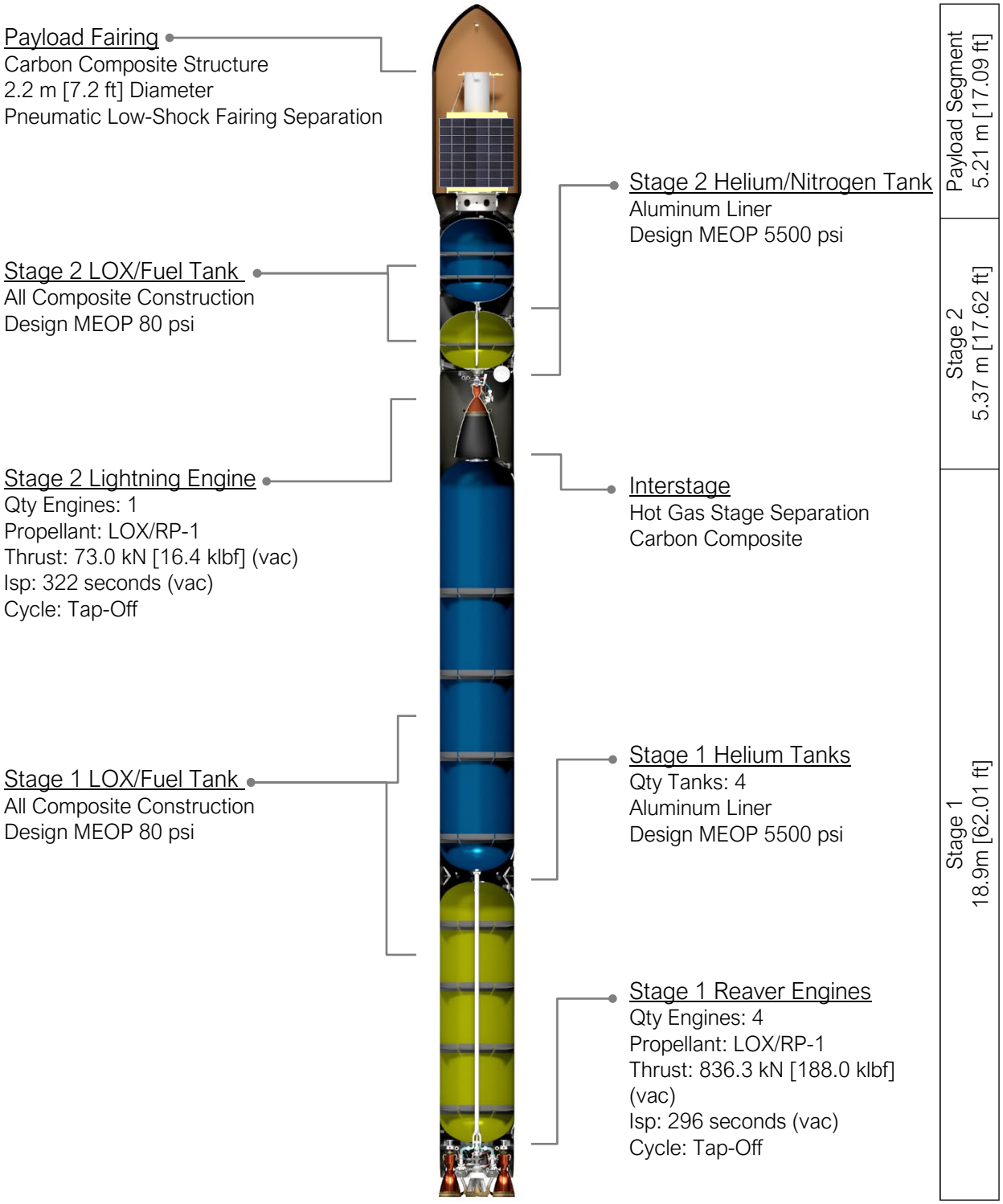


Figure 2. MK004 Alpha Launch Vehicle

Performance

The figures below show Alpha's performance capabilities from eastern and western ranges. These payload masses to orbit represent the total payload mass including the spacecraft, separation system, and adapter. These figures represent common orbits, please contact Firefly directly for other desired destinations. Alpha's performance may be affected by upper stage deorbit burns and regulatory constraints.

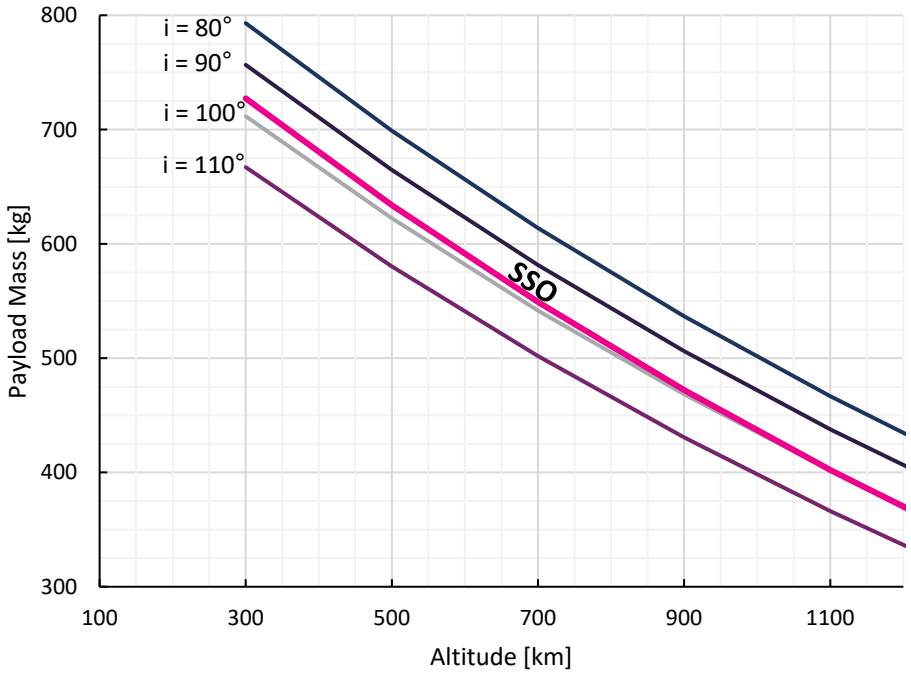


Figure 3. Alpha West Coast Performance Capability for Common Inclinations

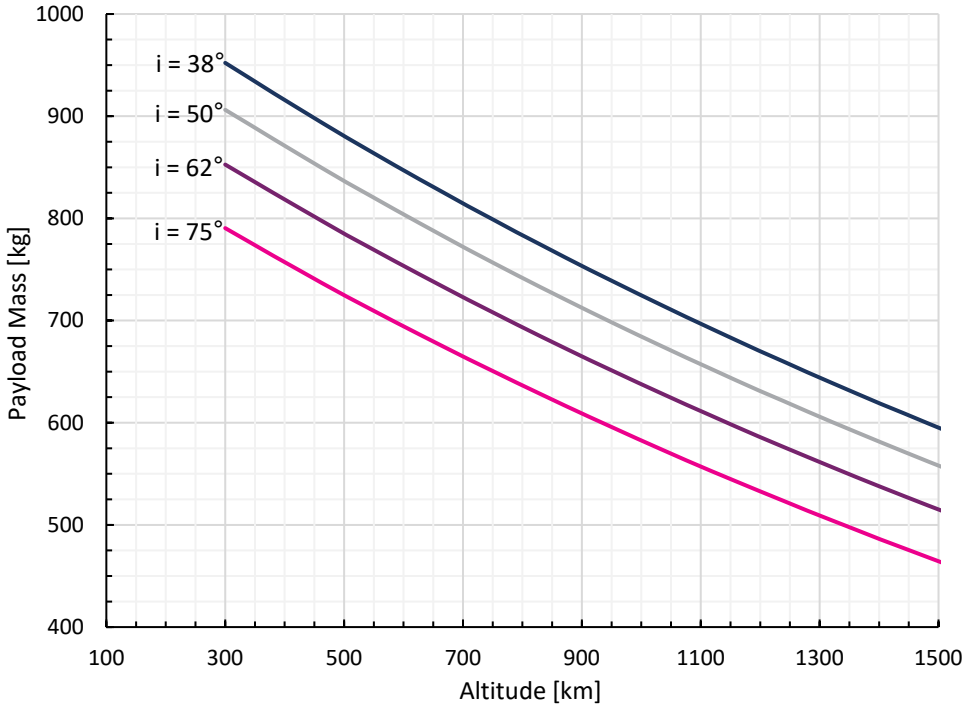


Figure 4. Alpha East Coast Performance Capability for Common Inclinations

Flight Profile

Figure 5 illustrates a representative flight profile of an Alpha launch vehicle 2-burn mission. Although all missions follow a similar profile, timing for key events will vary per mission.

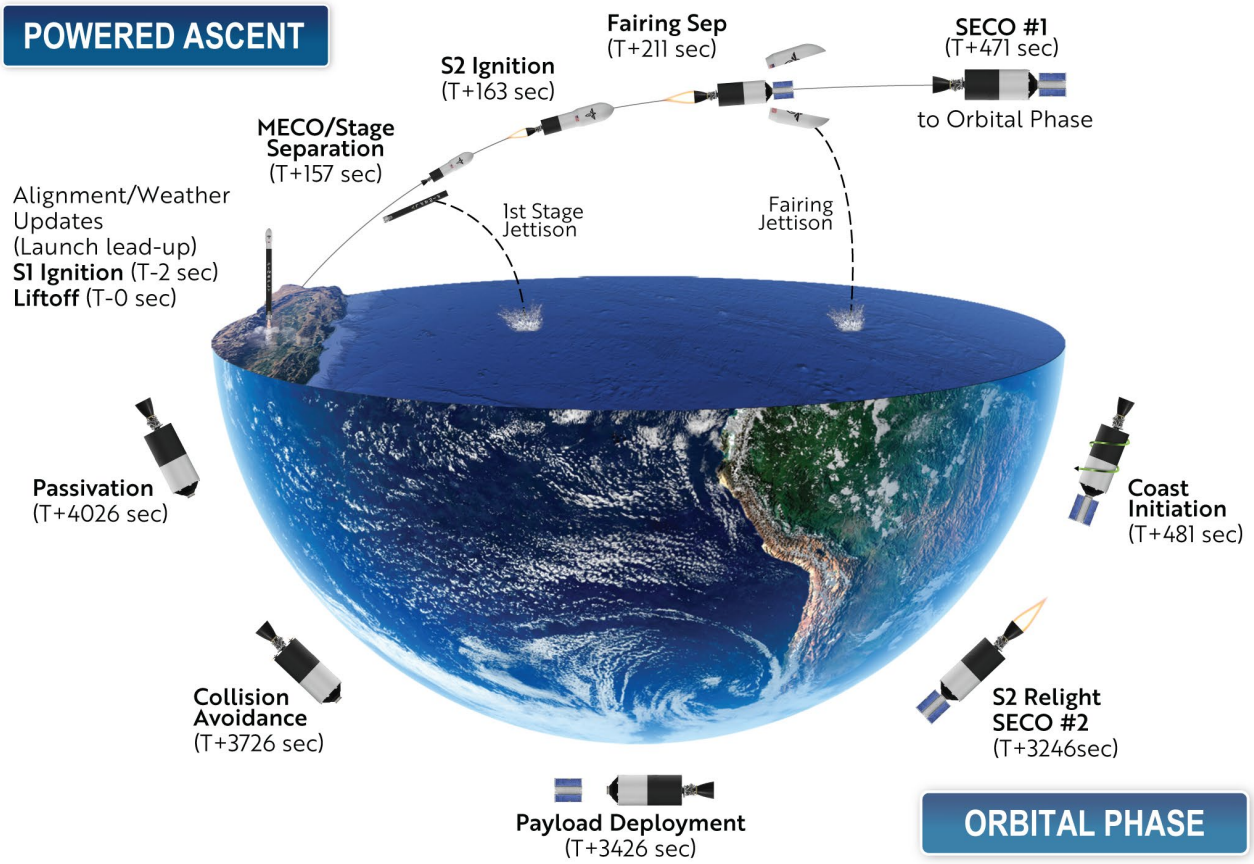


Figure 5. Alpha Flight Profile

Payload Injection & Separation

Precise pointing and orbital 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 2 represent orbital injection and payload separation dispersions for a standard LEO mission. Mission-specific accuracies will be developed as part of the mission design and analysis.

Table 2. Payload Injection and Separation

Payload Injection Accuracy
± 18.5 km perigee altitude
± 18.5 km apogee altitude
± 0.15 deg inclination
± 0.15 deg RAAN
Payload Separation Parameters
< 1.4 deg pointing accuracy on each axis
< 1 deg/sec stability in pitch, yaw, and roll

Payload Fairing

The Alpha payload fairing (PLF) is a carbon composite structure developed, manufactured, and qualified by Firefly. It measures 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 system fully tested prior to each flight.

The payload fairing remains sealed until launch ascent free molecular heating is below 1,135 W/m^2. Immediately thereafter, Alpha initiates a low shock separation event to deploy the two fairing halves from the Payload Base Assembly (PBA) and LV upper stage.

The dynamic payload envelope accounts for dynamic movement of the fairing and payload relative to one another, thermal expansion, and manufacturing tolerances. To avoid coupling with low frequency LV modes and violating this envelope, the spacecraft, or for multi-satellite payloads, the Integrated Payload Stack, should be designed to fundamental frequencies of greater than 8 Hz lateral and 25 Hz axial. The figure below shows the dynamic payload envelope with all units in inches.

Detailed drawings of the fairing envelope, access doors, and payload attach fitting interface are in appendix A.

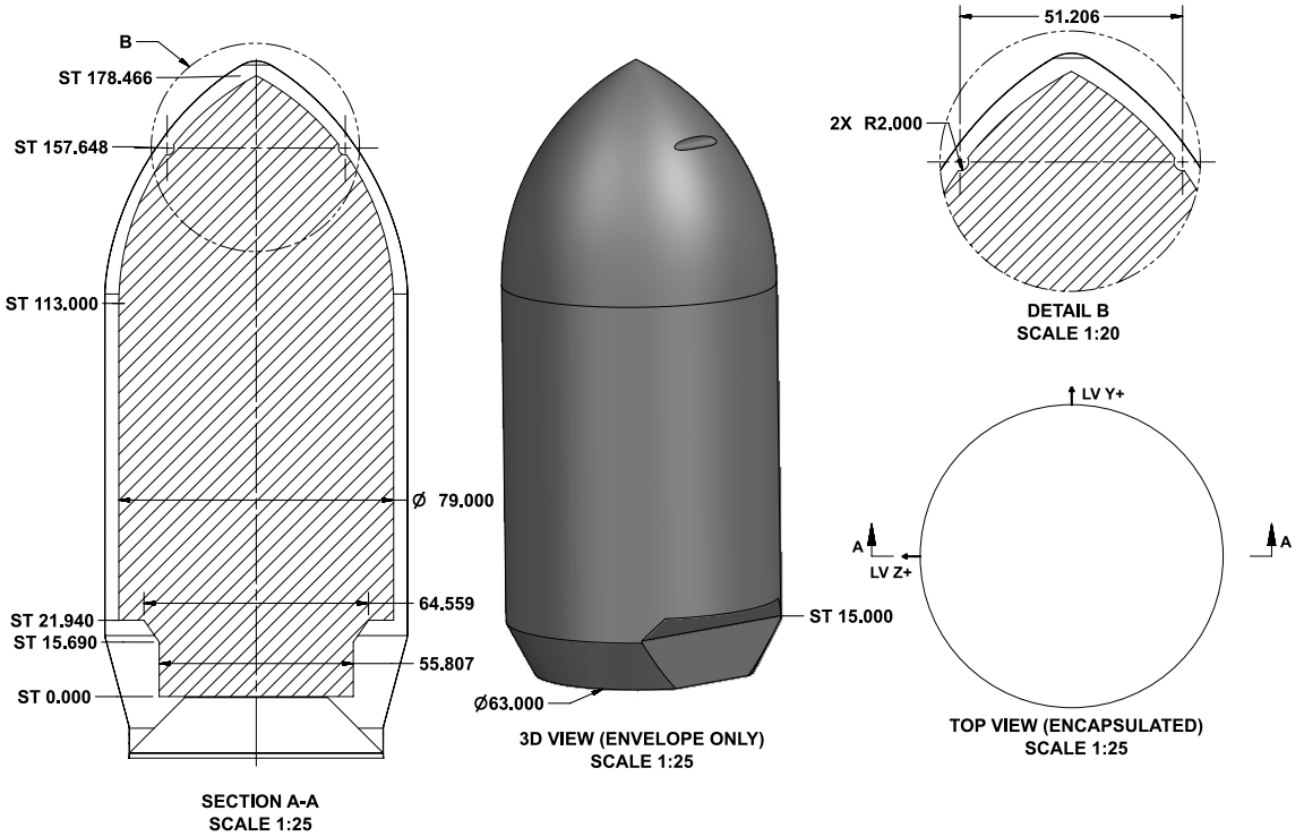


Figure 6. Alpha Payload Fairing Dynamic Envelope

Payload Interfaces

The Alpha vehicle features a standard 38.81” bolt pattern interface which is compatible with the industry standard 937mm adapter and other Firefly-specific dispenser structures. Firefly accommodates all industry standard interfaces and separation systems, depending on customer needs. Accommodations outside the standard bolt pattern may be negotiated and should be discussed early in the mission planning process.

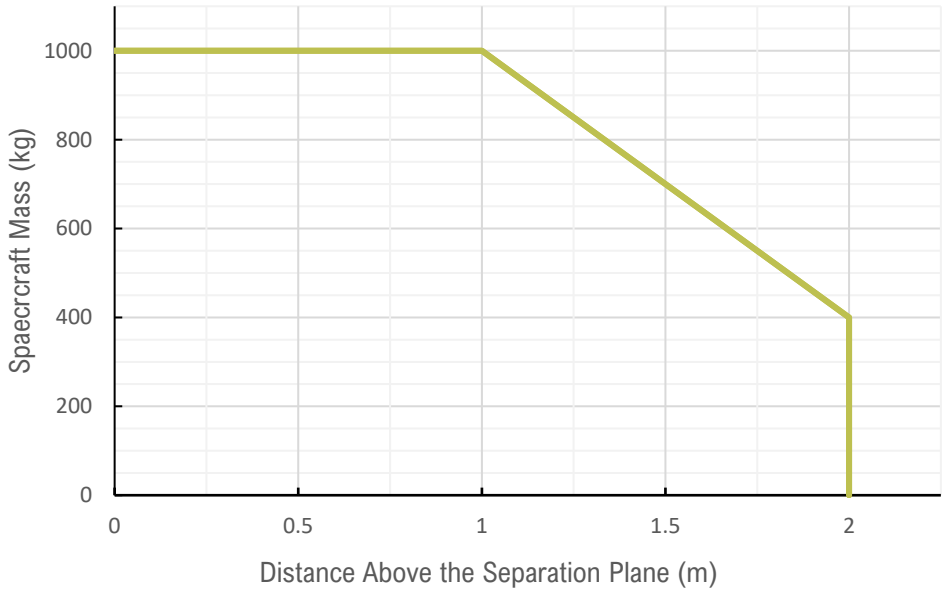


Figure 7. Allowable Payload CG Height

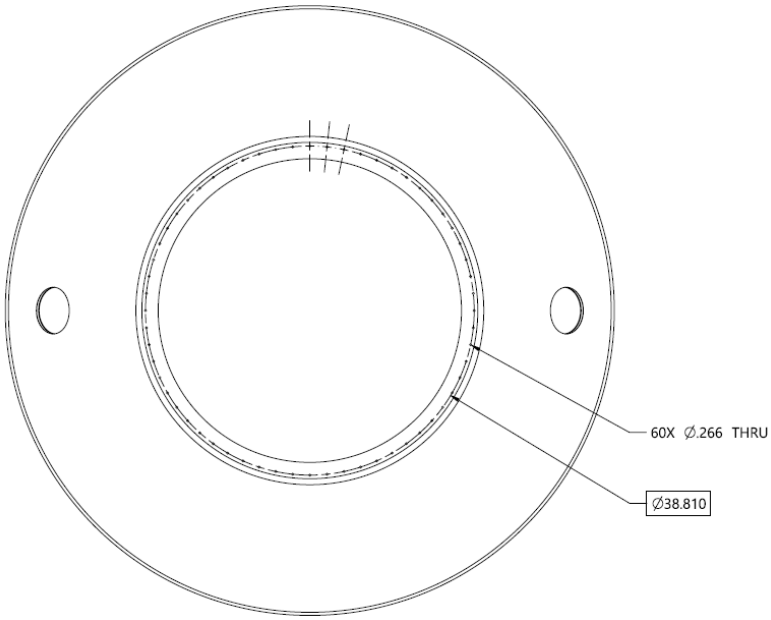


Figure 8. Payload Interface Dimensions in Launch Vehicle Coordinate Frame

Payload Accommodations

Firefly offers several standardized payload configurations. Each configuration is compatible with industry standard separation systems. The available payload volume for each configuration is shown in green in the figure below. Firefly also offers customized adapter design, testing, and integration as a service.

For customers with flexible destination orbits and launch dates, Firefly offers Rideshare options on Alpha. Customers looking for Rideshare should inquire with Firefly for available flights, but example options are shown below with conceptual dispenser structures. Firefly pairs Rideshare customers with missions that best fit their needs and executes with the same care and attention as a dedicated launch.

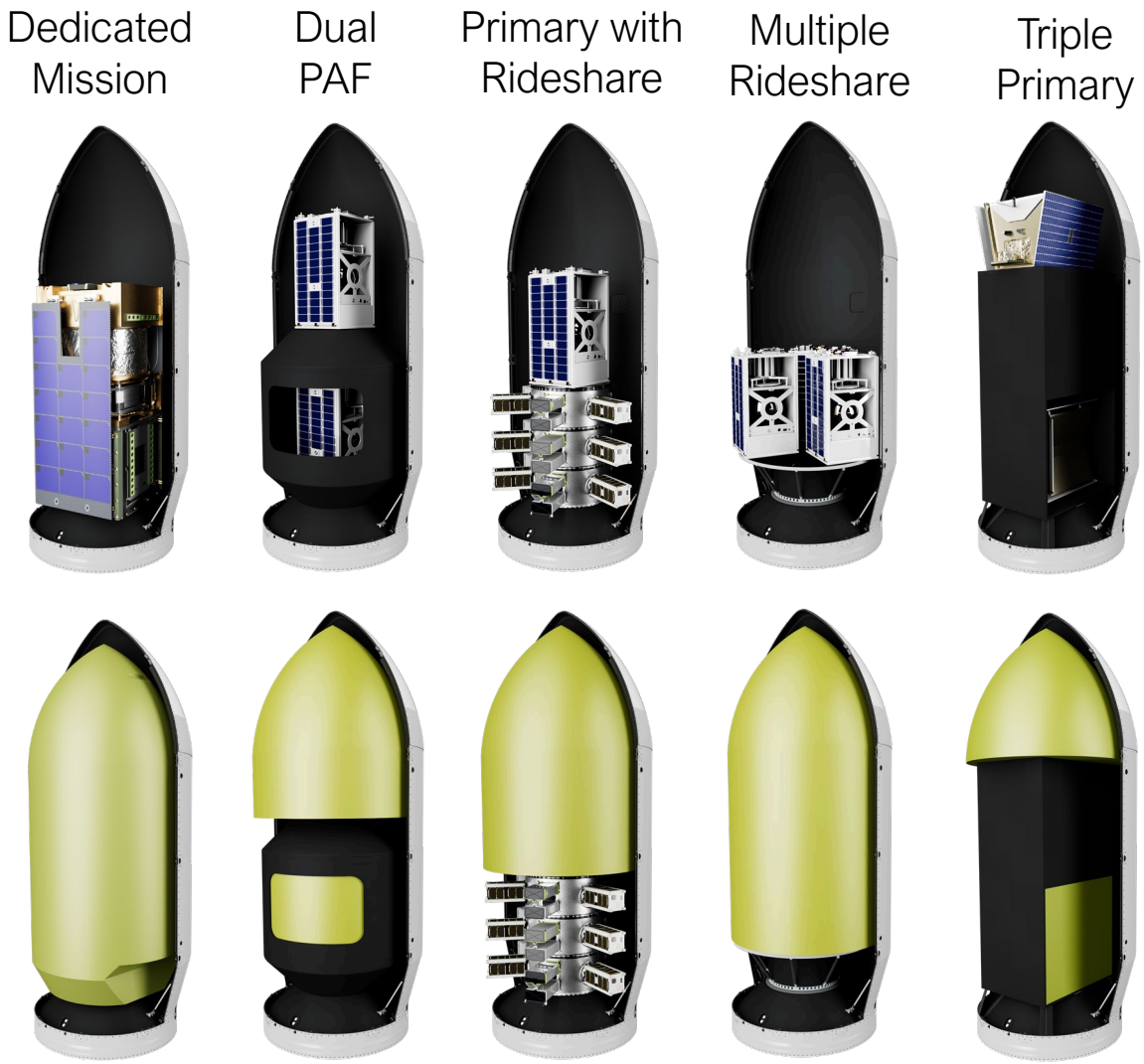


Figure 9. Common Payload Attach Fitting Configurations

Hypersonic Test Bed

Firefly offers a hypersonic testing service using the Alpha launch vehicle. Alpha is perfectly sized to support a variety of mission architectures including lofted, depressed, and reentry trajectories. Alpha's large payload fairing greatly enhances the flexibility of customers designing hypersonic test vehicles. Paired with Alpha's superior payload mass performance for hypersonic trajectories, Alpha is an excellent choice for heavier and multiple-target demonstrations. Example payload architectures for hypersonic missions are shown in the graphic below.

Firefly offers a customized architecture to meet customer needs. Alpha is capable of accelerating 1,500+ kg payloads to separation velocities of 6,000+ m/sec. Customers should inquire about their mission-specific mass and velocity requirements. Lofted trajectories launching from VSFB provide the opportunity for launching 1,100+ kg payloads 8,000+ km downrange with visibility to PMRF, Kwajalein, and other Pacific assets.

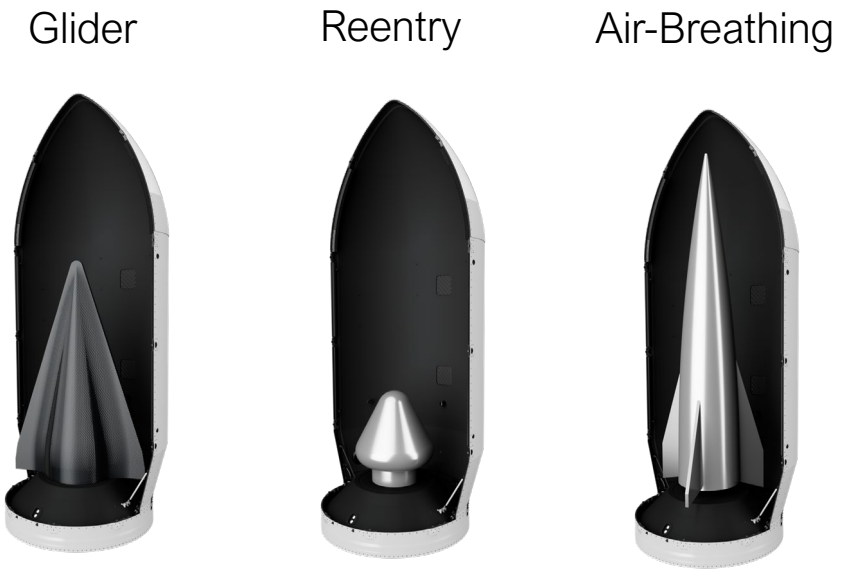
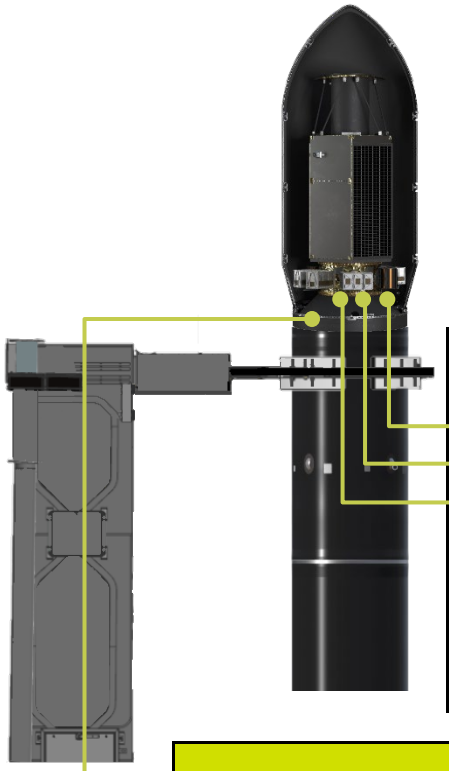


Figure 10. Alpha Hypersonic Mission Examples

Alpha Electrical Interfaces

Alpha provides an electrical interface between the spacecraft and the customer ground support equipment. The Alpha LV is equipped with both a flight interface and a ground interface. The flight interface with the spacecraft is for separation commands and separation monitoring. The ground interface is available up to T-0 via a quick-disconnect umbilical.

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



Flight Interface

- Twenty separation loops for LV to detect separation
- Unlimited separation loops for SC to detect separation
- Twelve 28 VDC separation commands and three temperature sensors:
  - 16 Amps cumulative simultaneous max
  - 8 Amps max on a single channel
  - Simultaneity < 1ms

Ground Interface Umbilical

Data: 24 contacts	Power: 28 contacts
• 3 x 1000 Mbit/s Ethernet • Or, 6 x 100 Mbit/s Ethernet • Or, 12 x Shielded-Twisted Pairs suitable for RS-422/232 • Or, any combination of the above with ≤ 24 pins using CAT5e Cable 24 AWG	• Up to 14 Power/Return pairs for Battery Charging or Voltage Monitoring • Shield Twisted Pairs 20 AWG • Max 7.5 Amps Each • 1.3Ω One-Way Resistance

Figure 11. Alpha Electrical Interface

3. FLIGHT ENVIRONMENTS

Alpha LV loads are flight proven and industry peer-reviewed. The loads and environments are less than those historically produced by small to medium class launch vehicles, limiting the need for payloads to expend 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, pad-based water suppression, and advanced composite structures that mitigate transmission of LV produced loads and environments. 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

The figure below 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 the loads for each payload.

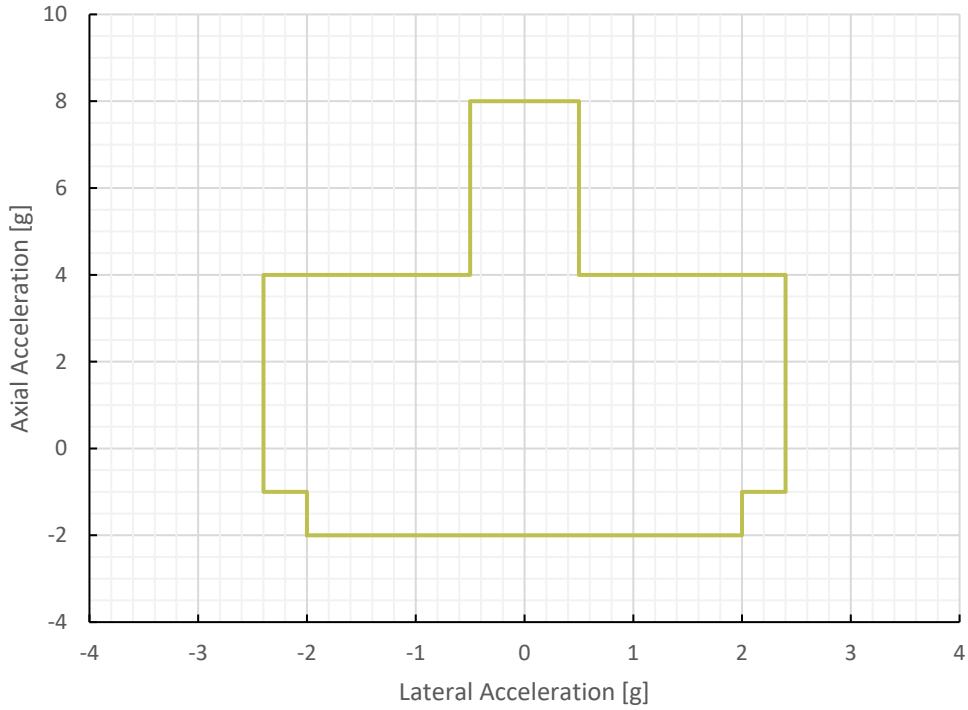


Figure 12. Alpha Maximum Quasi-Static Load Factors

Acoustics

Alpha LV acoustic protection is intended to provide an Overall Sound Pressure Level (OASPL) below 139 dB.

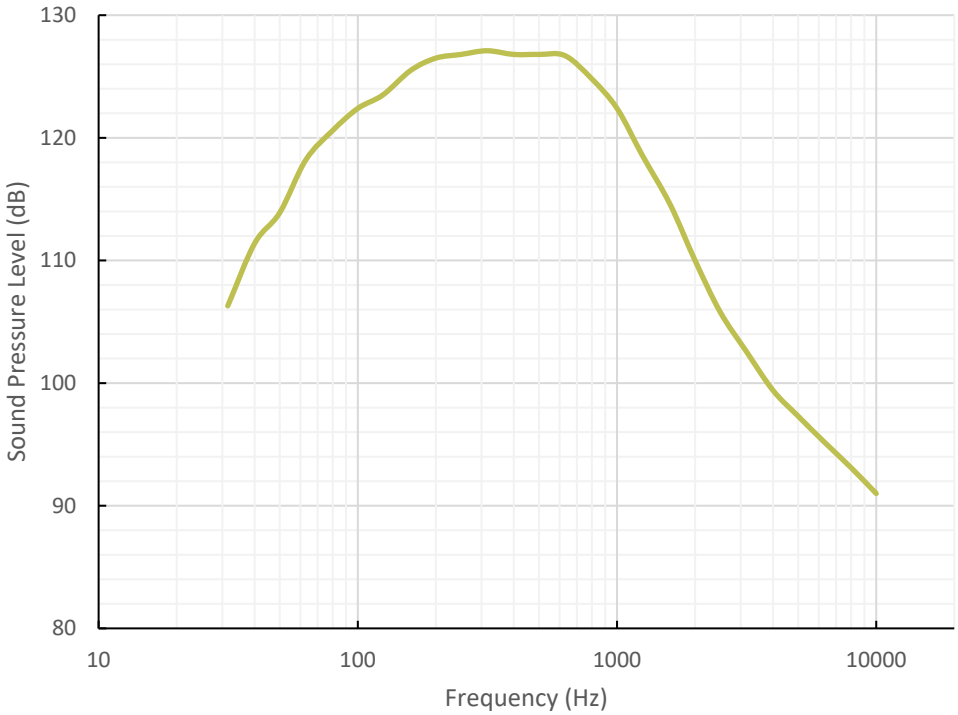


Figure 13. Alpha Maximum Predicted Acoustic Environment

Table 3. Alpha Sound Pressure Levels

Center Frequency [Hz]	Sound Pressure Level [dB]	Center Frequency [Hz]	Sound Pressure Level [dB]
31.5	106.3	630	126.7
40	111.4	800	124.8
50	113.9	1000	122.4
63	118.2	1250	118.6
80	120.6	1600	114.6
100	122.4	2000	110.0
125	123.5	2500	105.8
160	125.5	3150	102.6
200	126.5	4000	99.4
250	126.8	5000	97.3
315	127.1	6300	95.2
400	126.8	8000	93.1
500	126.8	10000	91.0
OASPL [dB]		136.5	

Shock

The maximum shock environment at the payload interface occurs during payload deployment. Shock levels at the payload separation interface due to hold-down release, stage separation, engine ignition and cutoff, and payload fairing separation are all maintained below a maximum acceleration of 750 g's at 1400 Hz. Shock environments heavily depend on the mission-specific payload separation system. The shock environment below is for the usual shock at the payload separation plane.

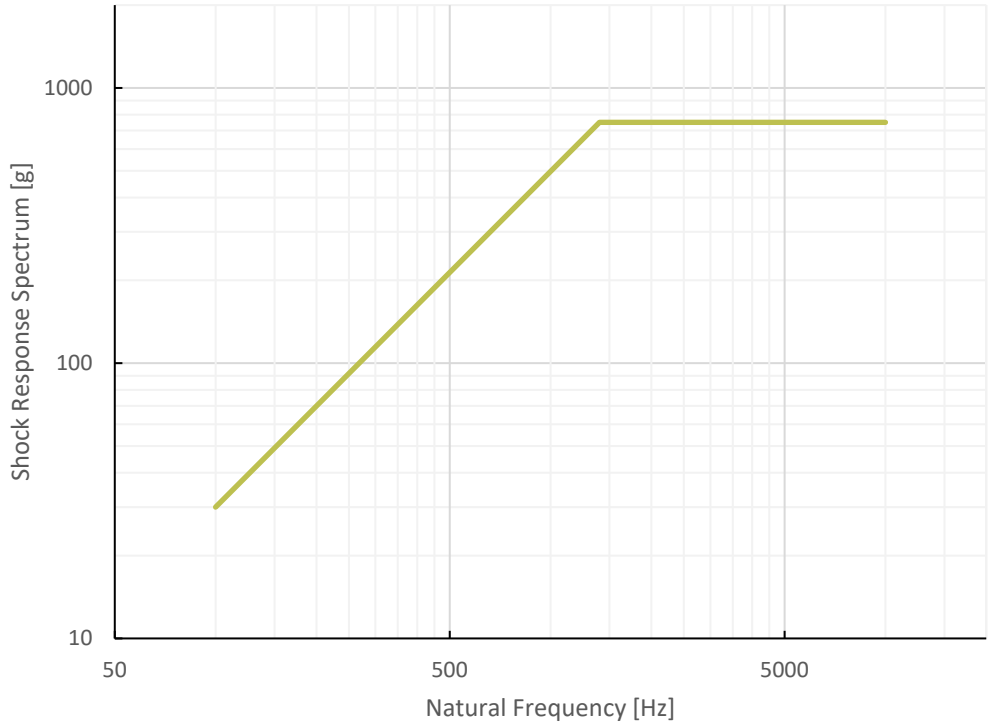


Figure 14. Alpha Maximum Predicted Shock Response Spectrum

Table 4. Alpha Frequency and Acceleration Levels

Natural Frequency [Hz]	Maximum Acceleration [g]
100	30
1,400	750
10,000	750

Random Vibration

Payloads are subjected to a combination of engine vibrations, vehicle structural modes, acoustics, and aerodynamic forces. 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 Power Spectral Density (PSD) is for a payload mass of 90 kg or greater. Lighter payloads may experience increased vibrations.

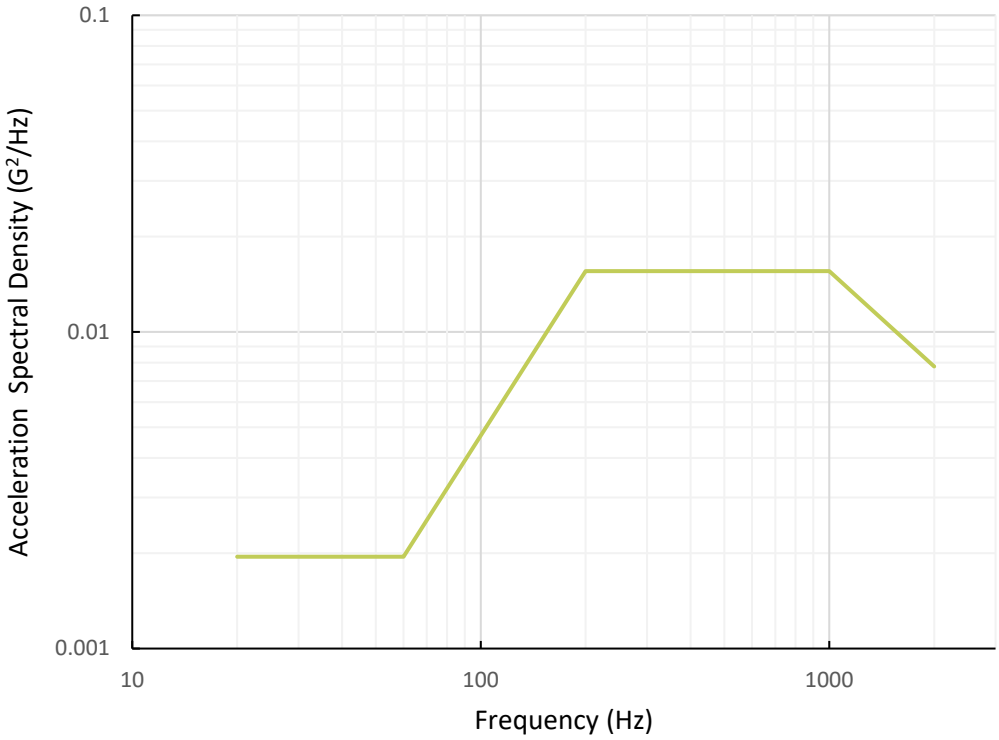


Figure 15. Alpha Random Vibration Environment Plot

Table 5. Alpha Random Vibration Frequency and PSD Levels

Frequency [Hz]	Alpha PSD Level [g²/Hz]
20	0.00195
60	0.00195
200	0.01556
1000	0.01556
2,000	0.00778
g_{RMS} [g]	4.94

Equivalent Sine Vibration

Maximum Alpha sinusoidal vibration environments envelope all stages of flight. These represent the maximum predicted sine vibe environments for the payload. A mission-specific CLA analysis is conducted to prove further compliance.

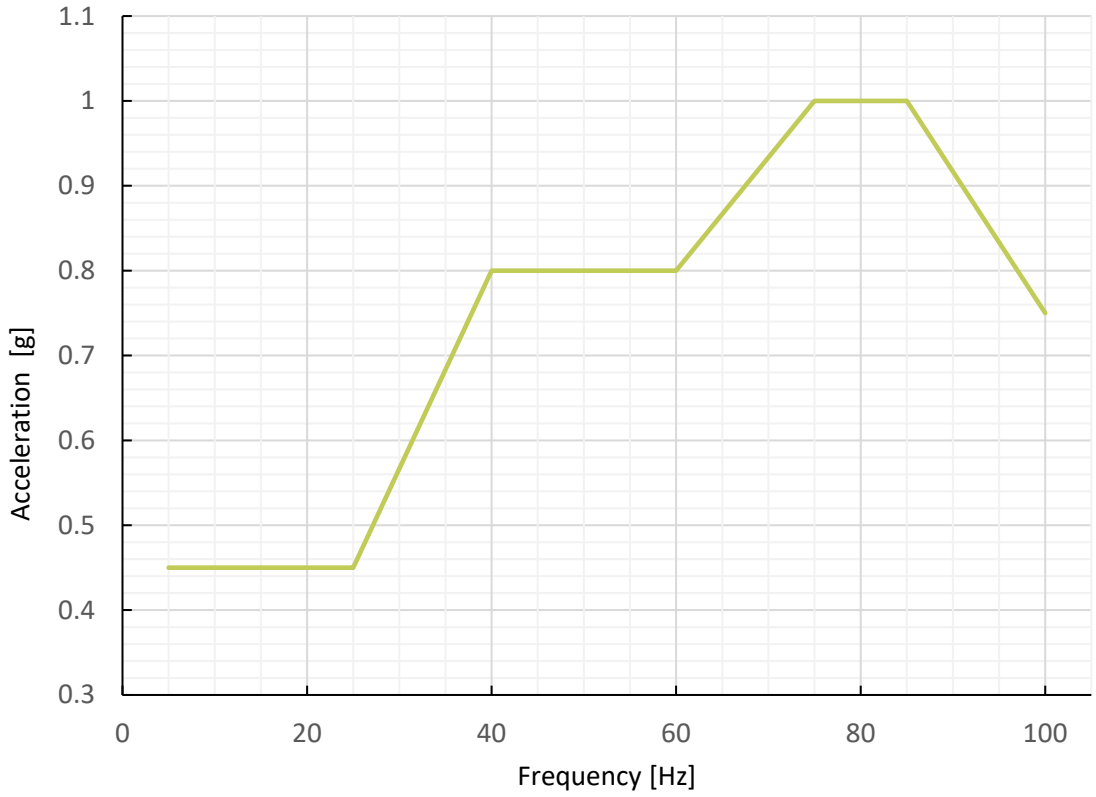


Figure 16. Alpha Axial Sine Vibration Environment

Table 6. Axial Sine Frequency and Acceleration Levels

Frequency [Hz]	Acceleration [g]
5	0.45
25	0.45
40	0.8
60	0.8
75	1.0
85	1.0
100	0.75

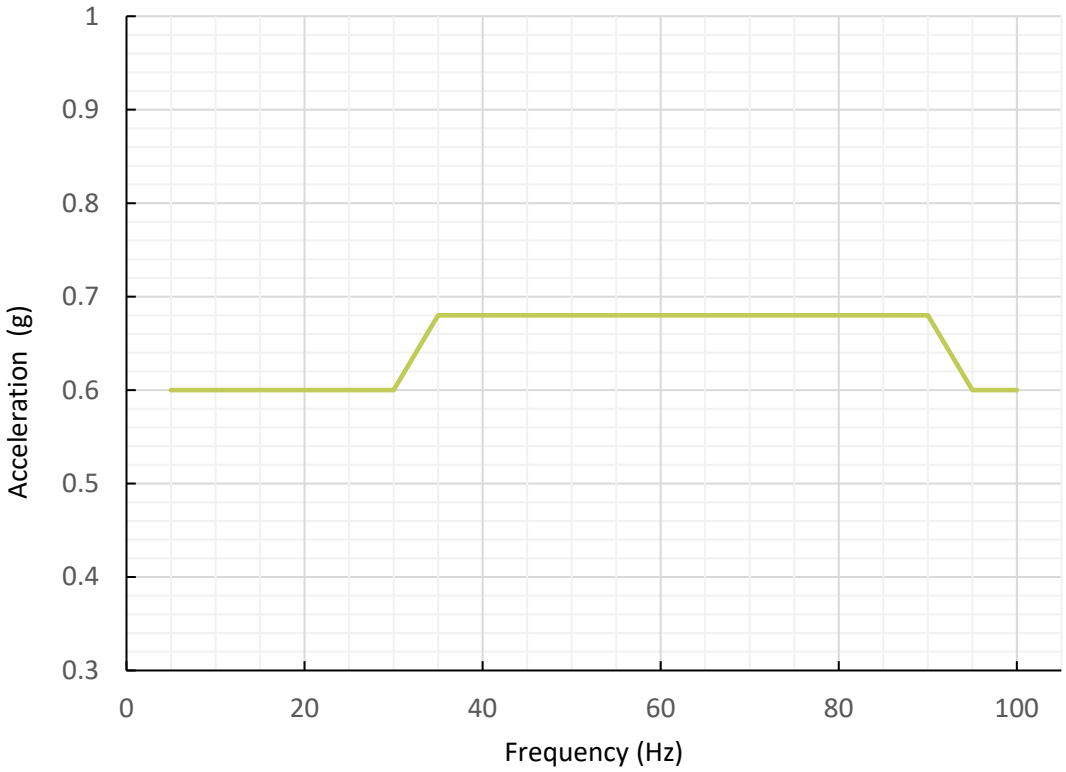


Figure 17. Alpha Lateral Sine Vibration Environment

Table 7. Lateral Sine Frequency and Acceleration Levels

Frequency [Hz]	Acceleration [g]
5	0.6
30	0.6
35	0.68
90	0.68
95	0.6
100	0.6

Pressure and Venting

During ascent, the fairing will relieve internal pressure through vents located at the aft end of the payload fairing. The pressure decay rate will not exceed -0.3 psi/second, apart from brief spikes, when the decay rate will not exceed -0.65 psi/second, for no more than 5 seconds.

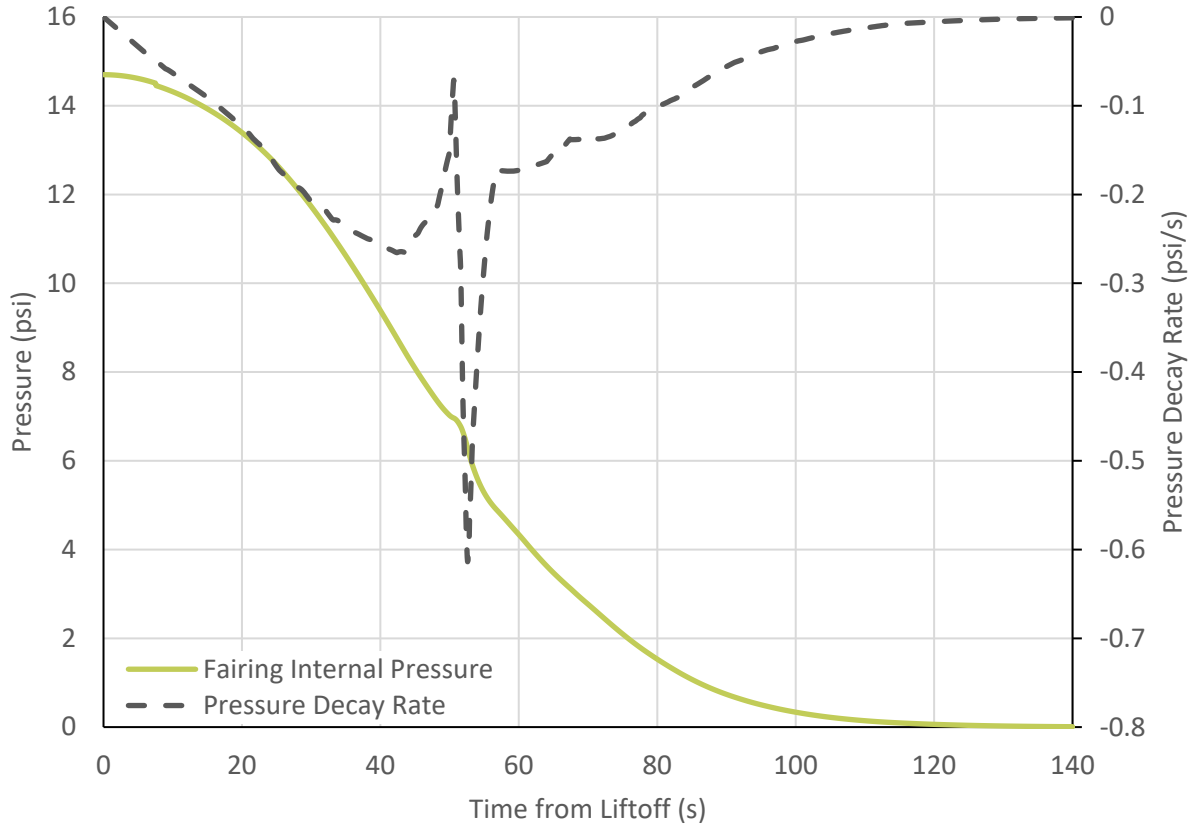


Figure 18. Typical Alpha Payload Fairing Venting Environment

Thermal and Cleanliness

The Alpha launch vehicle provides the payload with standard thermal, humidity, and High Efficiency Particulate Air (HEPA) clean controlled environments from encapsulation through liftoff. Firefly can accommodate contamination-sensitive payloads from integration in the Payload Processing Facility (PPF), roll-out to the launch pad, and through launch. For payloads with more extensive requirements, Firefly can provide additional cleaning, filtration, contamination mitigation protocol, and verification as a non-standard service.

Table 8. Thermal and Cleanliness Environments

Cleaning and Materials	Payload Processing	Transport & Pad Ops	Flight
All major surfaces including the PLF and PBA are Visibly Cleaned to IEST-STD-CC1246D	✓		
Major materials within line of sight of the payload comply to 1% TML 0.1% CVCM	✓	✓	✓
Air Cleanliness			
ISO 8 (Class 100K) HEPA air in PPF and PLF	✓	✓	
GN2 purge available as an upgrade	✓	✓	
Prevention of high velocity air impingement directly onto the payload	✓	✓	✓
Mission specific ISO 7 (Class 10k) available	✓	✓	
Temperature			
Maximum FMH < 1,135 W/m^2 [0.1 $BTU/ ft^2/s$]			✓
Temperature controlled air 55-85 deg F	✓	✓	
Relative air humidity controlled from 30-65%	✓		
Relative air humidity controlled from 0-65%		✓	

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 Radio Frequency (RF) or Electro Magnetic Interference (EMI). The Alpha vehicle is capable of interleaved telemetry for payload monitoring during flight. Customers must ensure payload components or material constituents sensitive to RF transmissions are compatible with the Alpha radio frequency and EMI/EMC environment provided in the table below.

Table 9. Alpha Radio Frequency and EMI/EMC Environments

Function	Frequency
S-Band Transmitter	2.2 – 2.29 GHz
Avionics Power Switching	100 kHz - 400 kHz, 440 kHz, 660 kHz, 960 kHz
GPS L-Band Receiver	L1: 1575.42 MHz
	L2: 1227.60 MHz
	L5: 1176.45 MHz

4. OPERATIONS

Standard and Non-Standard Services

As part of the launch package, Firefly offers the standard services listed below for primary customers. Firefly also offers mission unique services upon request. These non-standard services may have impacts to schedule and cost. Requests for mission unique services should be discussed early in the mission planning process.

Standard Services

- Dedicated Firefly Mission Manager
- Development of a mission-specific Interface Control Document (ICD)
- Review and Delivery of requirement verification artifacts
- Launch vehicle licensing, including FAA and Range Safety documentation support
- Provide results of modeling and analysis of the integrated mission, including performance analysis, CLA, thermal modeling, venting analysis, and EMI/EMC analysis
- Customer logo included on the launch vehicle fairing, for primary and dedicated mission customers
- Fit Check verification of the Payload to the Payload Adapter, for primary and dedicated mission customers
- Certified ISO 8 (Class 100K) environment for payload to PBA integration areas, encapsulation, and through launch
- Payload integration to PBA services
- Launch training for key launch personnel, for primary and dedicated mission customers
- Payload access prior to payload fairing closure
- Post-flight launch services, including payload separation confirmation and final payload deployment state vector

Mission Unique Services

- Payload Separation system provided by Firefly and spacecraft-to-separation system integration
- Customized or multi-payload dispenser or adapter
- Expedited launch campaign timeline
- Rapid response and replenishment missions
- Hypersonic and suborbital trajectories
- Provide full reports of modeling and analysis of the integrated mission, such as thermal modeling report, venting analysis report, air impingement report, and EMI/EMC analysis report
- Payload qualification support for regulatory compliance
- Certified ISO 7 (Class 10K) cleanroom for payload to PBA integration areas and encapsulation
- Contamination control analysis
- Payload hazardous fueling and pressurization accommodations
- Payload access after fairing closure
- Mission unique payload fairing access door
- Classified payload handling
- Dedicated payload GN2 purge, up to T-0
- RF transmission after payload encapsulation, and before payload separation
- Re-radiation system
- Payload-facing mounted cameras

Additional services may be available upon request.

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. The payload is removed from its shipping container and readied for checkouts. Once checkouts and any fueling are complete, combined SC and LV operations begin with mating of the SC to the payload adapter. Once the payload is fully assembled onto the PBA and any additional services performed, it is then ready for encapsulation.

Payload Encapsulation

Payloads are encapsulated within the payload fairing in a vertical or horizontal orientation. Once encapsulated, a continuous supply of HEPA filtered, and temperature-controlled air is supplied to the PLF. Direct airflow impingement upon sensitive components is minimized. Then the encapsulated payload is broken over to a horizontal position and readied for transport. The encapsulated payload remains in the horizontal position during transport and mate to the integrated launch vehicle.

Payload Fueling

As a non-standard option, hazardous, green, other propellants, and pressurization accommodations may be provided by Firefly. Depending on the 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.

A nominal payload processing timeline is shown in the figure below. Actual processing times are flexible based on mission constraints.

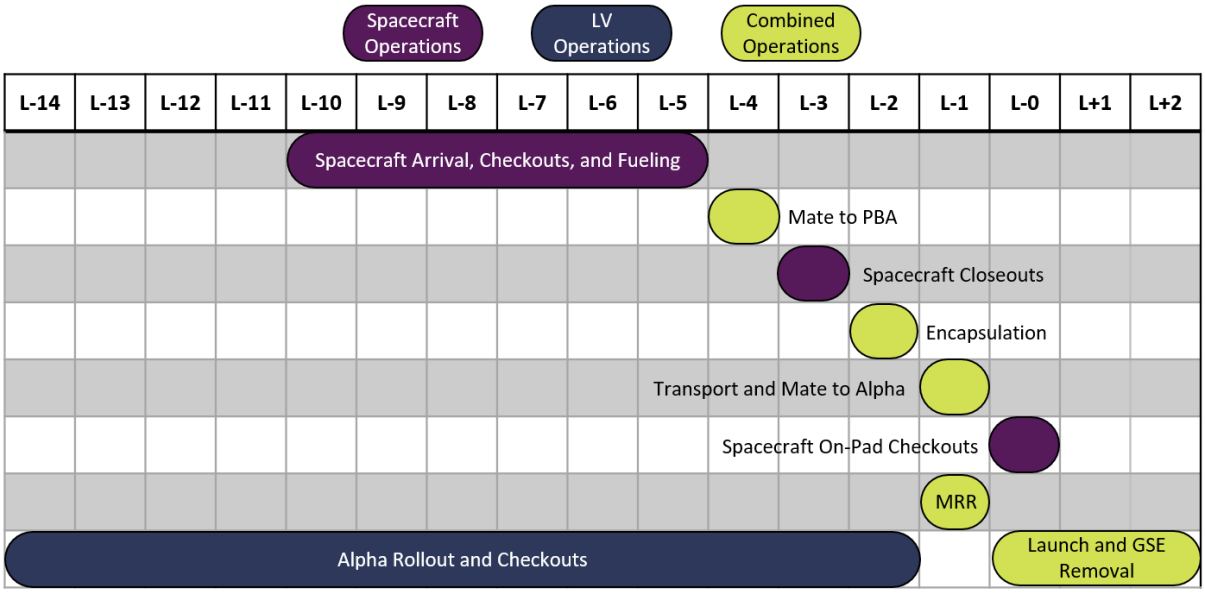


Figure 19. Nominal Payload Processing Flow

Launch Campaign Timeline

Each Firefly mission follows a standard mission timeline. Flexibility is offered for customers needing an expedited schedule and should be discussed early in the mission planning process. All dates provided in the table below are intended as guidelines, and not firm constraints.

Table 10. Notional Launch Campaign Timeline

Schedule	Event
L-9 m	Signing of Launch Agreement and Completion of the Payload Questionnaire
Contract Signing +2 w	Kickoff and Delivery of Payload Data Package
L-6 m	Mission Design Review (MDR)
L-4 m	Flight Interfaces Fit Check
L-60 d	Regulatory Deliverables due for Submission
L-6 w	Payload Shipping Readiness Review (PSRR)
L-4 w	Customer Delivery of Payload
L-2 d	Mission Readiness Review (MRR)
L-0	Launch
Payload Deploy +1 h	Final Confirmation of Payload Separation and State Vector

If the customer has selected a non-standard service for Firefly to procure their separation system, these may need to be ordered as early as L-12 months. Customized payload accommodations may include additional lead times.

Rapid response and replenishment missions are available as a non-standard service. For these missions, the mission analysis is done ahead of time. Firefly can store ready-to-launch payloads and a dedicated white-tail Alpha vehicle at the launch site until the request for launch. Upon receiving a request for launch, Firefly can process the payload and complete the launch in four weeks or less.

5. MISSION

Customer Deliverables

Table 11. Customer Deliverables

Deliverable	Description
Completed Payload Questionnaire	An important first step for mission planning is the completion of Firefly's Payload Questionnaire. This is provided by the Mission Manager and gives necessary insight into the mission 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 elements of the payload. Customers are expected to complete inputs to the Missile System Prelaunch Safety Package (MSPSP) using the template provided by Firefly. The Firefly Mission Manager integrates this information into both the Federal Aviation Administration (FAA) licensing application and the Range Safety Review Package.
Payload Engineering Data Package	The Engineering Data Package includes, but is not limited to: • CAD (inclusive of separation systems and appendages) • Mechanical Interface Control Drawing (MICD) • Electrical Interface Document • Thermal Model Data Inputs • Craig-Bampton Model and CLA Inputs • Archimedes Volume • Emitter Characteristics • 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. Customers are required to provide procedures for spacecraft operations conducted at the launch site.

Mission Management

Each customer is assigned a Firefly mission manager, who will remain the direct point-of-contact throughout the mission planning and launch process. Customers can expect transparency and open communication from their mission manager. The Firefly mission manager works closely with their customer counterpart mission manager, ensuring all facets of the mission planning and integration process are completed in a timely manner. The mission manager holds regular mission integration meetings to keep an open discussion with the customer. Acting as the launch site focal, the mission manager works to accommodate all SC and customer needs during the launch campaign.

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.

Customers are responsible for obtaining their own remote sensing, radio frequency approvals, and ensuring their payload meets all launching states involved in their mission's insurance requirements.

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.

6. FACILITIES

Corporate Headquarters

Firefly's Corporate Office is headquartered in Cedar Park, Texas. It is an open engineering environment to encourage collaboration.

Figure 20. Firefly's Texas Headquarters, Production, and Test Facilities

Production and Test Facilities

Launch vehicle production, integration, and testing are conducted in Briggs, Texas, at a 200-acre 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, and a 100,000 ft^2 production site. The site includes several operational test stands for engine, structural, component, and integrated stage testing.

Launch Complexes

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. Other orbit inclinations than those shown may be possible; inquire with Firefly for additional details.

SLC-2, Vandenberg Space Force Base

Firefly conducts Polar and SSO launches to high inclinations from SLC-2 at Vandenberg Space Force Base (VSFB), California. VSFB can support launch azimuths from 160 degrees to 260 degrees.

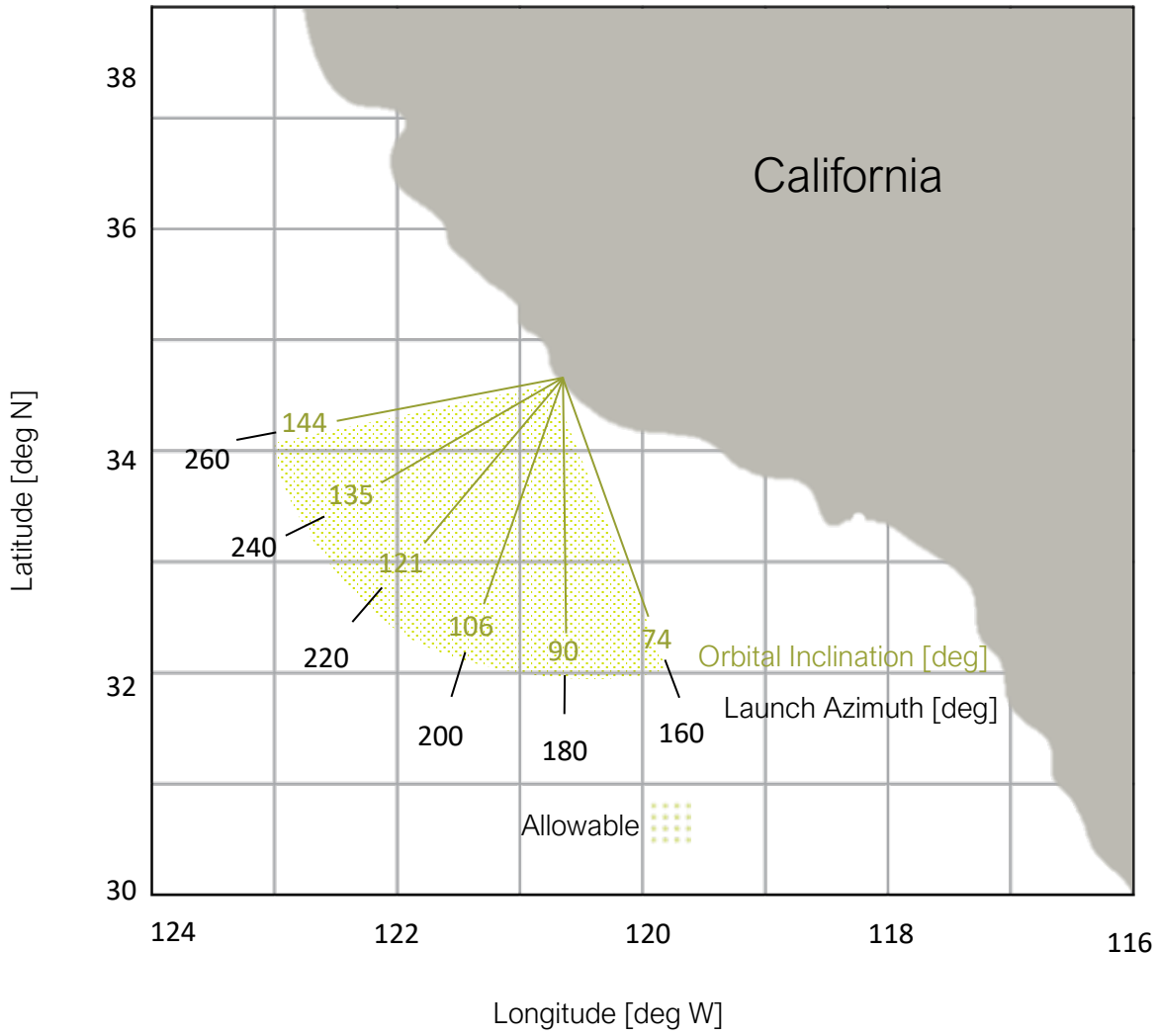


Figure 21. VSFB Launch Inclinations and Azimuths

LP-0A, Wallops Flight Facility

Launch Pad 0A is an established launch pad located at Wallops Flight Facility in Virginia. Wallops can support launch azimuths from 90 degrees to 160 degrees.

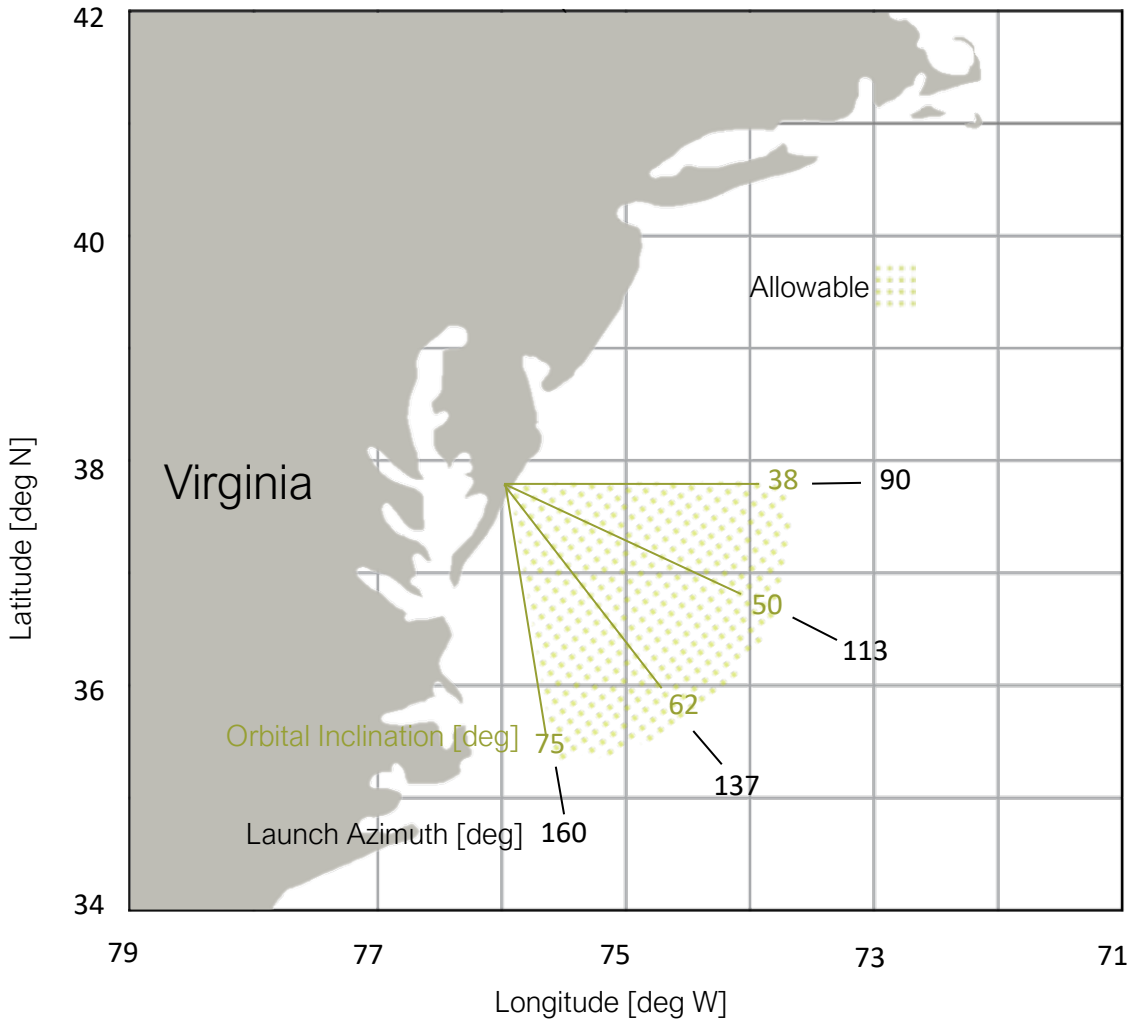


Figure 22. Wallops Flight Facility Launch Inclinations and Azimuths

LC-3C, Esrange Space Center

Swedish Space Corporation (SSC) and Firefly have signed a collaborative agreement to jointly launch satellites with Firefly's Alpha rocket from the newly inaugurated spaceport at Esrange Space Center in Sweden. Together, Firefly and SSC are establishing an orbital launch service in Europe with a flight-proven launch vehicle, supporting commercial, civil, and defense customers.

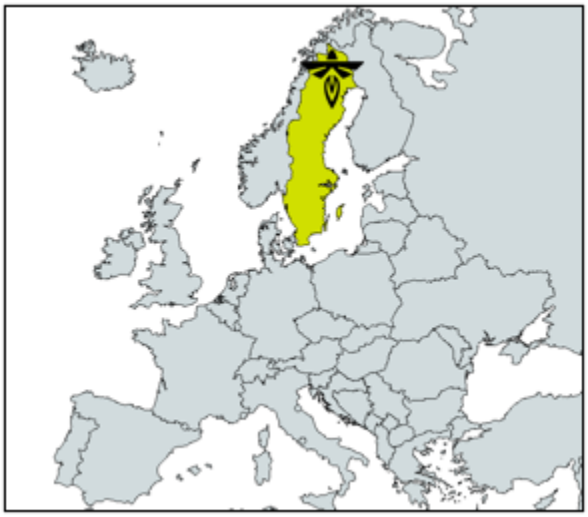


Figure 23. Esrange Space Center

Horizontal Integration Facility

An on-site Horizontal Integration Facility (HIF) is 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 facility is climate controlled and provides power and the high-pressure gases used for processing Alpha LVs. The VSFB HIF is a 5,000 ft^2 open high bay with an eave height of 25 feet. This allows for removal and unloading of components from 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 available for customers.

Figure 24. VSFB Horizontal Integration Facility

Payload Processing Facility

The VSFB PPF provides environment controlled space and equipment for payload processing and encapsulation with a high bay, an airlock, a garment room, and office space. The PPF is a 60 m^2 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 480 V three phase 60 Hz for processing. Additional power and equipment can be made available on a mission unique basis. Firefly provides transportation of the encapsulated payload from the PPF to the launch pad while maintaining the climate-controlled cleanroom environment.

Infrastructure

Firefly offers standard infrastructure for customers. In addition to office workspace, Firefly offers high-speed broadband internet access in the payload processing facilities. Electrical ground support equipment (EGSE) power sources are available at the VSFB PPF and the launch equipment building.

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 U.S. 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.

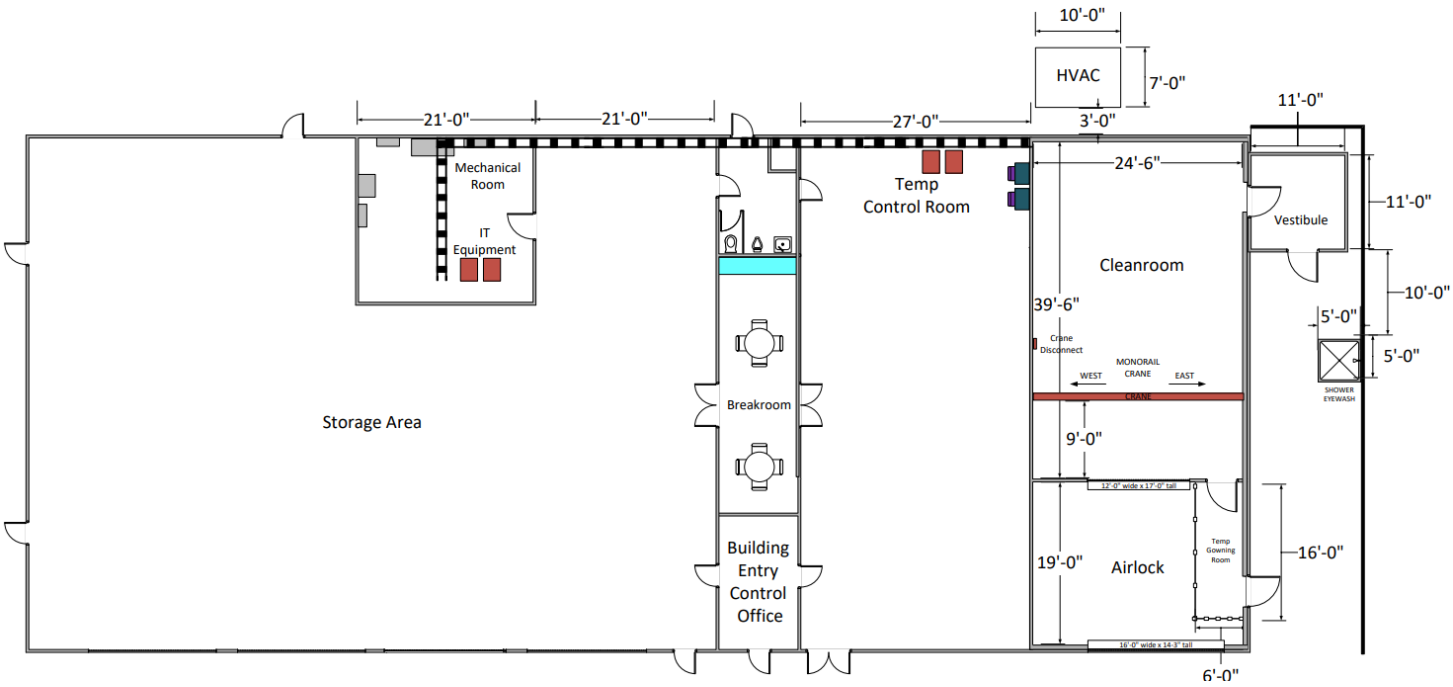


Figure 25. VSFB PPF Layout

7. REFERENCES

Acronyms

AFSPCM	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
CCSFS	Cape Canaveral Space Force Station
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
FMM	Firefly Mission Manager
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
MEOP	Maximum Expected Operating Pressure
MRR	Mission Readiness Review
MSPSP	Missile System Prelaunch Safety Package
OASPL	Overall Sound Pressure Level
PAF	Payload Attach Fitting
PBA	Payload Base Assembly
PCS	Probability of Command Shutdown
PLF	Payload Fairing
PPF	Payload Processing Facility
PS	Payload Segment
PSD	Power Spectral Density
QPSK	Quadrature Phase Shift Keying
RAAN	Right Ascension of the Ascending Node
RCC	Range Commander Council
RF	Radio Frequency
RP-1	Kerosene Propellant
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 Spectrum
SSO	Sun-Synchronous Orbit
TBC	To Be Confirmed
TBD	To Be Determined
TML	Total Mass Loss
TRL	Technology Readiness Level
VSFB	Vandenberg Space Force Base

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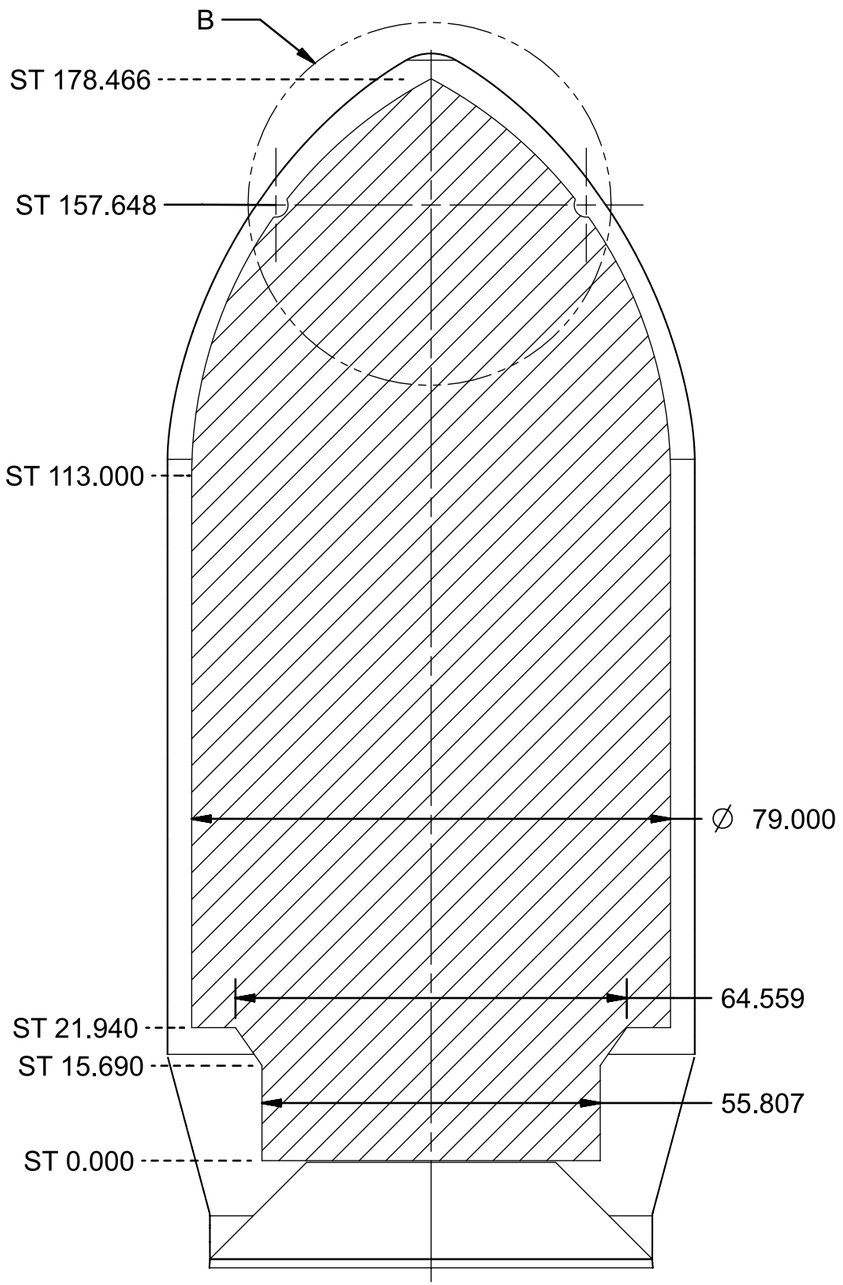
APPENDIX A

Appendix A contains detailed drawings of the Alpha fairing dynamic envelope and the payload base mechanical interface. The Alpha fairing dynamic envelope represents the maximum spacecraft volume the Alpha fairing can accommodate. The payload base assembly mechanical interface shows the standard spacecraft interface to the Alpha vehicle. Firefly can provide mission unique adapters with customized interfaces. All dimensions are in inches.



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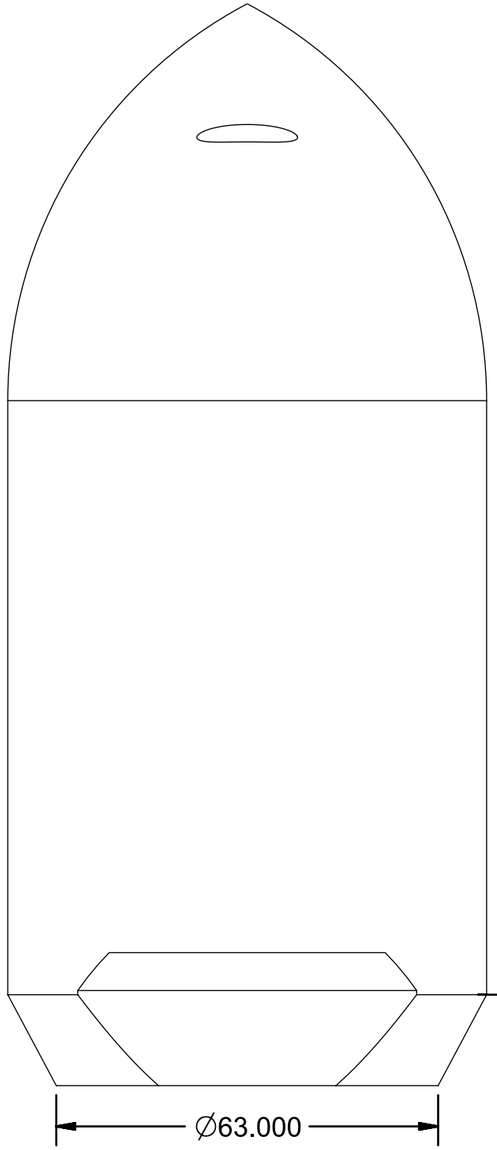

SIDE VIEW (ENVELOPE ONLY)
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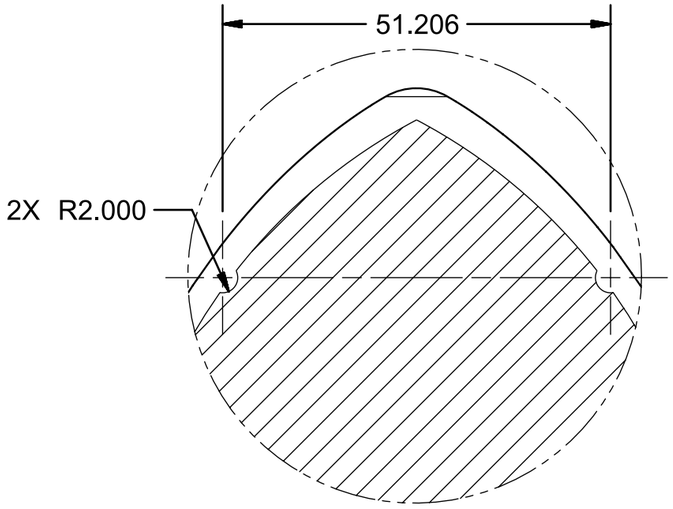

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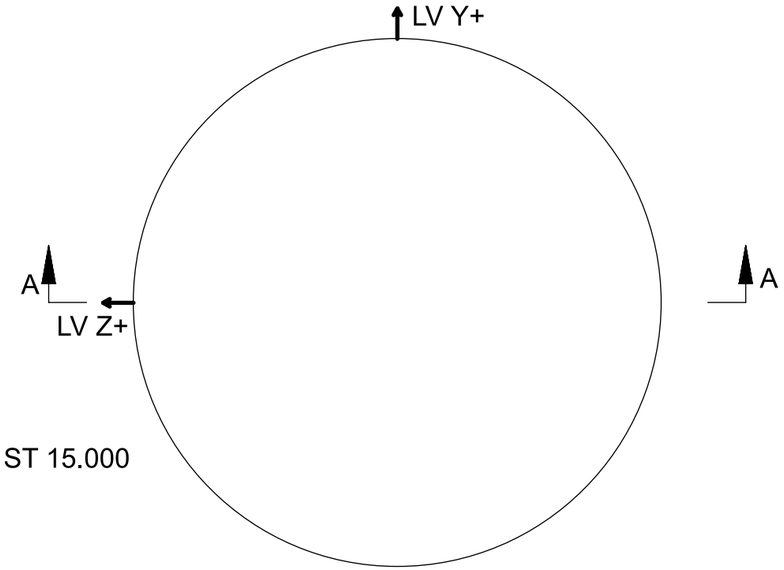

TOP VIEW (ENCAPSULATED)
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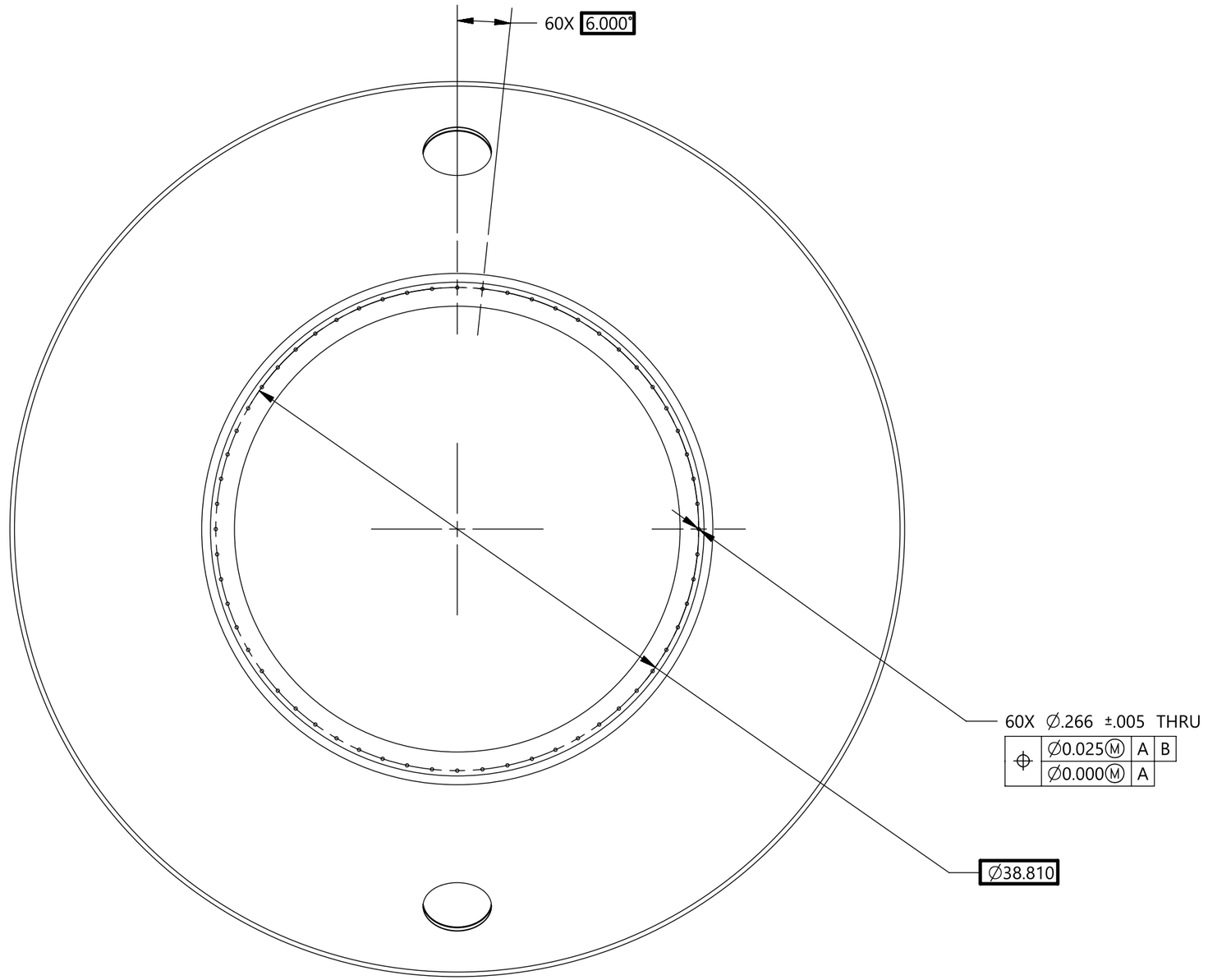

TOP VIEW
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