

VECTOR

Vector-H Forecasted Launch Service Guide



VSS-2017-023-V2.0 Vector-H

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Vector Launch Vehicle Family

Vector is fielding a family of small launch vehicles consisting of the Vector-R (Rapid) (“V-R”) and the Vector-H (Heavy) (“V-H”). The Vector-R is designed for rapid and frequent launch of payloads weighing up to 66 kg and will be available for commercial flights in 2018. The associated production and range infrastructure and being developed to support a launch cadence of up to 100 flights per year. The Vector-H is a larger vehicle based on the Vector-R design that can deploy 160 kg class satellites into LEO and launching small deep space missions. The Vector-H will be available in 2019 for commercial flights at launch cadences for a combined launch of the Vector-R and Vector-H of 100 flights per year. Our concept of operations (CONOPS) is based on the use of a transporter-erector-launcher (TEL) that provides extensive flexibility and enables activities at multiple ranges with minimal infrastructure. Early candidate launch sites are listed below and we are also examining several international opportunities:

- Pacific Spaceport Complex – Alaska (Kodiak Island, Alaska)
- Launch Complex 46 (Cape Canaveral, Florida)
- Spaceport Camden (Camden County GA)



Figure 1. Vector-H is slightly larger than the Vector-R, the smallest commercial satellite launch vehicle in the world with the highest launch rate by design.

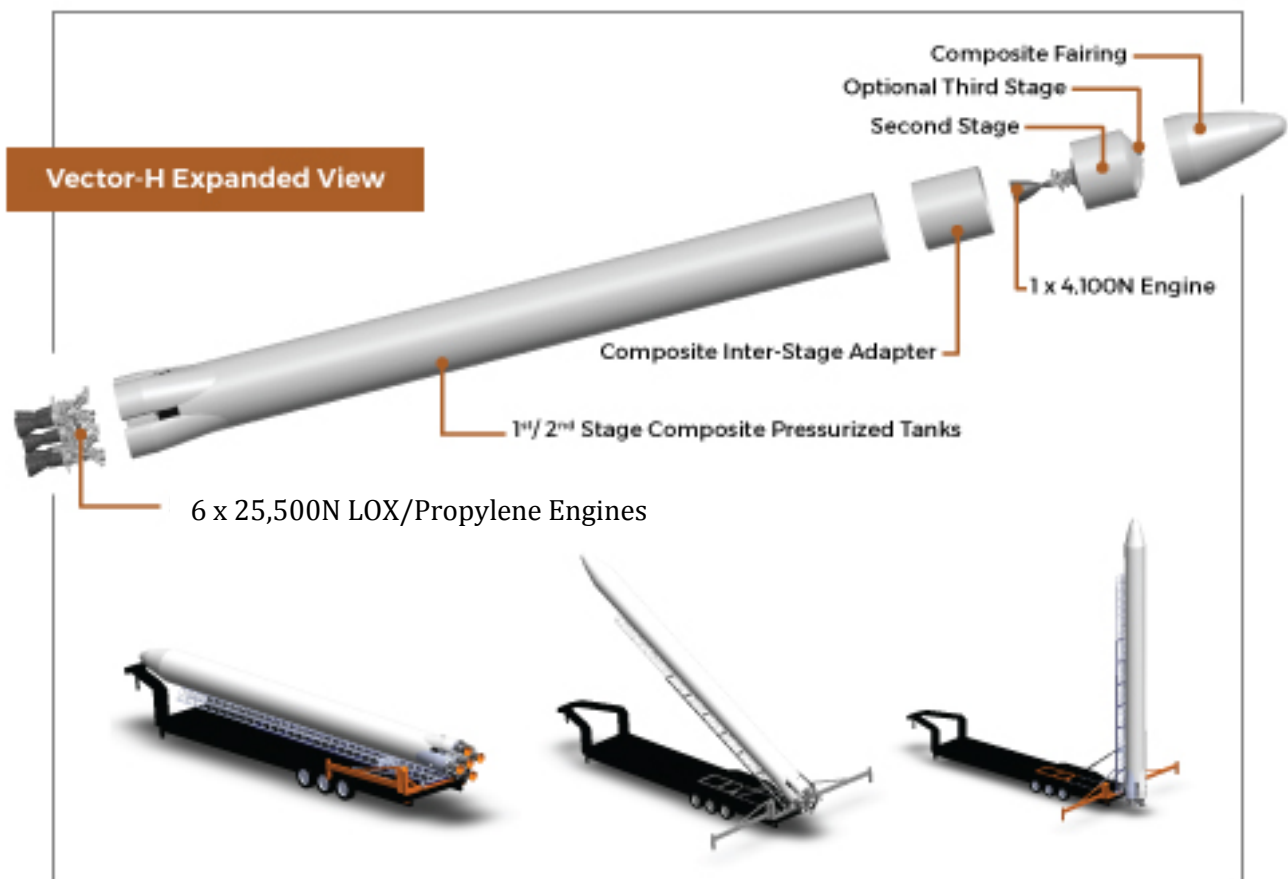
The Vector launch vehicle family derives historically from the Garvey Spacecraft nanosat launch vehicle (NLV) concept that has been under development for a number of years. These vehicles feature an all-carbon fiber structure along with pressurized propulsion feed systems operated by patent-pending pressurization systems using safe low-pressure systems. The Vector-R is a larger version of the NLV using three first stage engines and a larger second stage for more orbital insertion capability. The Vector-H is a stretched version of the Vector-R and uses a six engine first stage with longer tanks and a full diameter second stage. Both vehicles share common avionics and engines.

We offer optional third stages and both standard and enlarged payload fairings for both vehicles. Initially, payload integration takes place on-site at each launch facility. Medium term, we are pursuing options for enabling major payload integration tasks to be undertaken at customer facilities.

Vector-H Vehicle Overview

Until now, nano and micro satellites have relied on secondary launches aboard larger launch vehicles, leaving the choice of destination and launch schedule to others. Vector is dedicated to servicing micro satellites and will provide frequent and reliable space access allowing you to go where you want when you want.

The Vector-H launches ~160 kg to Low Earth orbit with a small, simple two-stage rocket. We launch into polar and Sun Synchronous orbits from the Pacific Spaceport Complex - Alaska (PSCA) and low inclination orbits from multiple ranges on the U.S. east coast now under consideration. Our optional Upper Stage will place up to 108 kg into 800 km orbits from CCAFS. Other launch locations under evaluation expand the profiles for insertion.



Vehicle Summary

- | | |
|--|---|
| <ul style="list-style-type: none"> • Overall length 19.5 meters • First stage diameter 1.1 meters • Gross Lift Off Weight (GLOW): 11,910 kg | <ul style="list-style-type: none"> • Pressurized propellant feed systems • No explosive ordinance, low shock • Autonomous flight termination |
|--|---|

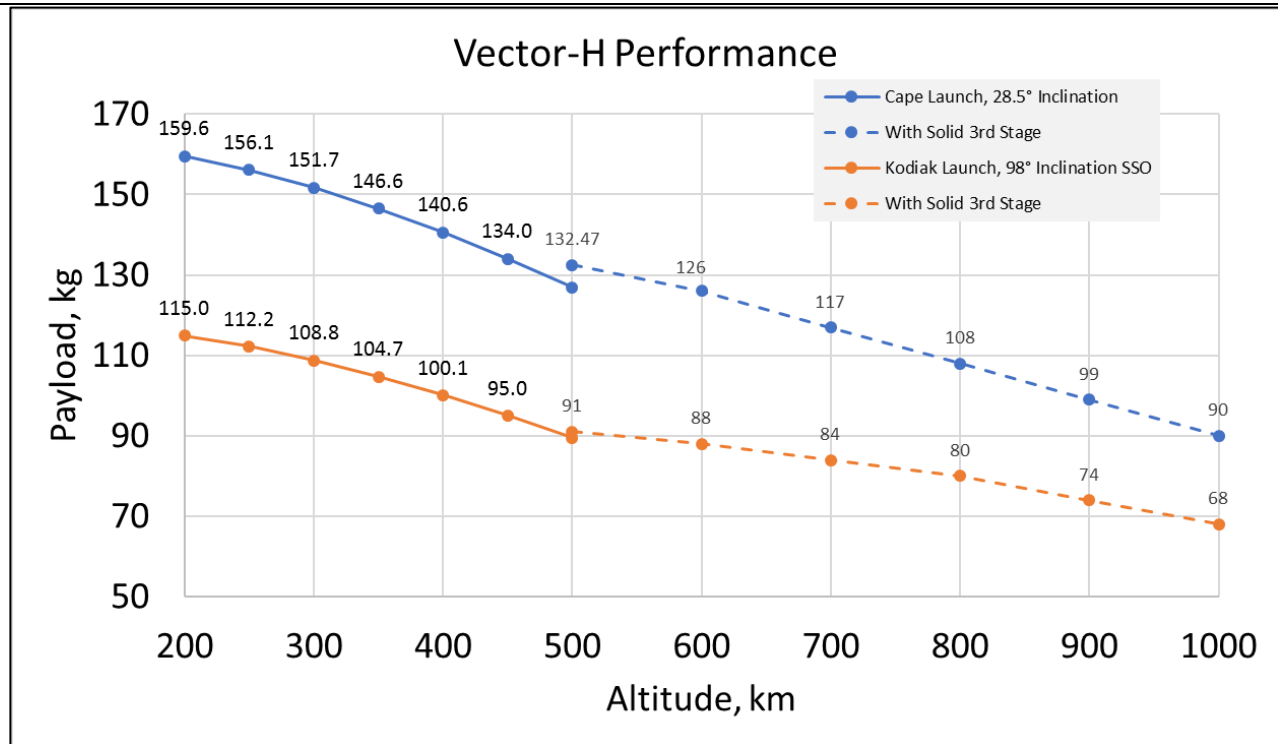
Figure 2 Vector-H Expanded View

Vector-H Capabilities

The Vector-H operates from a mobile launch platform from either the PSCA or the CCAFS. The Vector launch vehicle requires a minimum setup time, minimum range resources, and can operate from remote locations other than our standard ranges. The Vector-H is designed for flight rates of more than 100 flights per year at full operational capability.

Service	Value
Payload	<ul style="list-style-type: none"> 160 kg / 350 lbm to 200 km / 108 nmi circular 28.5 degree inclination Low Earth Orbit (LEO) 95 kg (210 lbm) to 450 km (243) nmi Sun Synchronous Orbit (SSO) Payloads launch WITHOUT canisters (flying naked) Payload Dynamic Volume: <ul style="list-style-type: none"> 1000 mm / 40 inch cone base diameter 650 mm / 25 inch cone top diameter at 1250 mm / 50 inch height from base 1250 mm / 66 inch overall payload fairing envelope length
Launch Altitudes And Inclinations	<ul style="list-style-type: none"> Up to 1000 km and greater depending upon payload and inclination West Coast US (PSCA): 60 to 102 degrees inclination East Coast US (CCAFS): 28.5 to 55 degrees inclination
Payload Delivery And Integration	<ul style="list-style-type: none"> Payloads can be integrated in our AZ or CA Payload Facility y (Class 100,000) Payloads are mated to the launch adapter and encapsulated with dry nitrogen and fairing for transport to launch site if required by the customer Encapsulated payload unit is integrated on Launch Vehicle at launch site
Payload Options	<ul style="list-style-type: none"> Standard PSC 8 Inch Light-band Adapter (non pyro) Optional 1U-12U launch adapters based on PSC Light-band (non pyro) Launch canisters (PPOD, ISIS containers) can be accommodated for customers but are not required. Standard dispensers supported include: Cal-Poly P-POD, NLAS, ISIS Quad Pack/EZ-POD, PSC 3U CSD, PSC 6U CSD, PSC 12U CSD, PSC 27U CSD, Tyvak 6U, Tyvak Rail-POD Payloads can be launched dormant or active depending on payload
Upper Stage Options	<ul style="list-style-type: none">

Vector-H Performance



Two Stage Vehicle - Baseline

Represented by the solid line in the graph to the left, offers the baseline orbit capability of the Vector launch vehicle family. The two-stage vehicle is capable of placing satellites directly into circular or elliptical orbits starting at 200 km. Orbit inclinations above 50 degrees are flown from the PSCA and 28-50 degree inclination orbits are flown out of the CCAFS.

Two Stage Vehicle + Upper Stage

Represented by the dotted line in the graph to the left, Vector offers a third stage. This is available in 3U, 6U, 12U and a full stage configuration that mounts to a Planetary Systems 8 inch Light-band bolt circle. The upper stage operates as a stand-alone stage.



Vector-H Upper Stage

The Vector-Upper Stage option uses solid propulsion for an extended 3rd stage capability. The thruster system has flight heritage from micro satellite applications. The upper stage comes in two configurations: Configuration 1 with power and ACS and Configuration 2 without power and ACS. Configuration 1 is intended to support multiple payload manifests and the Upper Stage provides its own power and guidance.

Operations & Mission Profiles

Vector offers a wide range of orbital inclination capability from various US launch sites. Mission operations and vehicle engineering are centered in Orange County, CA. Our primary launch vehicle factory is located in Tucson Arizona where payload integration operations are performed. The Orange County facility also performs payload integration. Payloads are integrated onto a head module and sent to flight facilities for vehicle integration.

Payload encapsulation occurs at the Tucson & Orange County factory or at the spacecraft manufacturing facility, and the head module is sent in a sealed container to the launch facility.

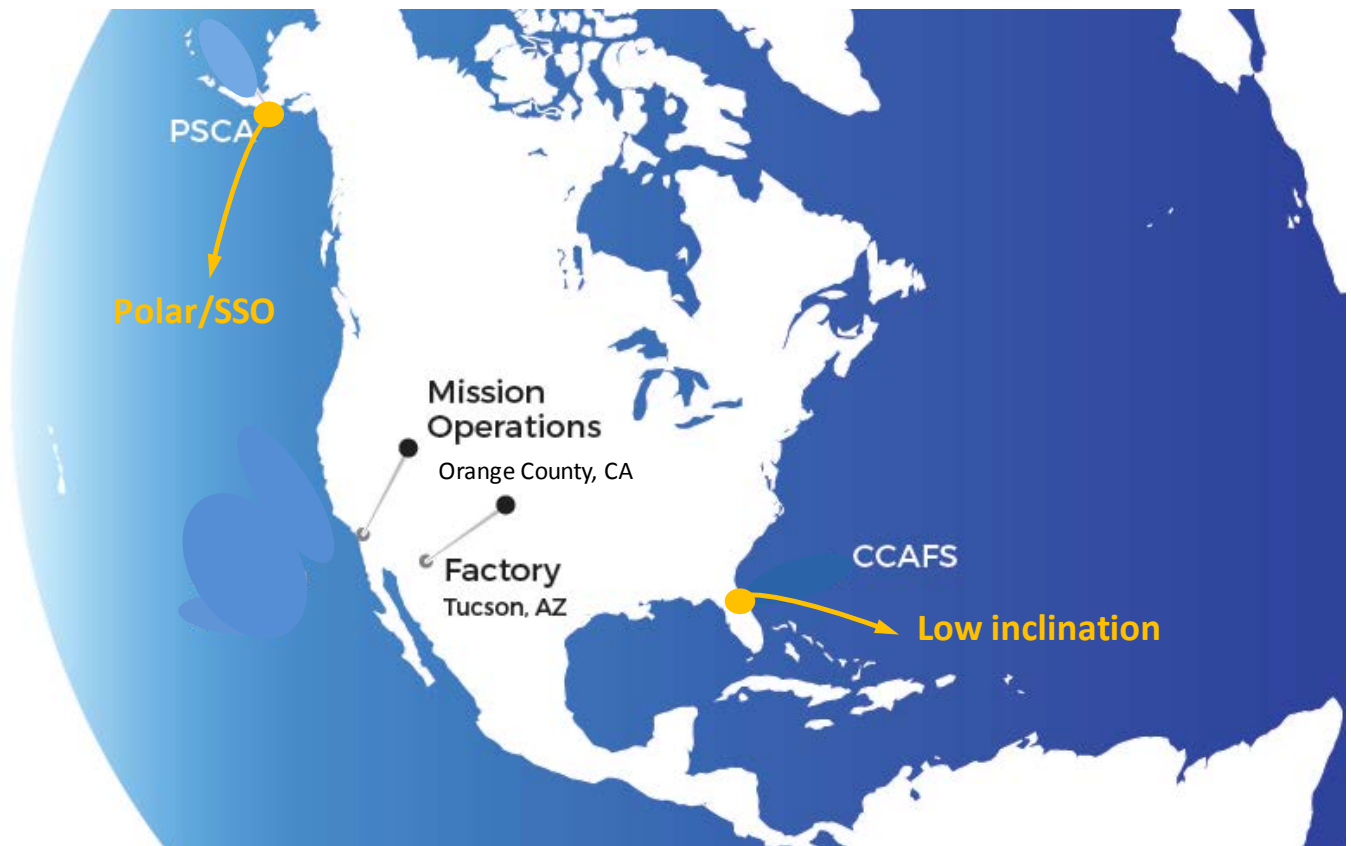


Figure 3 Launch Sites include: PSCA and CCAFS.

site for processing. In the base of prolonged storage of the payload, storage is in Tucson inside climate controlled and bonded storage areas. Several weeks prior to the launch, the encapsulated payload is shipped to the launch site and is integrated onto the vehicle the week of the launch. On the day of the launch, or the night before weather permitting, the vehicle is moved outside to the launch site, erected, and fueled. Launch occurs the same day. Vector has vehicle telemetry during the entire launch and offers payload power and telemetry as an option during launch.

Ship from
Vector to
Spacecraft
Provider

Receive at
Spacecraft
Provider

Spacecraft
Provider Load

Spacecraft
Provider
Secure

Spacecraft
Provider Ship

Receive at
Vector
Integration
Facility

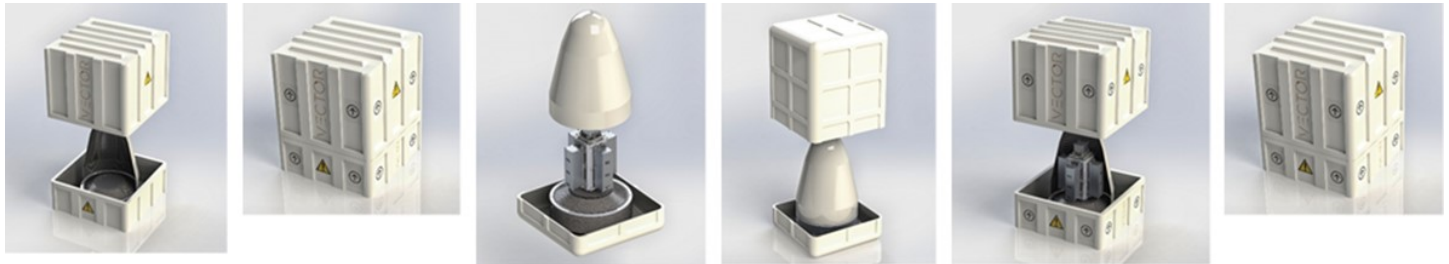


Figure 4 Payload ConOps

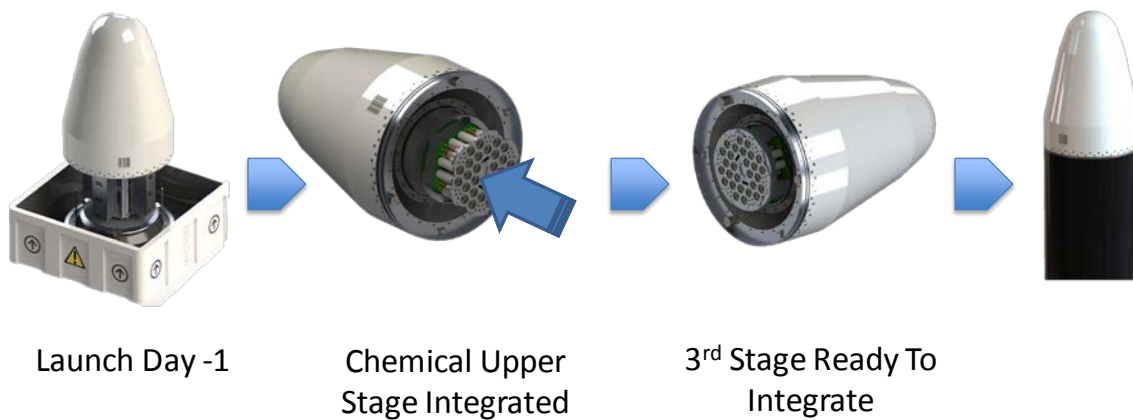


Figure 5 Payload Operations At Launch Site

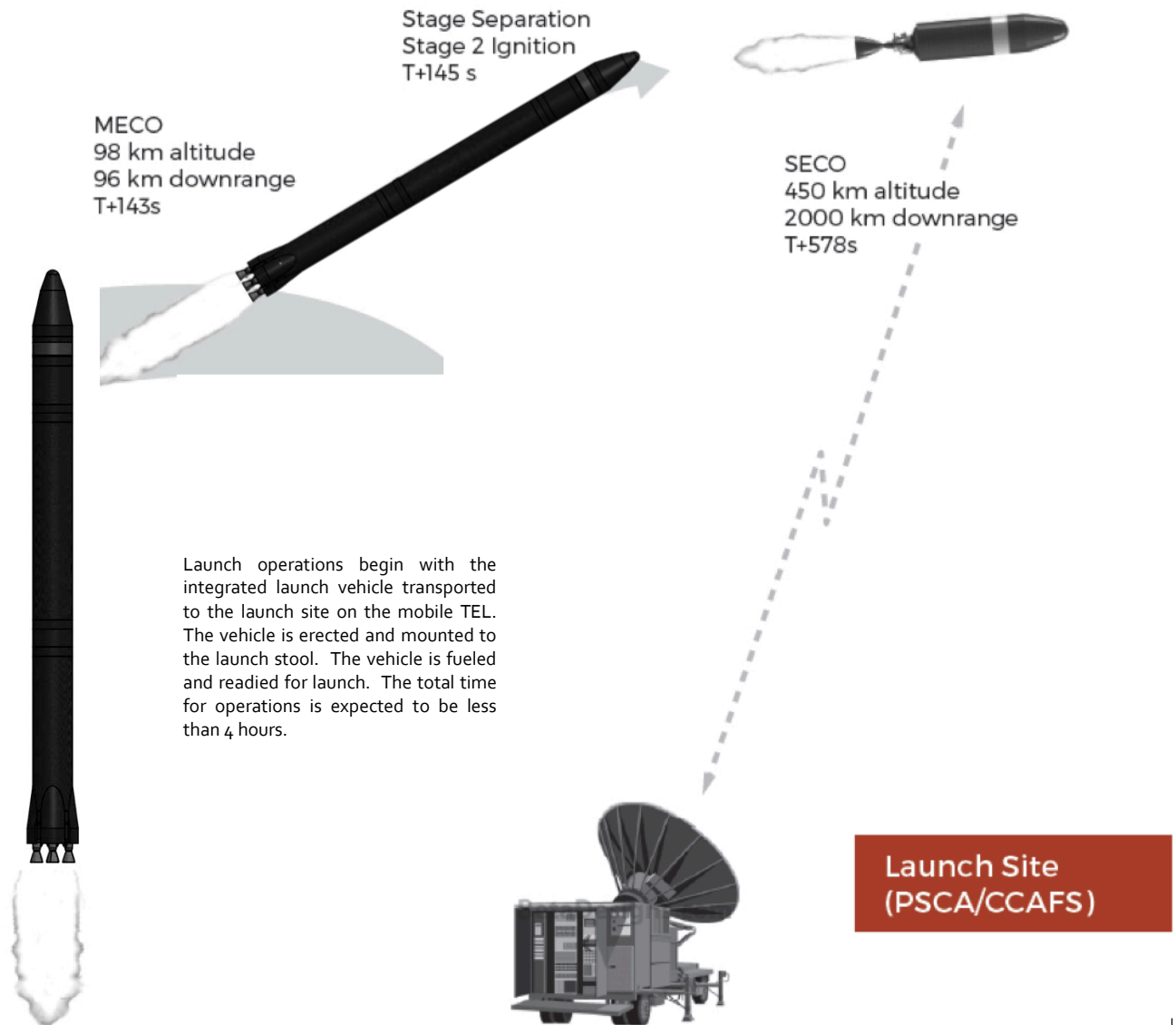


Figure 6 Launch ConOps

Vector launch operations are accomplished within a single day beginning with vehicle rollout and erection on our mobile Transportable-Erector-Launcher (TEL). The vehicle is fueled with Liquid Oxygen (LOX) and our proprietary densified Liquid Propylene. The baseline flight takes the first stage downrange 100 km until stage separation. The second stage places the spacecraft into a direct injection orbit in the nominal trajectory. Baseline capabilities are based on direct injection into orbit with the two-stage vehicle.

Third stage capabilities employ a 200-250 km staging orbit. The launcher places the payload and upper stage in this orbit and the upper stage begins placing the spacecraft in the final orbit. The upper stage requires as much as several months to place the payload in its final orbits through a constant vector low magnitude thrust.

Payload Services

Vector manifests single satellite launches, multiple identical satellites for constellations and mixed satellite. The

example manifest combinations are shown below for illustrative purposes only.

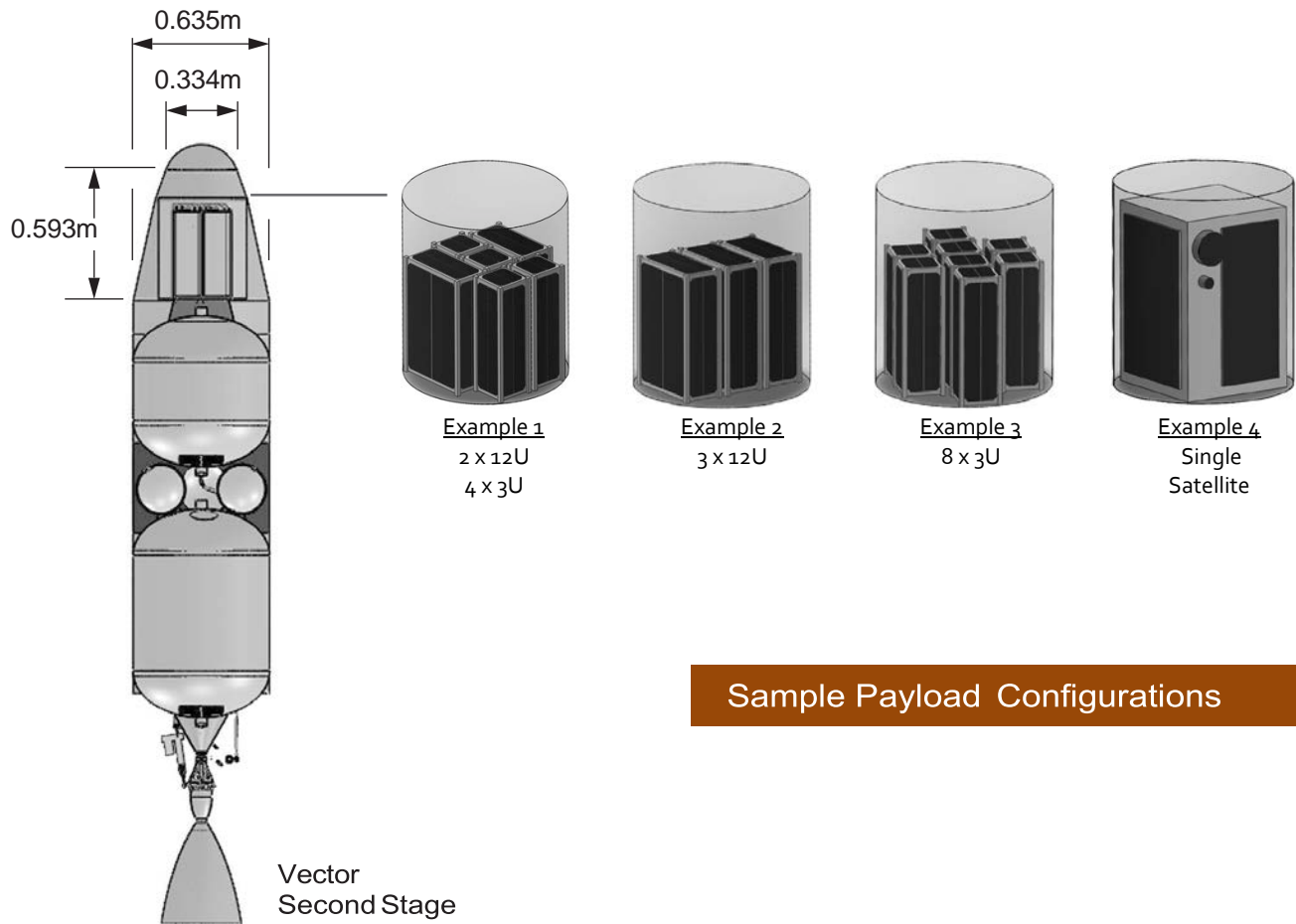


Figure 7 Sample (TBC) Payload accommodations for the Vector-H

Individual flight manifests will vary from those pictured above and this illustration is intended to offer a general concept of payload accommodations. The actual dynamic envelope for the launch vehicle is shown in the accompanying figure.

In all cases, no secondary payload structures are required and **the satellites mount directly to the launch adapter/separation system without the need for satellite ejectors or pods**. This frees you from the expense and volume constraints imposed by the classic Cubesat deployment systems. It also adds more mass capability to orbit by eliminating the inert mass of the ejection system. Satellites flying on Vector are free to employ propulsion systems and other satellite systems such as deployed antennas, satellite “on” during launch and satellite transmissions traditionally considered hazardous by rideshare arrangements. As the primary payload, you determine your own cleanliness and integration requirements and are not forced to build your payload to the most stringent requirements of your rideshare partner which often drives your costs very high with no benefit to you other than being able to launch!

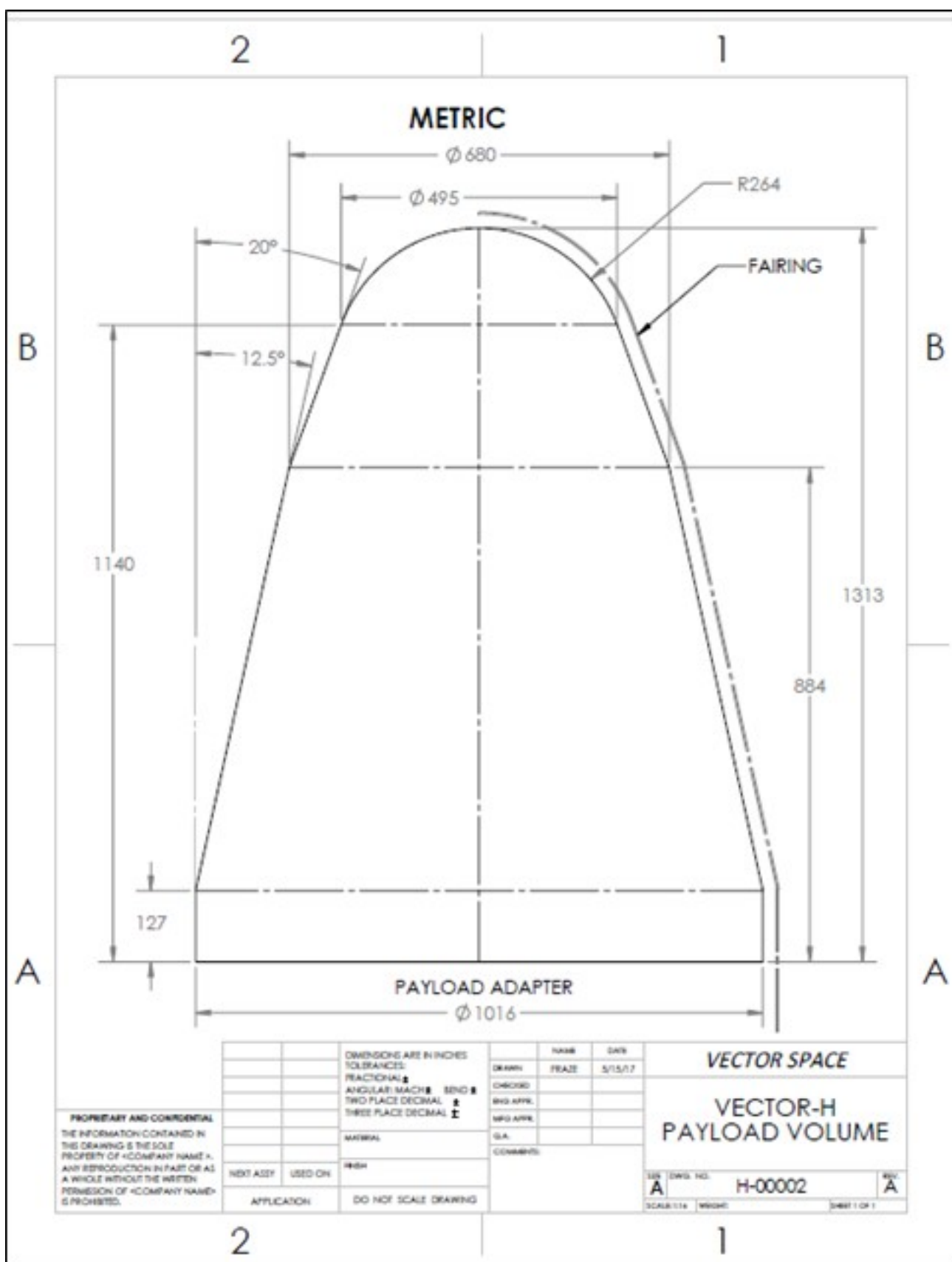


Figure 8 Standard Metric Fairing payload dynamic envelope for single satellite launches

If desired by the satellite operator, traditional Cubesat dispensers can be accommodated or you can employ Vector's mass saving and lower cost Light-band based adapters that allow you more volume and the possibility for expanded volume outside of the traditionally limiting dispenser volumes. The payload fairing can be made RF transparent, and single launched and constellation payloads can be launched in emitting configurations depending on the specific payload and mission requirements. Payloads with propellants and radiation requirements need to be cleared with mission safety and Vector Payload Support Engineering.

Another unique feature of Vector is the ability to accommodate dynamic launch scheduling. Our flight manifest at full operational capability will offer 100 flights a year or more out of our combined spaceport and three classes of service. Economy Class service for dedicated or mixed payload manifests is our lowest cost service and requires a flexible launch schedule and in some cases flexible destinations for mixed manifests. Business class service allows you to determine the destination orbit but remains flexible on the exact scheduling. Our Premium Class service allows you to call up a launch on short notice and determine the launch destination for your payload. This offers you both the flexibility to develop your space system at your pace and fly when you are ready. The standing army costs of having your team wait for years for a launch combined with significant opportunity costs of waiting to get to revenue are much greater than the higher price for Premium Launch Services.

Vector's spectrum of additional launch services includes tailored payload processing, additional launch stages, engineering and regulatory support, spacecraft power and communications services during launch integration and flight of the vehicle launch. Tailoring of the launch and payload processing to the customer's mission is available. Payload customers are normally expected to conduct payload testing or integration activities at the Tucson facility and not at the Launch Site.

Launch Environments

Vector's payload environments are comparable to other liquid fueled vehicles with max g loads of ≤ 5 g's. Since Vector uses no pyrotechnics on the Vector-H vehicle, shock loads and acoustics are minimal. The primary payload thermal environment during all ground storage, handling, encapsulation, and integration operations prior to launch at 10-40 degrees Celsius.

Vector plans to add the additional details, plot / graphs on the following during 2017:

- Vibe
- Acoustics
- Shock
- Thermal (including at fairing sep)
- EMI
- CG constraints?
- Pressure decay during ascent
- Humidity

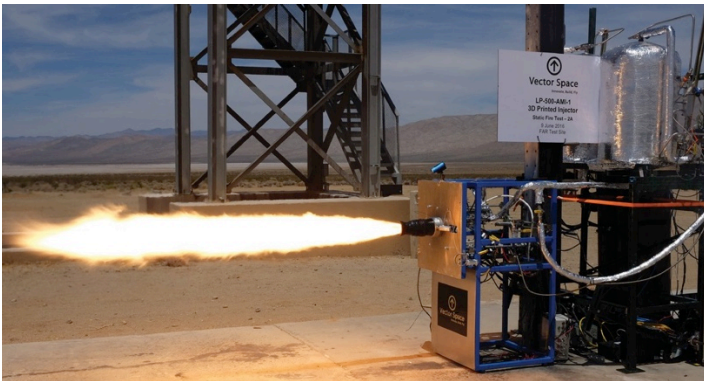
Launch Services offered by Vector

Service	Elements
Economy Launch	<ul style="list-style-type: none"> Standard 28.5° / 350 km orbit but inclination & altitude may vary Launch schedule first come first served and exact launch date not guaranteed 3.5 M\$ per launch <ul style="list-style-type: none"> 3U, 6U, 12U individually priced (with or without canisters) Launch call up notification may happen within 1 month
Premium Class Launch	<ul style="list-style-type: none"> Orbit specified by customer Launch schedule specified by customer guaranteed within 3 months 4.5 M\$ per launch <ul style="list-style-type: none"> 3U, 6U, 12U individually priced (with or without canisters) No launch call up notification date specified
Upper Stage	<ul style="list-style-type: none"> Upper Stage to extend altitude range of satellite placement Can remain attached to payload for extended altitude maintenance Configuration with or without power/ACS): \$0.75M
Additional Services	<ul style="list-style-type: none"> Standard PSC 8 Inch Light-band Adapter (non pyro) Optional 1U-12U launch adapters based on PSC Light-band (non pyro) Launch canisters accommodation Power during launch Satellite communications service from launch to injection Regulatory support Payload integration engineering support Special payload environment requirements
Fairing Options	<ul style="list-style-type: none"> Standard launch prices include standard size fairings Large sized fairings are currently under development Large size fairing available

During launch operations, the fairing may be purged with temperature-controlled gaseous nitrogen as an option. At the customer's request, electrical power is provided to the payload during launch operations.

Vector Facilities

Vector is headquartered in Tucson, Arizona with engineering located in Orange County, CA. The Tucson site houses our manufacturing and payload integration facilities. Orange County is in charge of vehicle engineering as well as vehicle development and flight operations.



Customer Contact

Vector is proud to bring unequalled customer service to the space launch industry. If you are flying with rideshare arrangements, you will be pleasantly surprised by the technical freedom and individual service of a dedicated Vector launch. Whether it's the technical freedom you gain, our devotion to detail, your interactions with our staff, our all-in-one service, or our responsiveness, the Vector micro launch experience is about to revolutionize the way micro space accesses space. If you are ready to launch your payloads or are considering using Vector, please email us at info@vector-launch.com.