DRAFT

Earth to Sky

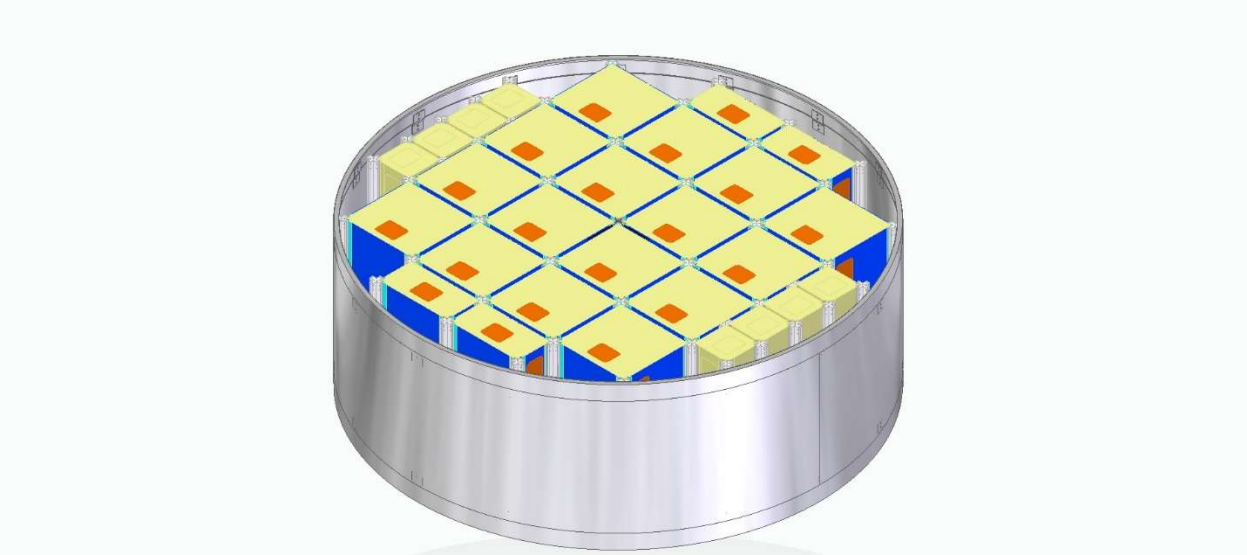
Customer Payload Handbook

Rev DRAFT

October 30, 2018

The Earth to Sky (ETS) Customer Payload Handbook provides information on what payload customers should expect when utilizing our launch services. The Cubesat Handbook identifies specific requirements and processes for flying aboard our Cubesat Ring. The Cubesat Ring is configured to fly a large number of cubesats with a built-in dispensing system. The Cubesat Ring supports the emerging CSD standard as well as the legacy P-Pod interface standard.

Cubesat Handbook



This handbook identifies key requirements to fly on our Cubesat Ring. Congratulations, you are almost there. If you have built or are building your Cubesat according to existing standards such as the CSD interface or the P-Pod dispenser interface, then you will meet our Cubesat Ring interface. If your Cubesat is built from standard components or qualified to fly on any existing launch vehicle then your Cubesat is ready to fly on the Sleek Eagle vehicle. Our environments are among the softest in the industry. If your satellite travels to our payload integration facility by truck or air or sea, then the

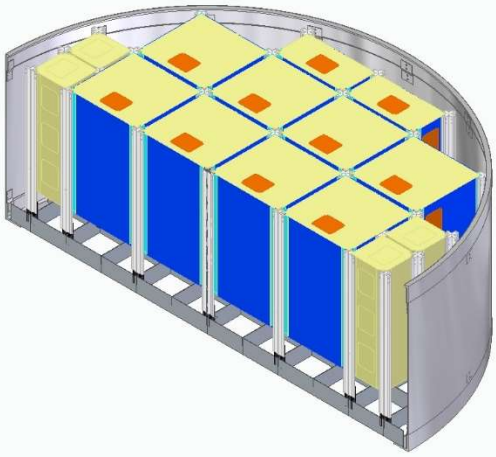
transportation environments likely exceed the Sleek Eagle flight environments. If your Cubesat is ready to operate in space, then the launch environments to get there have already been met.

Our goal is to make flying your satellite into space the easiest part of the journey. If you were planning to fly on any one of the following vehicles or a variant of them, then the payload integration process will be at least as simple and easy.

- Falcon 9
- Soyuz
- PSLV
- Atlas V
- Delta 4
- Minotaur
- Pegasus
- Stratolaunch
- Arianne
- Rocket Lab
- Earth to Sky
- Vector Launch
- Gilmore
- Virgin Orbit

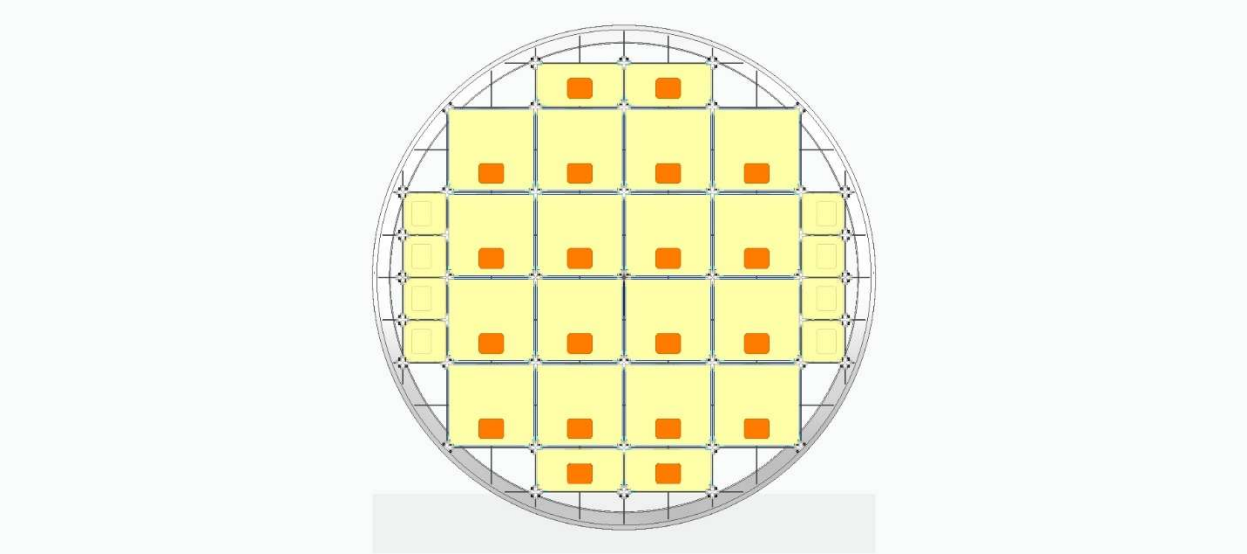
If your Cubesat is any of the following sizes, then the Cubesat Ring will accommodate your satellite.

- .5 U
- 1 U
- 1.5U
- 2 U
- 3 U
- 4 U
- 6 U
- 8 U
- 12 U
- 16 U
- 27 U
- 64 U



The Cubesat Ring provides capacity for a large number and combination of cubesats. The above shown graphic shows 16 – 12U/16U positions with 4 – 6U/8U positions and 8 1U/2U/3U/4U positions are available. The Cubesat Ring supports the larger, heavier satellites that conform to the emerging CSD standard as well as legacy cubesats.

Our integration timeline is among the shortest in the industry. We require your Cubesat to be at our integration facility 30 days prior to launch and ready to fly. We will integrate your Cubesat into our Cubesat Ring, integrate the Cubesat Ring onto the Sleek Eagle launch vehicle, launch your Cubesat into its destination orbit and deploy your Cubesat. We also provide visual verification of deployment as proof your Cubesat is in orbit.



Our Cubesat Ring provides 28 VDC power and ethernet LAN data connections to your Cubesat until deployment allowing you to monitor the health of your satellite during launch.

Sleek Eagle Launch Vehicle Information

Table XX: Launch services

STANDARD SERVICES

- Payload access prior to fairing closure
- Launch of the payload into the desired orbit
- Dedicated Earth to Sky Mission Manager to support mission planning, integration and launch
- ISO 8 (same as 100K) clean room payload and PAF integration space
- Payload processing, integration and encapsulation within the fairing
- Testing of payload interfaces at the launch site
- Range safety interface for the payload

• Acquisition and maintenance of mission- required licensing for launch vehicle, including US FAA and State Department

• Mission Simulation Test exercising operational readiness, vehicle resources and equipment and ground system support

• Mission Dress Rehearsal for key launch team members

• Post-flight launch services, including delivery of the Post-Flight Data Package, including payload separation confirmation, payload environment report and final orbit configuration

• Separation system provided by Customer

NON-STANDARD SERVICES

• Payload access after fairing closure

• Dedicate payload GN2 purge up until T0

• Payload heating and/or dedicated thermal control during cruise phase (prior to payload separation)

• Additional planning meetings

• Additional Customer offices and payload checkout space

• Increased cleanliness levels in payload checkout areas

• Additional fueling services and provisions for additional launch documentation hazardous fueling of the payload

• RF transmission after encapsulation and before payload separation

• Support for payload qualification for launch and range safety approval

• Separation system provided by Earth to Sky

Payload Insertion Accuracy

Precise pointing and orbit insertion are provided by an inertial navigation control module consisting of an IMU and GPS receiver on the upper stage of each vehicle. For a second-stage probability of command shutdown (PCS) of 99.7%, the following values represent the three-sigma (3σ) dispersions for a low-earth orbit direct insertion. Continued analysis may yield tighter tolerances as performance is refined.

• Perigee altitude: ± 5km Apogee altitude: ± 15 km Orbit inclination: ± 0.1o

3.1 Mission Planning & Preparation

Earth to Sky provides a single point of contact to guide every Customer through the entire mission planning and execution process. This Earth to Sky point of contact, the Payload Mission Manager, remains the primary liaison for the entirety of the Earth to Sky-Customer relationship. Customers can expect transparency and open communication throughout the entire process, with weekly status reports.

One fit check meeting is foreseen during the mission preparation phase, typically to take place at Earth to Sky's integration facilities at our Customers' convenience, combined with a meeting to finalize the payload to launch vehicle Interface Control Document (ICD). Activities and objectives of the fit Check include the following activities:

• Assemble a comprehensive mass and volume representative model of the entire payload segment, including all payloads (in the event of multi-manifested launch configurations) and separation systems and adapters,

• Validate the mechanical and electrical interfaces, and

• Where possible, validate the operation of all separation systems

3.2 Launch Campaign Timeline

Each Earth to Sky mission follows a standard timeline, starting with the initial Customer contact and finishing with the successful completion of the mission. Figure XX depicts a typical timeline. All timings and milestones are counted before (-) or after (+) the Launch Date. Insertion data is provided as early as possible, with the final confirmation of launch performance and parameters delivered no later than three hours after launch. Please note that all dates in the figure are guidelines, and not firm constraints; more compact timelines may be possible depending on Customer circumstances.

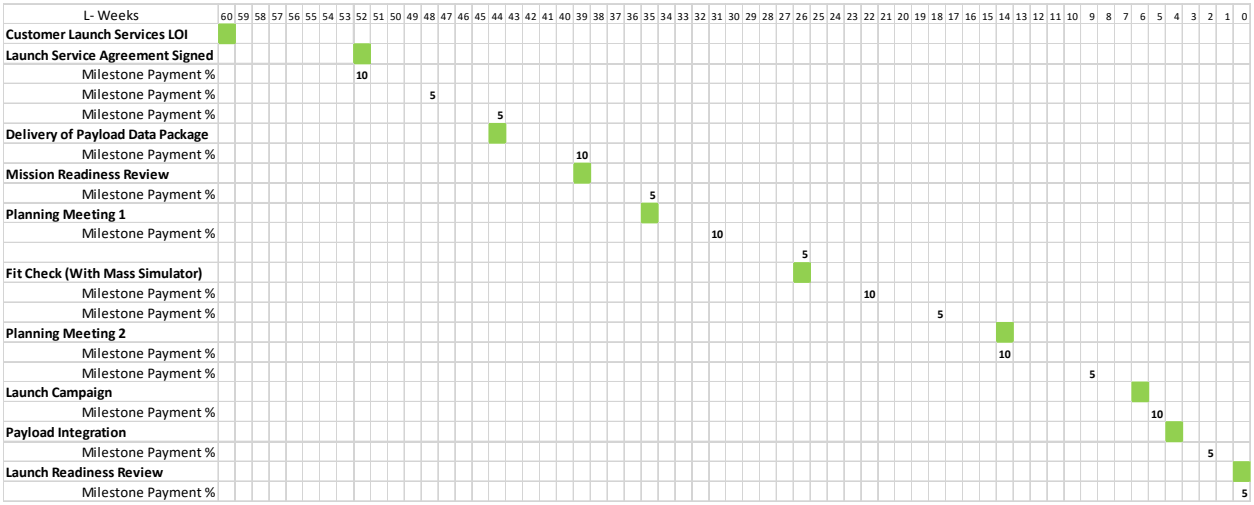


Figure XX depicts a notional launch timeline as the launch date nears, and Earth to Sky welcomes the opportunity to discuss adjustments for Customer needs. Additional or fewer days can be supported for payload operations depending on Customer needs. The current schedule carries two margin days post-payload mate to the launch vehicle.

The Mission Readiness Review (MRR) evaluates the status of the facilities, the launch vehicle, ground support, and payload in route to mission success. This review is the final review of the launch vehicle configuration and all hardware and software modifications needed to support spacecraft mission requirement. It is conducted before shipment of launch vehicle hardware to the launch site.

The Flight Readiness Review (FRR) ensures that safety systems and procedures are enabled and readied for mission success. The FRR examines previously performed tests, demonstrations, analyses, and audits

that determine the overall system readiness for a safe and successful flight/launch and for subsequent flight operations. It also ensures that all flight and ground hardware, software, personnel and procedures are operationally ready. The Flight Safety Review is incorporated into the FRR. The review shall include vehicle hazards, the status of any applicable waivers and any other issues that contribute to flight risk

The Launch Readiness Review (LRR) is the final prelaunch assessment of the integrated launch vehicle/payload system and launch-facility readiness for launch. It is the last critical review before launch.

4.2.3 Fueling & Fluid Checkout Panels

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

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

4.2.4 Cleanliness of Facilities

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

4.2.5 Customer Team Accommodation & Offices

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

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

4.2.6.1 Power

The following Electrical Ground Support Equipment (EGSE) power sources are provided for payloads at the Payload Processing Facility (PPF) and launch equipment building: 120V/240V single phase, and 208V three phase, 60 Hz. 50 Hz accommodations May be made via frequency converters; this requirement should be included within the ICD requirements and discussed during initial meetings.

4.2.6.2 Internet

High-speed, broadband internet access (both Ethernet and Wi-Fi) is available to Customers both in the offices provided and the payload processing cleanroom facilities. A single connection in each office/ area will be provided. This is not part of the mission network and can only be used generally – if local

networks are required it is expected that the Customers bring their own equipment to set up local networks.

4.2.7 Launch Vehicle Customer Access

Customer access to the launch vehicle is restricted to the combined payload/launch vehicle processing operations and activities. Customers can view the launch vehicle during agreed upon times, arranged in advance. Due to export compliance regulations, non-US Customers or personnel may view the launcher while it is in its processing and assembly facility only if the proper government approvals are in place.

4.2.8 Launch Pad Access and Viewing

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

4.2.9 Visitors & VIPs

It is understood, and expected, that Customers may invite VIPs and other visitors to view the launch. Earth to Sky endeavors to accommodate these individuals at the launch viewing sites. Hospitality services may gladly be arranged as a non-standard service offering. (Per FAA Regulations)

4.2.10 Post Launch

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

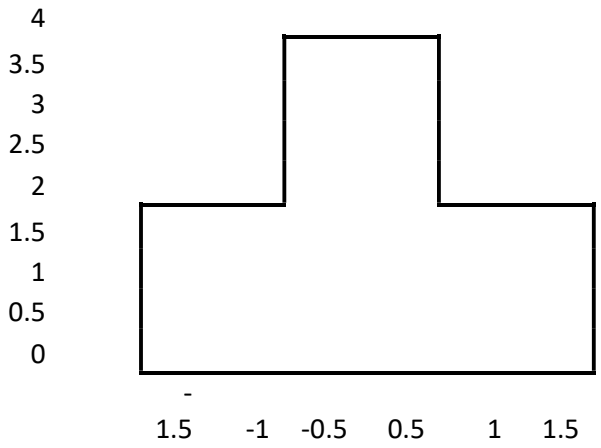
Insertion Orbit	Inclination Range	Vehicle	Launch Site(s)	Mass Capability
LEO mid-inclination	37.9 – 60 deg	Sleek Eagle	Wallops FF Pad 0B	Up to 1200 kg
LEO polar/ sun-sync	80-97 deg	Sleek Eagle	Wallops FF Pad 0B	Up to 850 kg

A study1 by The Aerospace Corporation found that 91% of known launch vehicle failures in the previous two decades can be attributed to three causes: engine, avionics and stage separation failures. With this in mind, ETS incorporated key engine, avionics and staging reliability features for high reliability at the architectural level of Falcon launch vehicles. Significant contributors to reliability include:

- Simplified Propulsion System

- The Sleek Eagle utilizes a pressure fed liquid oxygen/kerosene propulsion that dramatically reduces parts count and simplifies operational procedures. The restartable Ashton 12K engine has a spark torch ignition system that burns gaseous oxygen and gaseous hydrogen. The simplicity of the engine start sequence eliminates most failure modes related to engine starts. The igniter and engine are fabricated out of Inconel 718 using state-of-the-art additive manufacturing. This allows ETS to build the engines with standard production processes

Chang, I-Shih. "Space Launch Vehicle Reliability," *Aerospace Corporation Publication (2001).*



Acceleration environments for the Sleek Eagle Vehicle

The Sleek Eagle Customer Payload Handbook is a planning guide for pre-contract customers to understand logistics, launch vehicle environments, and interface planning for satellite integration into the Sleek Eagle launch vehicle. The Sleek Eagle launch vehicle has been designed to address the small satellite market as a low-cost satellite delivery system to LEO that utilizes standard satellite interfaces, simplified analysis requirements and a 12-month timeline from contract to launch.

This handbook includes descriptions on the various flight support hardware, interfaces, capabilities, launch environments, policies and top-level processes ETS uses to integrate, launch, and deploy your satellite to its destination orbit.