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## Chapter Glossary

(ACDS)	Attitude Determination and Control System
(CLIN)	Contract Line Item Number
(COTS)	Commercial-Off-the-Shelf
(CSLI)	CubeSat Launch Initiative
(CSO)	Client Space Object
(DPAF)	Dual Payload Attach Fitting
(EGSE)	Electrical Ground Support Equipment
(ESA)	European Space Agency
(ESPA)	EELV Secondary Payload Adapter
(FAA)	Federal Aviation Administration
(GEO)	Geostationary Earth Orbit
(GSE)	Ground Support Equipment
(ISS)	International Space Station
(JAXA)	Japan Aerospace Exploration Agency
(JEM)	Japanese Experimental Module
(JEMRMS)	Japanese Experimental Module Remote Manipulator System
(LEO)	Low-Earth Orbit
(LSP)	Launch Services Program
(MGSE)	Mechanical Ground Support Equipment
(MPAF)	Multi-Payload Attach Fitting
(MPEP)	Multi-Purpose Experiment Platform
(NASA)	National Aeronautics and Space Administration
(NICL)	Nanoracks Interchangeable CubeSat Launcher
(NOAA)	National Oceanic and Atmospheric Administration
(NRCSD)	Nanoracks CubeSat Deployer
(OMV)	Orbital Maneuvering Vehicle
(OTV)	Orbital Transfer Vehicle
(PCBM)	Passive Common Berthing Mechanism
(RCS)	Reaction Control System
(RUG)	Rideshare User Guide
(SLV)	Small Launch Vehicle
(SSMS)	Small Spacecraft Mission Service
(SSO)	Sun-Synchronous Orbit
(TRL)	Technology Readiness Level
(ULA)	United Launch Alliance
(USTP)	University SmallSat Technology Partnerships
(VADR)	Venture Class Acquisition of Dedicated and Rideshare



## 10 Integration, Launch, Deployment, and Orbital Transport

### 10.1 Introduction

The number of spacecraft launched in 2025 reached a new high, increasing by nearly 60% compared to 2024, totaling 4,577. A surge in Starlink constellation launches was largely responsible for this increase, accounting for approximately 70% of all spacecraft launched in 2025. Excluding Starlink, 45% of the remaining spacecraft launched in 2025 had a mass of 200 kg or less. While this represents a general decline in the < 200 kg class over the past five years, 2025 experienced a ~10% increase in launches of SmallSats between 11 – 600 kg, indicating a greater demand for larger platforms. While the average SmallSat mission still typically involves a spacecraft < 200 kg, the rise of larger next-generation spacecraft in constellations (i.e., Starlink, Iridium, Planet SkySat, Capella Acadia, etc.) will play a major role in the demand for fewer platforms that are bigger.

To address the growing demand for SmallSat launches, the “rideshare” launch market has emerged as a popular means for SmallSats to access space. This trend has been fueled by an increase in launch providers and improved launch capabilities, as well as the development of adapters and dispensers specifically designed for SmallSat and CubeSat missions. Rideshare launches are typically multi-manifest missions that either consist of 1) a large primary spacecraft that determines all the mission requirements (e.g., orbit, schedule, concept of operations, etc.), where secondary payloads are manifested to take advantage of the launch vehicle’s surplus mass, volume, and other performance margins, or 2) a single launch vehicle consisting entirely of SmallSats, also known as a “dedicated rideshare.” It should be noted that the term “payload(s)” in this chapter refers to the entire free-flying spacecraft deployed from a launch vehicle and is defined differently in Chapter 2 *Complete Spacecraft Platforms*, as instruments and technologies on spacecraft.

In support of making ridesharing a feasible option, orbital transport vehicles (OTVs) and orbital maneuvering vehicles (OMVs) provide “last mile” delivery services to their intended orbits for small satellites. These vehicles are becoming more common for microsatellite deployment and operational logistics. While historically referred to as “space tugs,” this term is being phased out by many in the commercial industry. The terms OTV and OMV are also falling out of favor, with many commercial offerings simply referring to the available systems as vehicles capable of in-space transportation services. For the purposes of this report, the terms OTV and OMV describe systems with onboard propulsion that can be launched to an approximate orbit and then propel themselves to one or more target orbits. There they can either deploy small spacecraft or serve as an integral part of a hosted payload. This chapter focuses on the use of these vehicles as deployers, while more information about hosted payload services is found in Chapter 2, *Complete Spacecraft Platforms*, Section 2.2.1. Some OTVs/OMVs are based on traditional rocket kick stages and are intended to work with specific launch vehicles. Several commercial companies have successfully flown OTVs/OMVs and are booking future launch manifests.

In 2022, NASA’s Launch Services Program introduced a new Indefinite Delivery/Indefinite Quantity (IDIQ) mechanism called the Venture Class Acquisition of Dedicated and Rideshare (VADR) launch services contract. The VADR contract was created to support more risk-tolerant NASA-sponsored missions with FAA-licensed commercial launch services using selected commercial providers. This approach enables unique launch capabilities for Class D or higher risk-tolerant payloads, including SmallSats and CubeSats, and since commercial services use a lower level of mission assurance for payloads with higher risk tolerance, this collaboration contributes to NASA’s science and research development efforts as an ideal mechanism for technical development. This contract mechanism supports both traditional and dedicated rideshare opportunities, offering lower-cost access to space with reduced NASA oversight and



mission assurance requirements. Initially awarded to 12 companies, the IDIQ VADR contract has since expanded through its on-ramp provision, with three additional vendors added in 2024. In 2025, Rocket Lab's Neutron was also included, broadening the contract's capabilities to medium-lift missions (1).

Educational SmallSat missions also have several avenues for accessing these opportunities. NASA's CubeSat Launch Initiative (CSLI) for example, has provided rides to a significant number of schools, nonprofit organizations, and NASA centers. The European Space Agency (ESA) "Fly Your Satellite" program is a similar program which provides launch opportunities to university CubeSat teams from ESA Member States, Canada, and Slovenia (3). NASA's University SmallSat Technology Partnerships (USTP) provides up to two years of funding and a collaborative partnership with NASA to advance university-led small satellite technologies (4).

The list of organizations/companies in this chapter is not all-encompassing and does not constitute an endorsement from NASA. There is no intention of mentioning certain companies and omitting others based on their technologies or relationship with NASA. The information is for awareness and guidance only. The performance advertised may differ from actual performance since the information has not been independently verified by NASA subject matter experts and relies on information provided directly from the manufacturers or from publicly available information. It should be noted that TRL designations may vary with changes specific to payload, mission requirements, reliability considerations, and/or the environment in which performance was demonstrated. Readers are highly encouraged to reach out to companies for further information regarding the performance and TRL of the described technologies.

## 10.2 State-of-the-Art – Launch Integration Role

Launch options for SmallSats include dedicated launches or rideshare launches. Regardless of the approach, integration with the launch vehicle is a complex and critical portion of the mission. The launch integration effort for a primary spacecraft typically includes the launch service provider, the spacecraft manufacturer, the spacecraft customer, the launch range, and sometimes a launch broker or integrator (2). When launching on a rideshare mission, the launch integration may become complex due to its multi-customer, multi-mission nature.

There are several options for identifying and booking a launch for a SmallSat. For rideshares, the spacecraft customer may choose to use a launch broker or launch integrator to facilitate the launch manifesting process or work directly with the launch service provider. A launch broker matches a spacecraft mission with a launch opportunity, whereas an integrator provides additional services related to multi-mission manifesting and/or integration.

Whether a spacecraft customer chooses to use a launch integrator or not, it is the responsibility of the spacecraft owner/operator to obtain the appropriate licensing for their spacecraft. These licenses may include: radio frequency licensing, remote sensing licensing, and laser usage approval (5)(6). The launch integrator or the launch service provider will require proof of licensure before integrating and/or launching the satellite. They will also require additional safety-related analyses and supporting data and documentation prior to launch, which typically includes orbital debris information, materials and venting data, and spacecraft-specific models (7).

For rideshare launches, many satellites are subject to a "do no harm" approach to protect the other spacecraft on the launch vehicle. A list of "do no harm" requirements is imposed on the rideshare satellites by the launch provider, launch integrator, or primary mission owner. These requirements vary by launch provider and launch integrator, but usually include restrictions on transmitters, post separation mechanical deployments, and hazardous materials. A comprehensive list of typical "do no harm" requirements is provided in the NASA Rideshare User Guide (RUG) (8).



### 10.2.1 Launch Brokers and Launch Integrators

A launch broker for small satellites is an individual or organization that matches a spacecraft with a launch opportunity, usually as a rideshare spacecraft. Typically, a launch broker does not provide any additional launch integration services beyond coordinating the relationship between the spacecraft manufacturer or customer and the launch service provider. Their purpose is to fill excess capacity on a launch, and they can also support negotiations between the launch provider and payload for scheduling, integration, safety testing, and cost (9).

Launch integrators work with the satellite customer and the launch vehicle provider to ensure that the customer's spacecraft is compatible with the launch vehicle by performing analyses and physical integration services. The launch integrator may provide the CubeSat dispenser, separation system, or other hardware required for integration, or these may be provided by the spacecraft customer.

### 10.3 Launch Paradigms

In the last decade, small spacecraft have accomplished some of the most prominent advances in the aerospace industry. The wide range of small spacecraft missions has reshaped the space industry, enabled academic research and commercial services, and strengthened scientific exploration and defense applications in both Earth orbit and deep space. The early SmallSat market grew rapidly from 2013 to 2020, by approximately 40%. This growth was driven by the widespread adoption of CubeSats. The "little platform that could" ignited academia's participation in space research and development, broadened commercial space services, and enabled numerous government research programs.

Three major trends emerged in the space industry after the adoption of CubeSats: the rise of CubeSat constellations, the evolution towards larger CubeSat platforms, and the use of CubeSat pathfinder demonstration missions. The first trend, CubeSat constellations, began with Planet Labs' Doves 3U high-frequency Earth observation constellation in 2013. Today, numerous commercial constellations deliver a variety of services, and as technology advances, upgraded satellites continually replace their predecessors. For example, Spire Global's Low Earth Multi-Use Receive (LEMUR) 3U constellation performs remote sensing for weather forecasting, and ship and aircraft tracking, with 65 active satellites (10). Hawkeye 360 operates a 3U CubeSat constellation to map radio frequency signals for geoanalytics with 30 active satellites (11), while Swarm Technologies introduced picosatellite Spacebees for low-bandwidth Internet of Things (IoT) connectivity. The second trend was the evolution of the CubeSat structure. The original 1U structure quickly expanded to 3U, then doubled in volume by 2014 with the 6U platform, and again in 2016 with the 12U platform (12). CubeSat deployers that were once constrained to one- to three-cubed canisters now offer up to 12U+ volume (see Section 10.4.1).

Finally, CubeSat-based pathfinder missions have demonstrated the viability of novel technologies. NASA's MarCO mission was the first-deep space CubeSat pathfinder to validate the survival of CubeSat avionics in deep space and demonstrate the capability to communicate with Earth (ref). NASA's Pathfinder Technology Demonstrator (PTD) series, based on a 6U bus developed by Terran Orbital Corporation, showcased advanced technologies that enabled direct infusion into a wider range of future science and exploration missions (13). Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) is a 12U spacecraft pathfinder mission to characterize near-rectilinear halo orbits for NASA's Artemis architecture and validating new navigation technology for the Lunar Gateway (14). CubeSat pathfinder missions are the foundation for modern SmallSat paradigms.

By 2020, the spacecraft market underwent another transformation with the deployment of Starlink's broadband *mega-constellation*. While commonly characterized by a numerical value of



satellites, NASA defines a mega-constellation as numerous satellites in close proximity with rapid separation velocities, creating elevated collision risks in LEO (15). Starlink alone accounted for 65% of all launched spacecraft that year in 2020, and this trend persisted through 2025. During this period, the platform’s mass grew significantly—from less than 300 kg to about 800 kg within four years, with the upcoming v3 platform estimated at 1,500-2,000 kg. This surge in high-volume, larger spacecraft reshaped industry standards. To support this, in 2023, the FAA's Annual Compendium of Commercial Space Transportation raised its mass limit for small spacecraft from 600 kg to 1,200 kg (16).

When examining non-Starlink launch statistics, the average SmallSat mission is getting heavier as they become more capable. In 2025, more companies launched pathfinder constellations that will eventually join mega-constellation status such as Amazon LEO broadband network and the Guowang project for China’s Satellite Network Group. Another new focus is on-orbit data centers, which could significantly increase computational power, storage, and raw data processing. China’s Three-Body Computing Constellation launched the first group of 12 spacecraft in summer 2025, and Starlink is exploring data center applications with its mega-constellation (17).

Of the total non-Starlink spacecraft launched in 2025: microsattelites (11 – 200 kg) accounted for 17%; minisatellites (200 – 600 kg) represented 24%; and nanosatellites (including pico- and femtosatellites) accounted for about 15%. There continues to be an upward trend in the use of spacecraft platforms < 200 kg, as illustrated in Figure 10.1 below.

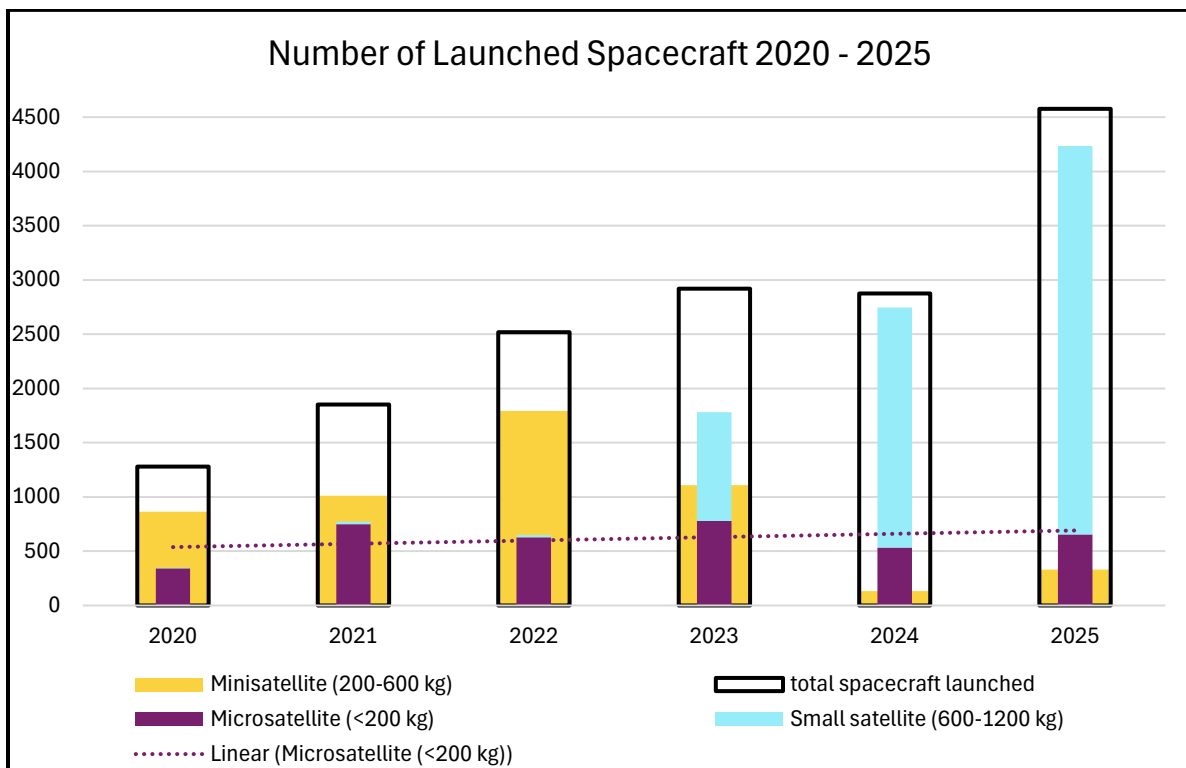


Figure 10.1: Number of spacecraft launched per year 2020-2025 in different mass categories.

The high volume of small spacecraft launches is expected to remain as SmallSat mission capabilities steadily expand. Companies are increasingly offering new or upgraded launch platforms focused on small satellites, including in-space services, rideshare programs, testing and integration, and mission support. Constellations, or multi-satellite missions, are broadening the applications of small spacecraft, while technical advances are enhancing broadband networks



and improving remote sensing applications. Today's SmallSat launch market includes dedicated vehicles for CubeSats and SmallSats, as well as rideshare programs that significantly improve access to space.

### 10.3.1 Dedicated Launches

Previously, small spacecraft were limited to secondary launch opportunities on large rockets, where the primary payload dictated the orbital parameters and launch readiness. Since it is not feasible for small spacecraft missions to use larger rockets due to the high per-kilogram cost, dedicated small launch vehicles (SLVs) are now an option, offering tailored access to space. SLV rides can be scheduled faster and can accommodate multiple destination requirements using an altitude control (or multi-ignition) system in the final stage. They also allow specific accommodations—such as a nitrogen purge or late battery charges—that are generally unavailable on rideshare missions (sometimes included as standard, or at additional cost). The trade-off is higher cost: dedicated launches have smaller manifests, lower launch frequency, and significantly higher price points compared to rideshare options.

Several small launchers are exploring options for satellite recovery and rocket reusability. Table 10-1 below highlights some of the current small launchers that have dedicated and tailored ride options for small spacecraft missions. Currently, Rocket Lab's Electron is the most widely used small vehicle as of April 2026. Several dedicated rocket companies across the globe have been in development for years and have either recently launched their maiden flights or are planning to do so soon.

<b>Manufacturer</b> <sup>Headquarters</sup>	<b>Vehicle</b>	<b>Performance to LEO (kg)</b>	<b>Number of Stages</b>	<b>Propellant Type</b>	<b>Recent Flight</b>
Rocket Lab <sup>USA</sup>	Electron	200	2	Kerosene	February 2026
Galactic Energy <sup>China</sup>	Ceres-1	420	4	Solid, Hydrazine	January 2026
Indian Space Research Organisation (ISRO) <sup>India</sup>	SSLV	500	3	Solid	August 2024
Firefly <sup>USA</sup>	Alpha	630	2	Kerosene, LOX	TBD
Northrop Grumman <sup>USA</sup>	Minotaur-1	580	4	Solid,	June 2024
<i>Upcoming, in development</i>					
Astra <sup>USA</sup>	Rocket 4	750	2	RP-1/ LOX	TBD
Innospace <sup>South Korea</sup>	Hanbit-Nano HyPER	90	2	Hybrid, Paraffin	December 2025
Isar Aerospace <sup>Germany</sup>	Spectrum	1000	2	LOX/ Propane	March 2026
Gilmour Space <sup>Australia</sup>	Eris	215	3	Hybrid	2026
Space One <sup>Japan</sup>	KAIROS	150	4	Solid, Liquid	December 2024

### Planned Launches

The expansion of small satellite capabilities will drive demand for dedicated launchers. Flying a spacecraft as a dedicated payload is the best method of ascent for missions that need a specific orbit, near full utilization of available launch vehicle performance, interplanetary trajectories, precisely timed rendezvous, or special environmental considerations. Technology developers and



the scientific community can take advantage of the rapid iteration cycles and low capital cost of small spacecraft to enable new advances in space capabilities and scientific understanding.

### **10.3.2 Rideshare Launches**

Rideshare arrangements provide cost-effective access to space using proven launch vehicles with scheduled flights throughout the year. Large launchers typically have excess mass and volume margins, enabling small spacecraft to fly as secondary payloads alongside primary missions. Ridesharing opportunities have expanded significantly—with more vehicles, orbits, services, and deployment methods now available. Modern rideshare mechanisms now exist that offer a variety of options for small spacecraft missions: commercial rideshare programs, purpose-built dispenser platforms attached to larger vehicles, and government launch services.

SpaceX's Transporter rideshare program offers Falcon 9 rides starting at \$350k for ~50 kg, with a high launch cadence (18). Rocket Lab has increased rideshare availability, completing 10 Electron rideshare missions in 2025 with planned launches in 2026. Other commercial rideshare options include orbital maneuvering and transfer vehicles are further discussed in Section 10.5. NASA's VADR launch services contract includes Standard Launch Services (CLIN 1) and Streamlined CubeSat Launch Services (CLIN 2), covering dedicated launches, anchor payload rideshares, and traditional rideshare options. Additionally, NASA's Science Mission Directorate Rideshare Office (SRO) coordinates rideshare opportunities across compatible payloads and government missions (19).

Future ridesharing will include lunar orbit services and high-energy orbits, as well as offering a larger variety of precise LEO orbits for multiple missions on a single launch. Ridesharing via orbital vehicles is discussed below in Section 10.5.

## **10.4 Launch and Integration Hardware**

This section describes the hardware required to mount, protect, connect, and release a spacecraft from the launch vehicle. The method by which SmallSats are deployed into orbit is a critical part of the launch process and depends on the satellite's form factor. CubeSats benefit from their adherence to standardized deployer designs which enable integration across multiple launch configurations. Spacecraft that do not conform to a canisterized configuration require different hardware, typically bolted directly to the launch vehicle. Hardware that attaches the spacecraft, protects it during ascent, and ultimately releases it includes primary structural interfaces (non-separating), dispensers, and separation systems.

The exact configuration and standards vary by launch vehicle, and selecting an appropriate and reliable launch option is part of the launch qualification process (9). With the rise of CubeSat constellations, integration hardware capable of launching multiple SmallSats simultaneously and consecutively has become standard. This section highlights examples of integration flight hardware for both SmallSats and CubeSats, though readers are encouraged to explore additional services. Other integration hardware such as fairings, umbilicals, isolation mounts, harnesses, sequencing systems, and MGSE/EGSE are essential but beyond the scope of this report.

### **10.4.1 Primary Structural Interfaces**

Primary structural interfaces such as adapter rings and platforms provide the mechanical connection between the spacecraft and the launch vehicle, ensuring proper load transfer and alignment. While they may host separation hardware, they are not inherently separation systems. These interfaces must meet strict requirements for bolt patterns, center-of-gravity limits, stiffness, and height to maintain structural integrity during ascent. The ESPA ring (Figure 10.2, top) exemplifies this concept as a multi-payload adapter originally developed by Moog Space and



Defense Group, featuring six 38 cm (15") ports that can each support up to 257 kg. Similar designs are now offered by multiple providers in various configurations (21).

Many launch vehicles also incorporate Dual or Multi-Payload Attach Fittings (DPAF/MPAF) for co-manifested missions, though these are typically vehicle-specific and not covered here. ESA's Small Spacecraft Mission Service (SSMS) dispenser for Vega demonstrates the trend toward modularity, allowing flexible arrangements to accommodate diverse payloads (20). These structural interfaces are critical for rideshare missions, as they enable efficient stacking and integration of multiple spacecraft while maintaining compliance with dynamic and environmental constraints.

#### 10.4.2 Dispensers for Canisterized SmallSats

The purpose of this hardware is to eject the spacecraft safely into orbit, and most services offer different features, interfaces, connections, and designs for small spacecraft specifications. The most recent CubeSat Design Specification document is found at <http://www.cubesat.org>, a website maintained and operated by California Polytechnic State University, San Luis Obispo, the creators of the CubeSat form factor.

The CubeSat form lends itself to container-based integration systems, or dispensers, which serve as an interface between the CubeSat and the launch vehicle. It is a rectangular box with a hinged door and spring mechanism. Once the door is commanded to open, the spring deploys the CubeSat. Many companies currently manufacture dispensers for the CubeSat form factor which follow one of two constraint systems: the rail-type dispenser, and the tab-type dispenser. Due to the large number of dispenser manufacturers, the different companies are not listed here. Instead, a brief overview of the two types of dispensers is provided.

A rail-type dispenser (Figure 10.3) supports CubeSats that have rails, which extend the length of the CubeSat on four parallel edges. The rails on the CubeSat prevent it from rotating inside the dispenser. After the dispenser door opens, the rails slide along guides inside the dispenser and the CubeSat is deployed. As such, it is important that any rail-based CubeSat follow the current development specifications to ensure compliance. This type of dispenser is the most widely manufactured configuration, with more than fifteen manufacturers worldwide. Some rail-type dispensers use a clamping mechanism to securely hold the CubeSats in place during launch.

A tab-type dispenser (Figure 10.4) supports CubeSats with tabs which run the length of the CubeSat on two parallel edges. Typically, the dispenser grips the tabs to hold the CubeSat in place, only releasing it after the door has been commanded to open. More developers



Figure 10.2: {top} ESPA Ring  
{lower} ESPA Grande Ring. Credit: Moog, Inc.

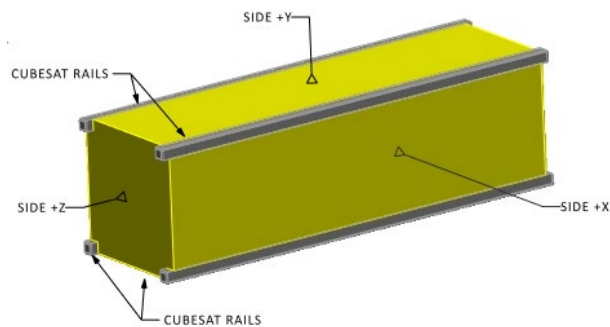


Figure 10.3: The Rail-type CubeSat. Credit: Cal Poly's CubeSat Program.



are beginning to develop their own tab-based designs for CubeSat dispensers. Many are based on the original Planetary Systems Corporation standard, however some offer features such as built-in isolation to accommodate for the launch vehicle environment such as the Maverick tabbed dispenser. In addition, there are some tab-based dispensers that do not grip the tabs. Rather, they provide a slot to accommodate the tab, which slides freely within the slot. While use of tab-type dispensers is growing, they remain a minority among dispensers purchased and used by developers.

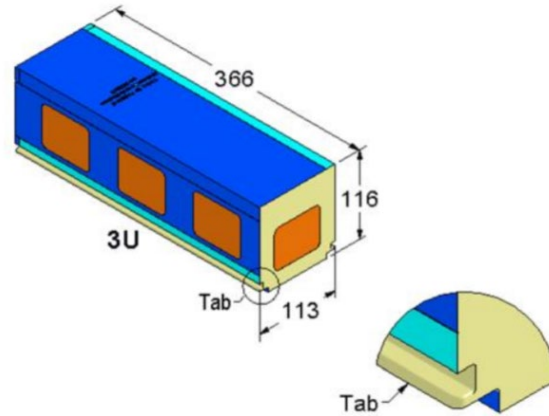


Figure 10.4: The Tab-type CubeSat. Credit: Planetary Systems Corporation.

While CubeSats generally design their spacecraft with considerations for either rail versus tab, the choice of the actual dispenser is commonly the launch vehicle provider or launch broker/integrator's. They determine which dispensers will be installed on the launch vehicle. As each dispenser manufacturer has slightly different volumes and requirements, it is beneficial to design the CubeSat for as wide a range of dispensers as possible to maximize launch opportunities. When selecting a dispenser, key considerations include size compatibility, deployment dynamics such as tip-off rates, initiator and door mechanisms, and compliance with safety and electrical inhibit requirements. Deployment profiles also differ between ISS-based and direct launch vehicle missions, and factors like reset capability and shock isolation can influence reliability and cost.

Additionally, some dispenser manufacturers have features that may violate the “do no harm” requirements set forth by the launch vehicle or launch integrator. Therefore, it is beneficial for the CubeSat to evaluate “do no harm” recommendations from a variety of organizations, as these requirements can vary from flight to flight on the same launch vehicle based on the risk posture of the primary payload and/or the mission “owner” (8).

Table 10-2 provides a non-comprehensive list of commercial dispensers that provide spacecraft physical and material requirements for integration. In response to the demand for larger CubeSats, dispensers for 12U and 16U CubeSats are now available through several launch service providers, including Voyager Space, United Launch Alliance (ULA) through the Atlas series, and a variety of European vendors.

<b>Table 10-2: Commercial Small Spacecraft Dispensers / Deployers</b>			
<b>Manufacturer Headquarters</b>	<b>Product</b>	<b>Volume Configurations</b>	<b>Type</b>
Cal Poly <sup>USA</sup>	Dispenser	1U, 3U	Tab
COMAT <sup>France</sup>	Dispenser	3U, 6U, 12U	Rail
Dhruva Space <sup>India</sup>	DSOD	1U, 3U, 6U, 12U, 16U	Rail
Exolaunch	EXOtube, EXOpod Nova Cubesat Deployer	0.25U, 1U, 2U, 3U, 6U, 6U XL, 8U, 12U, 16U	Rail
Gran Systems <sup>Taiwan</sup>	MyPOD and Test PODs	3U, 6U, 12U, 16U	Rail
ISISPACE <sup>The Netherlands</sup>	DuoPack, QuadPack	1U, 2U, 3U, 4U, 6U, 8U, 12U, 6UXL, 12UXL, 16U	Rail
Maverick Space Systems <sup>USA</sup>	Mercury series	3U, 6U, 6T, 12U, 12T, 16U	Rail, Tab



NPC Spacemind <small>Italy</small>	SMPOD	1U,2U,3U,4U,6U,6U XL, 8U, 12U, 12U XL, 16U	Rail
Rocket Lab <small>USA</small>	Canisterized Satellite Dispenser (CSD), and Advanced Satellite Dispenser (ASD)	3U, 6U, 12U  6U, expandable to 3U–12U	Tab
Tyvak <small>USA</small>	Railpod III, 6U NLAS, 12U Deployer	3U, 6U, 12U	Rail
UARX Space <small>Spain</small>	RAMI	1U, 2U, 3U, 6U, 12U	Rail
Voyager Space <small>USA</small>	NanoRacks CubeSat Deployer (NRCSD)	1U, 2U, 3U, 6U	Rail
Xterra <small>USA</small>	CubeSat Dispenser (XCD)	1U,2U,3U,6U,6UXL,8U,12U,16U	Rail

### 10.4.3 Separation Systems

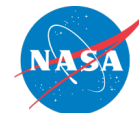
Small satellite missions that do not meet the CubeSat form factor or use a CubeSat dispenser for integration into the launch vehicle require a different separation mechanism. Separation devices for SmallSats generally follow either a circular pattern or a multi-point (three or four- point) pattern bolted to the launch vehicle. Depending on the launch vehicle or integrator, separation systems may already be in place and available to secondary spacecraft. It should be noted that separation systems are often among the most complex hardware involved in spacecraft launch operations. Prior to launch vehicle selection, NASA LSP recommends that the spacecraft team explicitly define the requirements for their separation system and properly evaluate the launch provider feedback to ensure compatibility.

If a spacecraft is given the option to bring its own separation system to launch, great care should be taken in its selection, including the development maturity and flight heritage of any separation system. Engineers must ensure the system is properly sized for the spacecraft's flange and load requirements, meets stiffness and strength criteria, and uses a low-shock release method to protect sensitive instruments. Additional considerations include tip-off rates, redundancy in initiators, electrical inhibit compliance, and integration compatibility with the launch vehicle. These factors are critical for mission success and should be addressed early in the design process.

Circular separation systems use two rings held together by a clamping mechanism and are more commonly used in ESPA-class and larger microsatellite missions. One ring is attached to the launch vehicle, and the other ring is attached to the spacecraft. Once the clamping mechanism is released, the two rings separate and are pushed apart by springs. Clamp bands are separation systems that hold a spacecraft tightly to the launch vehicle and transmit launch loads—the mechanical forces the spacecraft experiences during ascent (vibration, shock, axial loads, lateral loads). General rules of thumb: clamp bands are sized to ensure they can safely carry these launch loads without slipping, damaging the spacecraft interface, or overstressing the structure. They remain locked during ascent and then release via a tensioned band mechanism or frangible device once the spacecraft reaches orbit.

Marman band separation systems use energy stored in a clamp band, often along with springs, to achieve separation. The Marman band is tensioned to hold the spacecraft in place. Some Marman bands use pyrotechnic devices to cut the clamping bolt; however, many companies offer a low-shock release mechanism which is potentially better for spacecraft sensitive to shock.

Modern multi-point systems are made with low-shock mechanisms to minimize structural damage to sensitive electronics or optical hardware on the spacecraft, and are popular for small/mid-size spacecraft due to lower shock and modularity. Several companies are now providing multi-point separation systems instead of circular band systems. Using a multi-point separation system may



result in mass savings over a circular separation system. However, some systems require additional simultaneous signals from the launch vehicle provider to ensure proper release, such as the PSM 3/8B low-shock separation nut developed by Beyond Gravity to fit OneWeb satellites. ISISPACE has the M3S Micro Satellite Separation System (see Figure 10.5), which is designed for satellites up to 100 kg, but can be configured for higher masses.

The separation system directly influences—or impacts—the spacecraft loads on the launch vehicle. Given the stiffness and fundamental frequency requirements of traditional rideshare missions, many companies are favoring 4-point separation systems for MicroSats and SmallSats as a viable alternative to traditional MLB or clamp band systems. These systems function in a similar way to the systems above and are typically rated for microsattelites ( $\leq 100$  kg); however, offer less complexity than a traditional MLB or clamp band system. For example, EBAD's Payload Release Module has a 4-point spacecraft dispensing application and can accommodate lateral or axial separation.

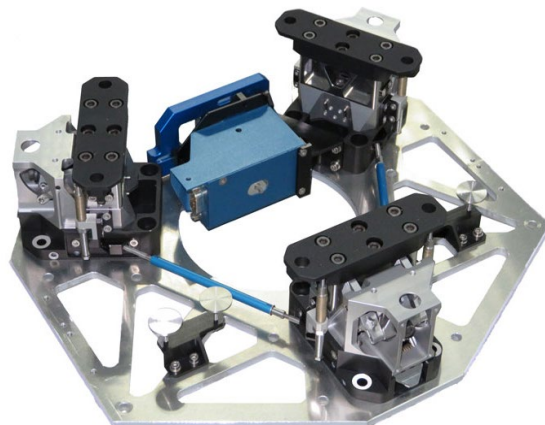


Figure 10.5: ISISPACE M3S Micro Satellite System. Credit: ISISPACE.

The rapid acceptance of this launch solution is driven by the fundamental frequency requirements of traditional rideshare launches, with the goal that reduced stiffness at the interface will increase the compatibility of SmallSats and MicroSats for those types of launches. In addition to reduced complexity, many of these also result in cost savings, which can be passed on to both the integrator and the SmallSat manufacturer. Many integrators are exploring the addition of such systems into their portfolios to accommodate launches in the near future.

### Cake Topper and Plate System for Rideshares

SpaceX has developed a system that differs from the SPA system for rideshare missions to SSO (Transporter Missions) and mid-inclination orbits (Bandwagon Missions). This system of plates rather than a ring is intended to allow more payloads to be included in the circumferential space for flight on their commercial rideshare missions. In addition, for larger spacecraft or spacecraft that cannot be horizontally mounted during flight, they also offer a cake topper option. Figure 10.6 shows these two options. The blue box shows the plate option, which has a specific set of rideshare loads for the mission's part of Transporter or Bandwagon missions. The green box denotes the cake topper option, which also has separate environments. User guides for both configurations are available on the launch provider's website. For missions that will fly under the VADR contract, please contact NASA's Launch Services Program (LSP) for additional guidance and applicable environmental constraints.

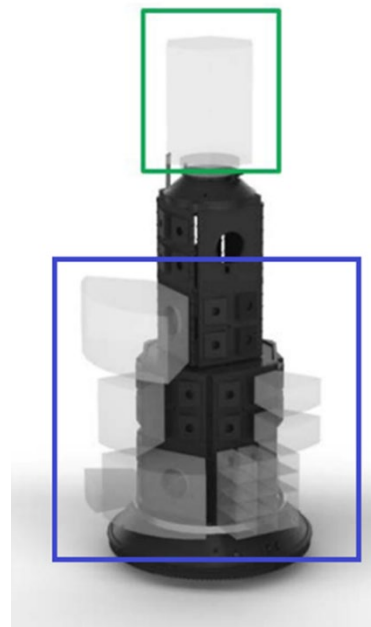
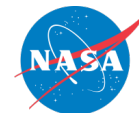


Figure 10.6: SpaceX cake topper (green) and Plate System (blue) configurations. Credit: SpaceX.

**Table 10-3: SmallSat Separation Devices**

<b>Manufacturer Headquarters</b>	<b>Product</b>	<b>Max Payload capacity (kg)</b>	<b>Type</b>	<b>Key features / Compatibility</b>
Beyond Gravity Switzerland	PAS 381S, PSR 1575 mm (62"), PSM 3/8B	200	Clamp band Multi-point	Vega rocket Moog ESPA
Ensign Bickford Aerospace & Defense (EBAD) <sup>USA</sup>	Payload Release Ring (PRR)-8	70	Hold-Down & Release	Configurable, based on the SpaceX electrical interface
	PRR-15 Release Ring	250	Hold-Down & Release	
	Payload Release Module	1000	Hold-Down & Release	Compatible with SpaceX Transporter 9 and Transporter 12 Rideshare missions
Exolaunch Germany	CarboNIX series	500	Clamp band	Any launch vehicle
	Quadro Arrow	250	Spring Pusher System	Supports SpaceX Transporter rides
	Quadro Versa	1000	Multi-Point	Compatible with SpaceX rideshare interfaces
ISISPACE <sup>The Netherlands</sup>	M3S Micro Satellite Separation System	120	Hold-Down & Release	Configurable and compatible
Rocket Lab USA	Mark II Motorized Lightband	1000	Clamp band	Configurable and compatible
	Advanced Lightband (ALB)	1000	Clamp band	Configurable and compatible
SAB Aerospace <sup>Italy</sup>	Vampire	1500	Clamp Band	Vega and Vega-C
Sierra Space	QwkSep LPSS	300	Clamp Band	Moog ESPA grande
UARX Space Spain	SAU&RON-8	80	Clamp Band	ESPA compatible
	SAU&RON-15	350	Clamp Band	
	SAU&RON-24	800	Clamp Band	

## 10.5 Orbital Transfer / Maneuvering Vehicles (OTV/OMV)

One of the main disadvantages of riding as a rideshare is the inability to launch into the desired orbit. For rideshares with a primary spacecraft, the primary mission determines the orbital destination, so the secondary spacecraft orbit usually does not perfectly match the needs of the secondary payload. However, by using an OTV or OMV, secondary spacecraft can maneuver much closer to their desired orbits. OTVs are generally more coarsely propulsion capable, while OMVs may offer hosted systems more in terms of power, pointing, and communications. The OTV/OMV market is nascent, with many planned systems but few with existing flight heritage. This emerging technology is an area of interest in the near term for both SmallSats and CubeSats, as it offers a significant capability to reach destinations not previously achievable with systems of this scale. The ability for small spacecraft to reach new orbits could enable a much wider range of mission designs for destinations both near and far.

The distinction between OTV/OMVs and hosted payload providers is not always clear, with many OTV/OMVs offering both the deployment of free-flying spacecraft at secondary orbits from the vehicle and the hosting of instruments or technologies that stay attached to the vehicle. Similar



OTV/OMV systems can be used to service other spacecraft, including deorbiting or relocation to a graveyard orbit. For information regarding those capabilities, refer to Chapter 13 *Deorbit Systems*.

Commercial delivery and deployment system launches have increased in frequency since the early 2020s. The vehicles that flew successfully in 2025 all had their pathfinders launched in 2023. Figure 10.7 is a launch timeline of OTV/OMVs with commercial payload services as part of the vehicle's documented purpose. This cadence is expected to continue upward as more vehicles become space-qualified and as new companies emerge. The data is derived from publicly accessible data and only includes launches by the providers described in this report. There may be more launches than indicated herein, and the success of the launch/mission is not accounted for.

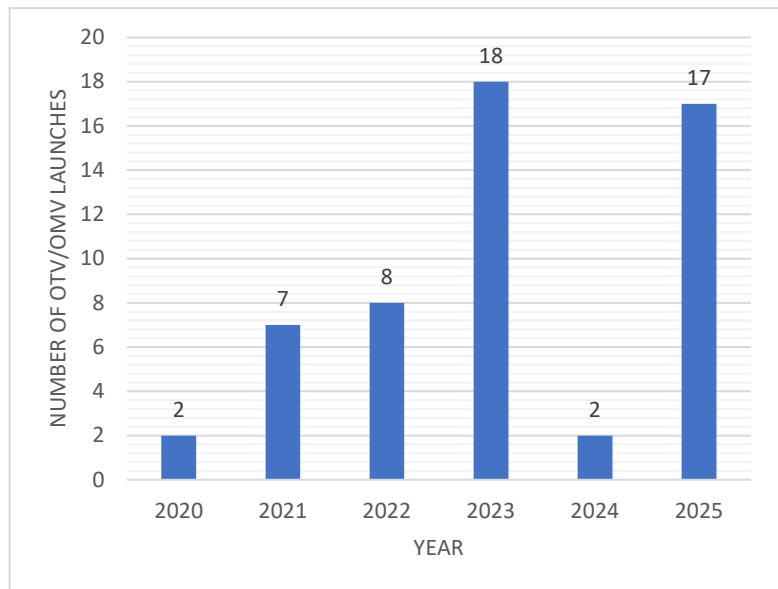


Figure 10.7: Number of OTV/OMV launches between 2020-2025. Credit: NASA

### 10.5.1 Commercial Development/Services

As discussed above, the ESPA ring provides a structure to which SmallSats or CubeSat dispensers are mounted. The idea of adding propulsion to an ESPA ring led to many of the early commercial OMV/OTV vehicle designs. Systems that were originally derived from the ESPA ring include the retired SHERPA vehicle by Firefly (previously Spaceflight Inc.) (28), the Northrop Grumman Space Systems (previous Orbital Sciences Corporation) ESPASat Product Line, and the Moog METEOR. The ESPASat product line has gone through multiple programs with multiple names. The ESPASat line has significant flight heritage from the Long Duration Propulsive ESPA (LDPE) satellites, now known as the Rapid On-Orbit Space Technology Evaluation Ring (ROOSTER) program of the United States Space Force (USSF). While the SHERPA system is no longer commercially available, Firefly is now offering rides on its Elytra OTV/OMV product line, which appears to build upon the ESPA ring heritage for specific compatibility with Firefly's small- and medium-lift launch vehicles. Rocket Lab is another launch provider offering an OMV/OTV platform. The Photon system is an evolution of the Electron launch vehicle Kick Stage.

Other systems are being developed from the ground up by commercial entities to provide orbital transport, hosting, and deployment services. For example, Northrop Grumman, in addition to its ESPASat series, has a proven Mission Extension Vehicle (MEV) that can host payloads, but is primarily developed to dock and extend the life of large GEO satellites. To date, the MEV has successfully extended the life of two Intelsat systems.

The current state-of-the-art OTV vehicle offerings tend to advertise thousands of km/s of delta-V, which enable the following services:

- Altitude change / planetary transfer – changing the altitude from where the vehicle was deployed by the launch vehicle. This could be an altitude raise or lowering operation, depending on the needs of the integrated payloads. In some cases, if escape velocity is



reached, this maneuver can be used to transfer to lunar orbits or beyond. A payload delivery and deployment vehicle could perform multiple altitude raises and lowers during a single mission.

- Inclination change – changing the angle of the orbit with respect to the angle at which the vehicle was initially deployed by the launch vehicle. This can be done during the same burn as an altitude change to increase efficiency, or as a standalone operation. This operation dramatically changes what is viewable on the ground swath of the orbiting spacecraft. It can also dramatically change the solar incidence of the orbit.
- Phasing – this refers to changing the position of a spacecraft within a given orbit. Assuming the same orbit of two spacecraft, the phasing of each of them would dictate at what time each of them is over a specific ground swath. This is typically achieved with a “slow-down” burn to achieve a smaller orbital period, and then a “recircularization” burn to return the spacecraft to its original orbit.
- Constellation deployment – this is the ability for a single payload delivery vehicle to drop multiple spacecraft into a constellation formation. This dramatically reduces the propulsive need of the individual small spacecraft and can enable constellations of small spacecraft to achieve much more than they could if they needed propulsion to deploy and phase themselves.

Many OTVs and OMVs are designed with a large excess propellant volume so that after the initial contracted services, the hosting vehicle can remain in orbit and be contracted for additional future services such as deorbiting via “pushing” another spacecraft or contracted inspection services. Some providers are developing systems specifically for these in-space services, including Astroscale, Starfish Space, and Turion Space. Technology gaps in the development of all these highly capable space vehicles include RF licensing challenges, ACDS component availability, reliable propulsion systems, and lack of standardization for payload interfacing.

The following sections contain an overview of commercial OTV/OMV vehicles and their development status, and Table 10-4 provides corresponding vehicle parameters.

### **Elytra**

The Elytra vehicle line is a series of orbital vehicles offered by Firefly Aerospace. The smallest vehicle is the Elytra Dawn, optimized for intra-LEO mobility. The largest vehicle is the Elytra Dark, which offers payload transportation to lunar orbit and beyond. The Elytra line builds on Firefly’s previous Space Utility Vehicle design and experience, as well as the Spaceflight SHERPA (Firefly acquired Spaceflight in 2023). The first Elytra Mission 1 is planned to fly on Blue Origin’s New Glenn rocket no earlier than 2026 to demonstrate rapid payload reconfiguration prior to launch, Firefly in-house technologies, as well as two on-orbit deployments. For more information, visit <https://fireflyspace.com>.

### **Chimera**

Epic Aerospace has a line of Chimera systems ranging from smaller LEO vehicles up to larger GEO-targeting vehicles. The LEO vehicles are intended to enable altitude changes from 450 km from the deployment location to larger, rapid and phasing maneuvers (3 hours of Local Time at Ascending Node (LTAN) change in less than 90 days is advertised). The GEO systems advertise capabilities beyond Earth, with trans-lunar injection from GTO/LEO as an option. The first LEO Chimera system was launched in January of 2023 and is currently operational, and the most recent launch was the Chimera GEO 1 in February 2025 as a rideshare payload. For more information, visit <https://epic-aerospace-web.netlify.app>.



## **ION**

The ION Satellite Carrier system by D-Orbit provides distinct LEO environments to customers and even offers in-orbit testing to third-party payloads. Missions with the same orbital plane can be released into their specific 'slots' without phasing maneuvers. Additionally, this system provides on-orbit advanced storage and computational capabilities.

The ION Carrier was first used in 2020 to deploy Planet Labs' constellation satellites and has been used 21 times as of December 2025 to deploy small satellites. The most recent flight occurred in November 2025, when two ION Carriers delivered eight missions to sun-synchronous orbit at an altitude of approximately 510 km. D-Orbit supported Europe's first Capture-the-Flag (CTF) cybersecurity competition that also occurred in November 2025, where seven ION vehicles provided telemetry for the realistic mission scenarios to identify and exploit vulnerabilities in space systems. For more information, visit <https://www.dorbit.space>.

## **Photon**

The Kick-Stage-derived Photon system is a flight-proven vehicle that deploys payloads to target orbits not otherwise achievable by the Electron launch vehicle. In addition, the system can be mounted on an ESPA port of other launch vehicles as a secondary payload. Rocket Lab advertises other vehicles alongside Photon that can be used for hosted payload services and orbital insertion services: the Explorer, Lightning, and Pioneer.

The Photon system has flown seven times as of March 2026; most recently in November 2025 with the ESCAPADE mission, which involved two spacecraft on modified versions of the Photon traveling to Mars to characterize the Martian atmosphere. For more information, visit [www.rocketlabusa.com/](http://www.rocketlabusa.com/).

## **Quark**

The Quark vehicles by Atomos (now part Katalyst Space Technologies) aim to offer many in-space services to small spacecraft such as deployment and orbit changes (raising, phasing, and inclination), rendezvous, docking, and satellite life extension. The first version, Quark-LITE, launched in spring 2024, and despite communication and tumbling issues, it successfully showcased rendezvous, docking, and refueling capabilities—laying the groundwork for more advanced GEO missions (29). Upcoming Atomos GEO-1 and -2 missions were planned to implement the Quark-Alpha with payload delivery to GEO by 2026, though the status is unknown.

## **Vigoride**

The Momentus Space Vigoride orbital service vehicle has flown three times with a maximum payload capacity of 750 kg to LEO, and can be launched from an ESPA Grande ring, SpaceX XL rideshare plate, or a dedicated launch vehicle. Propelled by a microwave electrothermal thruster, it enabled orbital maneuvers and payload deliveries. The first flight in May 2022 experienced a solar-array deployment anomaly, while two subsequent flights in 2023 were successful. Additional units like Vigoride-7 are slated for missions beginning in 2026. For more information, visit <https://momentus.space/>.

## **OSSIE**

UARX Space developed the Orbit Solutions to Simplify Injection and Exploration (OSSIE) orbital transfer and hosted payload vehicle. This spacecraft is designed to be modular and scalable to satisfy customer requirements by using either electric or chemical propulsion. The vehicle is designed to transport payloads of up to 400 kg and incorporates green propellant thrusters for orbital maneuvering. UARX Space leads the system architecture, mission design, and operational concept, with selected European partners contributing to specific subsystems, including



guidance, navigation, and control. The first OSSIE qualification mission, planned for launch in 2026, will demonstrate multi-customer operations, supporting 12 payloads ranging from PocketQubes and CubeSats to hosted payloads (31). For more information, visit <https://www.uarx.com/>.

### **Mira**

The Mira Orbital Transfer Vehicle by Impulse Space provides several specific services such as orbital transport, constellation deployment, payload hosting, deorbiting maneuvers, and others. Mira's first launch was in November 2023 (LEO Express 1) and has since then met all mission objectives over the course of nine months. LEO-Express-2 mission (also dubbed Remora) launched in January 2025 and involved Starfish Space's autonomous satellite guidance software that enabled the Mira vehicle to perform close-proximity maneuvers with another Mira vehicle (32). While the Mira vehicle was designed for payload hosting, deployment, and orbital adjustments, the Helios vehicle is a high-powered kick stage advertised to provide transportation services out to Cislunar environments. Helios uses a combination of liquid oxygen and liquid methane to transport more than 4,000 kg of payload from LEO to GEO in less than 24 hours. The first flight is planned for some time in 2026 (33). For more information, visit <https://www.impulsespace.com>.

### **Optimus**

Space Machines Company developed the Optimus vehicle to carry hosted payloads and perform close inspections of Client Space Objects (CSOs) in LEO. Optimus first operated in 2024 with 8 hosted payloads from international customers and was powered by a bi-propellant chemical propulsion system (34). Optimus is getting 'upgraded' with a "Block-2" platform for more agility and maneuverability for carrying sensitive sensors for detailed inspection images to be taken of satellites from 10 km. Optimus Viper is planned for the next launches in 2026 and 2027 to LEO mid-inclination and SSO orbits. For more information, visit <https://www.spacemachines.com>.

### **Blue Origin**

The Blue Ring space mobility vehicle by Blue Origin is advertised to provide in-space computing capability, hosting services, and delivery services for more than 3,000 kg of commercial and government payloads. Blue Ring aims to support missions in medium Earth orbit out to the cislunar region as a host spacecraft platform. It uses a combination of chemical and solar electric propulsion with rollout solar arrays. The maiden flight of Blue Origin's rocket New Glenn, DarkSky-1, launched in January 2025 with the Blue Ring pathfinder though a booster was lost during landing. In November 2025, New Glenn launched successfully a second time, including the reusable first stage, and will test Blue Ring's mission operation capabilities and core flight systems in space for the first time (36). Additionally, this launch carried and deployed NASA's Escape and Plasma Acceleration and Dynamics Explorers (ESCAPEDE) mission of twin-minisatellites that will study Mars's space weather.

### **Laelaps**

The Laelaps spacecraft by Kall Morris Inc. is designed for various on-orbit servicing capabilities that is built around a 15-inch ESPA-class satellite bus and equipped with a multi-armed, articulated robotic device called REACCH. By launching as a rideshare option on commercially available launch vehicles, Laelaps can relocate multiple objects in space with its onboard electric propulsion and REACCH. REACCH does not require any docking adaptor for a safe capture and release on-orbit and will maneuver functioning assets throughout LEO without affecting operability. For more information, visit <https://www.kmi.space/laelaps>.

**Table 10-4: Commercial Orbital Transfer / Maneuvering Vehicles**

<b>Company Headquarters</b>	<b>Vehicle</b>	<b>Heritage</b>	<b>Operational Altitudes</b>	<b>Maximum Payload Capacity (kg)</b>	<b>Delta-V (m/s, max payload)</b>
Atomos Space USA	Quark	Flown	LEO	400	-
Blue Origin USA	Blue Ring	Upcoming	-	-	-
D-Orbit Italy	ION	Flown Successfully	-	-	-
Epic Aerospace Argentina	Chimera LEO Block 0	Flown Successfully	+/- 450 km from LEO deployment	300	200
	Chimera LEO Block 1	Upcoming	+/- 450 km from LEO deployment	300	950
	Chimera GEO Block 0	Upcoming	GTO to TLI	300	1800
	Chimera GEO Block 0 / Bus	Upcoming	GTO to TLI	290	1800
Exolaunch Germany	Reliant Standard	Upcoming	+/- 275 km from LEO(?) deployment	200	-
	Reliant Pro	Upcoming	+/- 275 km from LEO(?) deployment	260	-
Exotrail France	Spacevan LEO	Flown Successfully	LEO (~400-2000 km)	~200	~500
	Spacevan GEO	Upcoming	Above LEO (e.g., MEO, GEO, Cislunar >2000 km)	~150	~2200
Firefly USA	Elytra Dawn	Upcoming	LEO	-	-
	Elytra Dusk	Upcoming	LEO to GEO	-	-
	Elytra Dark	Upcoming	LEO to Lunar/Planetary	-	-
Gilmour Space Technologies Australia	ElaraSat bus	Flown Successfully	LEO	30	-
Impulse Space USA	Mira	Flown Successfully	LEO	300	500
	Helios	Upcoming	GEO	-	-
Intuitive Machines USA	Nebula	Flown	MEO, GEO, Lagrange Points, NRHO, LLO	-	-
Kall Morris Inc. USA	Laelaps	Upcoming	LEO	-	-
Moog USA	SL-OMV	Upcoming	400 - 700 km	6 x 12 (+ additional, if containerized)	< 200

**Table 10-4: Commercial Orbital Transfer / Maneuvering Vehicles**

<b>Company</b> Headquarters	<b>Vehicle</b>	<b>Heritage</b>	<b>Operational Altitudes</b>	<b>Maximum Payload Capacity (kg)</b>	<b>Delta-V (m/s, max payload)</b>
	METEORITE	Upcoming	500 – 1200 km	100 (or more, with caveats)	>175
	METEOR	Upcoming	500 – 1200 km	750	>400
Momentus <sup>USA</sup>	Vigoride	Flown Successfully	250 - 2000 km (GEO and LLO also available)	800	< 2000
Rocket Lab <sup>USA</sup>	Photon	Flown Successfully	LEO, MEO, GEO, and beyond	-	-
Space Machines Company <sup>Australia</sup>	Optimus Viper	Flown	300 – 700 km	50	500
TransAstra <sup>USA</sup>	WorkerBee (multiple configurations)	Upcoming	LEO, MEO, GEO, HEO, Lunar/Planetary	200 – 2000	-
UARX Space <sup>Spain</sup>	OSSIE	Upcoming	350 – 1000 km	400	690
Quantum Space <sup>USA</sup>	RANGER	Upcoming	LEO, MEO, GEO, cislunar	6000	Up to 10 km/s

Information not disclosed or unknown is represented as -



## 10.6 International Space Station Options

The International Space Station (ISS) provides several methods for deploying CubeSats and SmallSats. The sections below discuss SmallSat deployment from the ISS as well as deployment above the ISS. The ISS also accommodates hosted payload instruments and experiments, but those accommodations are outside the scope of this chapter, as they are for individual instruments and experiments themselves and are not satellites.

### 10.6.1 Deployment from ISS

The ISS provides several options for deploying satellites. Generally, satellites are launched below the ISS to avoid potential contact with the ISS. Below are several options for launching from the ISS.

#### Nanoracks CubeSat Deployer (NRCSD)

Nanoracks CubeSat Deployer (NRCSD) (Figure 10.8) is a self-contained CubeSat dispenser system that mechanically and electrically isolates CubeSats from the ISS, cargo resupply vehicles, and ISS crew. The NRCSD is a rectangular tube that consists of anodized aluminum plates, base plate assembly, access panels, and deployer doors. The inside walls of the NRCSD are a smooth-bore design to minimize and/or preclude hang-up or jamming of CubeSat appendages during deployment, should they become released prematurely.

For deployment, the platform is moved outside via the Kibo Module's Airlock and slide table, which allows the Japanese Experimental Module Remote Manipulator System (JEMRMS) to move the dispensers to the correct orientation and provide command and control to the dispensers. Each NRCSD can hold six CubeSat units as large as a 6U (1 x 6U). The NRCSD DoubleWide can accommodate CubeSats up to 12U (2 x 6U) with Nanoracks being able to launch up to 48U per cycle. The CubeSats deploy at a 51.6° inclination, into a 400 – 420 km orbit 1 to 3 months after berthing at the station.



Figure 10.8: Nanoracks CubeSat Deployer. Credit: Nanoracks.

#### Nanoracks ISS MicroSatellite Deployment – Kaber Deployer Program

Nanoracks Kaber Microsat Deployer is a reusable system that provides command and control for satellite deployments into orbit from the Japanese Experimental Module Airlock Slide Table of the ISS. The Kaber supports satellites with a form factor of up to 24U and a mass of 82 kg and uses a Nanoracks separation system with a circular interface similar to the separation systems discussed above. Satellites are launched to the ISS on a pressurized launch vehicle, mounted to the Kaber deployer, and deployed outside the ISS (43).

#### JEM Small Satellite Orbital Deployer (J-SSOD)

The Japanese Experimental Module (JEM) Small Satellite Orbital Deployer (J-SSOD) is a Japanese Aerospace Exploration Agency (JAXA) developed CubeSat deployer used to launch CubeSats from the ISS. The J-SSOD can launch CubeSats up to the 6U form factor (2x3



configuration). The satellites, with their dispensers, are installed on the Multi-Purpose Experiment Platform prior to the Kibo's robotic arm Japanese Experiment Module Remote Manipulator System (JEMRMS) transferring the Multi-Purpose Experiment Platform (MPEP) to the release location. At that point, the CubeSats are deployed (44).

### **Bishop Nanoracks Airlock Module**

A new airlock module, Bishop, was developed for the ISS by Nanoracks, Thales Alenia Space, and Boeing, and is the first commercial, privately developed module for the space station. Bishop provides more than five times the volume of the current Japanese Experimental Module (JEM) airlock, allowing for larger satellites and payload experiments. Bishop can host satellites and payloads, as well as deploy them, based on the needs of the mission. It has been attached to the exterior of the ISS since December 21, 2020, and has been instrumental in deploying CubeSats from the ISS (46).

### **10.6.2 Deployment Above ISS**

Regular access to the ISS is very attractive for many satellite providers. However, the lower altitude of the ISS means the in-orbit lifetime for satellites is generally shorter. This section discusses the options that have been developed to deploy CubeSats above the ISS using a cargo resupply module.

#### **Nanoracks Interchangeable CubeSat Launcher (previously E-NRCSD)**

The Nanoracks Interchangeable CubeSat Launcher (NICL) is a system to deploy CubeSats into orbit above the ISS by using the Northrop Grumman Cygnus ISS Cargo Resupply vehicle. The first mission to use the ENRCSD was on the OA-6 mission in March 2016; the updated E-NRSD design (NICL) was scheduled to have its first flight in March 2023; however, the geopolitical situation between Ukraine and Russia has impacted the concept of operations that would have enabled this demonstration. Specifically, the ISS program currently will not allow the Cygnus mission to boost above the station to deploy CubeSats, so the NICL will be delayed until that changes.

In the past, up to 36U of CubeSats in any form factor up to 16U could be deployed above the ISS with each Cygnus mission. CubeSats are installed in the Nanoracks deployer and mounted externally to the Cygnus vehicle before launch. They remain external to the ISS for the duration of time that Cygnus is attached to the station, so the associated space environment should be taken into consideration when designing spacecraft (e.g., survival of spacecraft components in extreme temperatures, and unexpected behaviors or annealing of materials that undergo long durations of thermal cycling). The deployment altitude is dependent upon the propellant margins remaining in the Cygnus, but is typically 465-500 km, meeting a minimum of 45 km above the ISS altitude (47). It is hoped that this capability will return soon, allowing additional deployment options for CubeSats from the ISS.

#### **SEOPS SlingShot**

SEOPS SlingShot is a system to deploy CubeSats into orbit above the ISS using the Northrop Grumman Cygnus ISS Cargo Resupply Vehicle. The first mission to use the SlingShot was in 2019. SlingShot can fly up to 72U of CubeSats per Cygnus mission; the largest CubeSat form factor it can fly is 12U. This deployment method differs from the ENRCSD in that the satellites and their dispensers are flown to the ISS as pressurized cargo on a resupply mission. Astronauts remove the satellites and install the dispensers onto the Cygnus Passive Common Berthing Mechanism (PCBM) just prior to Cygnus' departure from the station. Once Cygnus departs the ISS, it raises to an altitude of approximately 500 km and deploys the CubeSats (48). As these CubeSats are hosted in a different location and manner than the ENRCSD CubeSats, it is possible



for Cygnus to carry CubeSats in both locations on a single mission. Due to the geopolitical situation in Europe, this capability is also on hold with the hope that it will return in the future.

## 10.7 Summary

The spacecraft launch market has adjusted to the increasing accessibility of spaceflight. Advances in technology and reduced launch costs have laid the foundation for this booming industry. Spacecraft constellations, typically ranging from a few kilograms to over 300 kg in mass, are driving much of this demand. Starlink's mega-constellation of 800 kg platforms represents more than half of all spacecraft launched in 2025. This trend is expected to accelerate in 2026, with significant expansion in both platform size and constellation scale.

To support this growing demand, a wide variety of launch mechanisms now make space more accessible for smaller missions. NASA's VADR launch services contract offers dedicated launches, anchor payload rideshares, and traditional rideshare options. Commercial providers like Rocket Lab and SpaceX deliver low-cost access to space, while expanded ridesharing opportunities now include more vehicles, orbits, services, and capabilities. The rise of commercial OMV/OTV services has enhanced the value of smaller missions by enabling longer mission lifetimes, greater capabilities, and orbital maneuvering for smaller spacecraft. The number of available commercial OMV/OTVs continues to grow, with new pathfinder designs launching this year.

In parallel, government and commercial sectors are investing in research and development for in-space services, including hosted payload rideshares and deorbit/reentry services. This surge in LEO spacecraft has amplified the importance of space situational awareness to ensure effective tracking, collision avoidance, and debris removal. Constellations continue to dominate the launch demand, driven by broadband communication networks and high-resolution imaging enabled by advancements in miniaturized technology. Furthermore, autonomous swarms of microsattellites are showcasing modern hardware and software capabilities, opening new frontiers for future multi-spacecraft missions (49).

For feedback solicitation, please email: [arc-sst-soa@mail.nasa.gov](mailto:arc-sst-soa@mail.nasa.gov). Please include a valid business email.

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