The advent of reusable commercial medium-/heavy-lift launch vehicles will drive growth in the small satellite (smallsat) industry by enabling low-cost access to space for constellation operators in geosynchronous orbits (GEO) and non-geosynchronous orbits (NGSO). Innovations in reusability, high-performance engines, and larger payload fairings are changing the economics of launch, providing significant value to smallsat operators. Reusable, medium-/heavy-lift launch vehicles like Blue Origin’s New Glenn and SpaceX’s Falcon offerings offer smallsat operators affordable access to space and significant value in the form of decreasing time to market, rapid fleet refresh, and solution scalability.

This article describes how the evolution of space launch capabilities will impact the smallsat industry. Specifically, it describes the developments in the launch services market, smallsat operator launch preferences, and the enabling role played by heavy-lift vehicles.
Introduction

Demand for commercial launch services has changed considerably from 2010 to 2020. Compared to the prior decade, there were more launches of large high-throughput satellite (HTS) geostationary systems and constellations of smallsats supporting a range of applications from communications to remote sensing. Moreover, several companies announced plans to deploy non-geosynchronous (NGSO) mega constellations of hundreds and, in some cases, thousands of spacecraft to service burgeoning connectivity markets. In fact, in the last 2 years, SES, Iridium, Telesat, OneWeb, and SpaceX deployed test and/or operational spacecraft for their respective NGSO systems. During the same period, changes to US Government policy further added to medium-/heavy-lift launch demand. For example, NASA drove additional demand by outsourcing the delivery of cargo to the International Space Station (ISS), and the US Air Force began competing launch services contracts. These policies increased the size of the addressable market and allowed for greater competition among established providers and new entrants. These shifts in US Government policy coupled with the evolution of commercial satellite architectures have changed the global launch services landscape.

Within the launch market, there are four categories of launch customer verticals addressable by US medium-/heavy-lift providers: (1) commercial, (2) US government civil (USG civil), (3) US government national security space (USG NSS), and (4) international civil/military. From 2010 to 2018, the number of addressable launches for US medium-/heavy-lift providers averaged 36 per year. (Note: Certain Ariane 5 missions to GTO count as dual launches.)

There was modest growth at approximately 3% year-over-year during this period. Growth is attributed to demand from the commercial and USG civil verticals. For reference, the total number of addressable launches to US-based commercial medium-/heavy-lift launch providers comprised about 40% of all global orbital launch events over the last decade. The other 60% of launches include those for governments with their own launch capabilities (e.g., Russia, China, France) and launches on small and light-lift vehicles (e.g., Minotaur, Pegasus).

As shown in Fig. 1, the commercial vertical was the largest in terms of volume of launches, representing roughly half since 2010. This vertical is primarily comprised
of operators of commercial communications satellites that operate in GEO, and each weighs between 3,000 and 6,000 kg.

Launch demand from commercial operators in particular is in the midst of a large transformation that could be defined by the proliferation of non-geosynchronous orbit (NGSO) constellations, primarily in LEO and MEO, and smallsats in GEO. Over the next decade, several companies plan to deploy large constellations of smallsats in LEO to provide global broadband connectivity services. Many of these constellations are so large that they require a significant increase in commercially available launch capacity to ensure that they can to deploy their targeted number of spacecraft to close their business cases and meet regulatory guidance. In fact, the growth of NGSO constellations in the commercial market could ultimately comprise a majority of future launch demand in the 2020s and beyond encompassing initial deployment, evolution, and replacement missions. In 2019 alone 120+ NGSO smallsats belonging to SpaceX and OneWeb were deployed. The numbers for 2020 were projected to increase sharply, but planned deployments were curtailed by the effects of the Covid-19 virus and the OneWeb bankruptcy.

Beyond LEO, operators are moving forward with plans to operate “Micro GEO” satellites weighing 300 to 1,500 kg and targeting niche connectivity applications. Start-up providers like Saturn, Astranis, and Ovzon are seeking to provide service to underserved areas of the world and for smaller national satellite communications projects, using satellite form factors that are 4 to 20 times smaller than traditional GEO satellite platforms and employing software-defined payloads. These spacecraft can offer significant and targeted bandwidth that can meet new and existing customer needs. Astranis’ spacecraft, for example, have ~7.5 gigabits per second of throughput capacity (Via Satellite 2019). These systems will require shared launches on medium—/heavy-lift vehicles to achieve greater cost savings. Micro GEOS may also require much more frequent refresh, especially when compared to large HTS and classical GEO systems, as their lifespans are expected to be about half that of legacy systems (~7 years instead of 15 years). Their size, refresh requirements, and need for fast time to market may ultimately drive demand for new launch approaches,
specifically for direct injections into GEO versus more classical transfer orbits. Eliminating electric orbit raising time and extending life on orbit are two major advantages of GEO direct missions, the benefits of which are enhanced given the size and expected lifespan of these small spacecraft.

### 2 Access to Space for Smallsats

Over the last decade, commercial interest in smallsats increased because they were considered relatively inexpensive, flexible, and easily upgradeable platforms (Avascent 2015). In swarms or constellations, smallsats also offer the advantage of disaggregation to large platforms. This changed operational risks and provided other commercial benefits (e.g., coverage, revisit, redundancy). Smallsat constellations are now viewed as complements to larger satellite systems and, in some cases, as substitutes.

The increasing capability of smallsats coupled with their attractiveness for commercial and government applications has accelerated demand for launch services to accommodate them. This has driven more interest and investment in (1) medium-/heavy-lift launch vehicles with bulk deployment capabilities, (2) small-/light-lift launch vehicles with targeted deployment capabilities, (3) ridesharing systems, and (4) managed services offerings.

These investments have increased the number of launch options available to smallsat operators. Today, they can launch on dedicated and multi-manifested/rideshare missions; they can buy launches directly from service providers or from brokers and third-party aggregators; and they can even outsource the space segment entirely to managed services providers, such as constosat operators like Loft Orbital.

Historically, satellite operators have used medium-/heavy-lift expendable launch systems for the initial deployment of satellite constellations to LEO and MEO orbits (refers to satellite constellation operators whose individual spacecraft have a mass of more than 100 kg). There are operators of satellites that weigh less than 100 kg, such as Planet and Spire, who have used a combination of medium-, light-, and small-lift vehicles to initially deploy, refresh, and augment their constellations. Smallsat constellation operator launch preferences are dictated by their manufacturing throughput, risk posture, time-to-market requirements, fleet size, and spacecraft mass/size (refers to satellite constellation operators with individual spacecraft mass of more than 100 kg).

Iridium, Globalstar, Orbcomm, O3b, and OneWeb all selected medium-/heavy-lift launch vehicles (Soyuz, Delta II, Falcon 9, Zenit, and Ariane 6) as the price per satellite and per gigabit deployed on orbit is lower compared to using small launch systems. Deployment schemes are derived from constellation architectures, including the number of planes, number of satellites per plane, and the mass and volume of the satellites.

With larger mega constellations, the use of larger, reusable heavy-lift vehicles can dramatically reduce capital expenditures for constellation operators by lowering launch costs, typically the largest single cost associated with deploying the
broadband satellite system. For example, New Glenn’s payload capability of up to 45 metric tons delivered to LEO, combined with a 7 m fairing that is twice the volume of the largest launch system operating today, will reduce per satellite launch costs and lower capital expenditure requirements for constellation operators like Telesat and OneWeb. Telesat’s Chief Executive Officer Dan Goldberg stated that they selected the heavy-lift New Glenn because “Blue Origin’s powerful New Glenn rocket is a disruptive force in the launch services market which, in turn, will help Telesat disrupt the economics and performance of global broadband connectivity” (Henry 2019).

Moreover, for many operators, time to market with an operational constellation is critical. Deployments that maximize the amount of spacecraft deployed in one launch event will dramatically reduce the time between concept development and commencement of operational services. Time to market for connectivity providers and imagery companies may further drive demand for new launch business models and procurement approaches.

3 Bulk Deployments, Multi-manifesting, and Ridesharing

Access to space for smallsat operators typically involves a trade-off between price and control over schedule/orbit. Many operators, especially those in early stages of system development and financing, sacrifice control over schedule/orbit for inexpensive launch services. This section explores three launch approaches that smallsat operators have adopted to deploy their smallsats and constellations.

3.1 Bulk Deployments

While the Geneva-based International Telecommunication Union’s (ITU) 2019 report on global broadband deployment stated that more than 50% of the world’s population now has access to the Internet, a large portion of those users are underserved, and more than three billion people remain unconnected. Satellites are a low-cost way to provide service to rural and underserved areas of the world where deploying fiber-optic cable is cost-prohibitive.

Demand to launch the initial population and replenishment of fleets of NGSO broadband constellations is expected to increase dramatically over the next decade to meet the growing demand for Internet connectivity around the world. Bulk deployments are launches that take nearly the entirety of launch vehicle’s performance to deliver large quantities of spacecraft. For example, SpaceX is currently bulk deploying its Starlink constellation on Falcon 9, as is Arianespace for OneWeb on Soyuz 2. Satellite operators, particularly those planning to offer broadband services, will require medium-/heavy-lift launchers for bulk deployment of their systems. These commercial operators will need access to low-cost launch systems that have the capability and availability to ensure continuity of coverage and service quality.
These NGSO spacecraft are expected to weigh between 100 kg and 1,000 kg, which necessitate launch systems with the most performance to orbit and fewest volume constraints. NGSO mega constellation operators intend to operate in multiple planes at varying altitudes and inclinations (e.g., mid-inclination LEO, SSO). Some operators will operate their satellites at low altitudes (sub 700 km) to ensure low latency and rapid reentry. While demand for constellation bulk deployments will grow, it could be variable on a year-by-year basis depending on refresh cycles. These operators require medium/heavy commercial launch services that offer low costs, high availability, and sufficient performance (mass/volume) to meet customer needs and regulatory deployment, service, and coverage requirements.

### 3.2 Multi-manifesting

Overall payload mass launched has continued to grow, both in the form of larger satellites and in the form of multi-manifested payloads. The increase in multi-manifested payloads has been influenced primarily by new NGSO satellite constellation launches, the growth in availability of capable smallsat platforms, increasing diversity in GEO broadband spacecraft, and a proliferation of rideshare options on existing and new launch systems.

Satellites planned for GEO will continue to be launched alongside co-passengers. Multi-manifested missions, like those launched on Ariane 5, will continue to be popular means to reaching orbit. In the near future, operators of micro GEO satellites and flexible light GEO spacecraft (FlexLight), which are characterized by their ability to reconfigure in orbit and offer flexible coverage, will seek multi-manifested approaches to reach orbit. Example FlexLight platforms include Thales Alenia Space’s Space Inspire, Airbus’ OneSat, and Boeing’s 702X platforms. (Note: Industry experts also refer to these FlexLight satellites as software-defined satellite (SDS). Such approaches can help ensure low-cost access to space for operators of large and small spacecraft in GEO.

### 3.3 Ridesharing

The market for rideshare launch services has grown significantly over the last decade. The onset of capable, smallsat form factors and the availability of affordable launch services for auxiliary payloads have increased the number of satellites launched globally. While the number of launches globally experienced modest growth, the number of payloads launched into space annually has increased dramatically. In fact, the annual number of payloads launched has more than doubled over the years 2012 to 2019 (Fig. 2).

Ridesharing capabilities and multi-manifesting are responsible for the democratization of access to space as well as new companies and business models, which is driving an unprecedented expansion in the quantity of satellites deployed over the last decade.
Rideshare is an approach to deploying multiple payloads into orbit on a single launch by leveraging excess capacity. Rideshares are defined as missions for non-primary payloads on a particular launch campaign (ULA 2015). For launch service providers, rideshare is a means of asset utilization.

There are several types of rideshares. There are launches of auxiliary payload rideshares, where one or more secondary payloads share a launch with a primary payload customer. There are dedicated rideshare missions, where there is no single primary payload that has priority rights; under this approach, mission capacity is shared between several satellites. Lastly, there are propulsive rideshares, where an auxiliary platform with propulsion is co-manifest alongside primary payloads. These propulsive systems offer independent orbit-tailoring and dispensing capabilities.

Ridesharing offers many advantages to satellite operators. It gives them access to an abundance of available flight opportunities across multiple vehicles. For certain missions, ridesharing on larger launchers may even enable some degree of weight and volume flexibility over smaller vehicles. But, perhaps most important, there is a perception of affordability versus dedicated launches. This perception is exacerbated when operators compare launches on smaller systems whose price per kg of payload to LEO, for example, can be eight times more expensive than options on medium—/heavy-lift rideshare alternatives.

At the same time, there are drawbacks to ridesharing. Historically, there has been limited price transparency, though SpaceX’s SmallSat Rideshare Program has challenged this notion directly by publicly announcing a $1 M per 200 kg price tag for capacity on Falcon 9 to SSO and mid-inclination LEO. There is also less orbit control, meaning satellite operators may need to trade a more optimized orbit that could be achieved on a smaller rocket for a less ideal orbit on a rideshare mission. Again, some companies, such as smallsat propulsion providers and on-orbit transfer companies (e.g., Momentus), those that offer last mile delivery with altitude

Sources: Blue Origin and Space Activities in 2019, Jonathan McDowell, Rev 1.3

Fig. 2 Launches and count of payloads deployed (2012–2019)
raising systems, believe this drawback can be solved affordably by adopting their respective products and services. Rideshare missions also have less schedule control, as they tend to be subject to vehicle availability and delays with the primary payload. Lastly, some rideshare missions have relatively inflexible contract terms and conditions, which can prove burdensome to satellite operators.

4 Conclusion

A key market-defining enabler of smallsat launch, whether bulk deployments, multi-manifested missions, or rideshare, is reusable medium—/heavy-lift launch vehicles. These systems offer unparalleled cost savings relative to expendable alternatives and have superior availability, as they are not constrained by manufacturing throughput or ultra-specialized supply chains. Moreover, vehicles with high-performing upper stage engines and large payload fairings will further enable smallsat operators to deploy systems that offer superior services and products to their respective customers.

On November 23, 2015, Blue Origin’s New Shepard suborbital rocket became the first launch vehicle to climb above the 100 kilometers Kármán line, the internationally recognized border between the Earth’s atmosphere and outer space, then return to safe land vertically. That same New Shepard booster and capsule repeated the achievement four more times with limited maintenance before being retired. SpaceX’s Falcon 9 medium-class launch vehicle first flew to space and landed successfully a month later in December 2015. Subsequent Falcon 9 and Falcon Heavy boosters have flown to space and back three times. Blue Origin is now completing design of the New Glenn heavy-lift system, which baselines a minimum of 25 reuses per booster. Following these successes, ESA announced their own reusable rocket engine development program dubbed Prometheus, and the French and German space agencies CNES and DLR have started work on a reusable first stage flight demonstrator named Callisto.

These medium—/heavy-lift reusable boosters were developed with the goal of dramatically lowering the cost of access to space for satellite operators and space agencies, allowing a thriving space economy to grow and flourish. For mega constellations their large architectures require both increased heavy-lift performance and more payload fairing volume to efficiently deploy and replenish constellation planes.

5 Cross-References

▶ Frequent and Reliable Launch for Small Satellites: Rocket Lab’s Electron Launch Vehicle and Photon Spacecraft
▶ New Launchers for Small Satellite Systems
▶ Retrofitting and Redesigning of Conventional Launch Systems for Small Satellites
▶ Smallsat Rideshares and Launch Aggregators
References

Avascent, *Space Market Disruption: The Smallsat Revolution*. (2015)

C. Henry, “Telesat signs New Glenn multi-launch agreement with Blue Origin for LEO missions”, *Space News*. (January 31, 2019)

J. McDowell, Space Activities in 2019, 12 January 2020, Rev 1.3

United Launch Alliance, *United Launch Alliance Rideshare Capabilities for Providing Low-Cost Access to Space*. (2015)

Via Satellite, *The Software-Defined Future of Satellites*. (2019)