SMALL SATELLITE MARKET INTELLIGENCE

Q3 2017

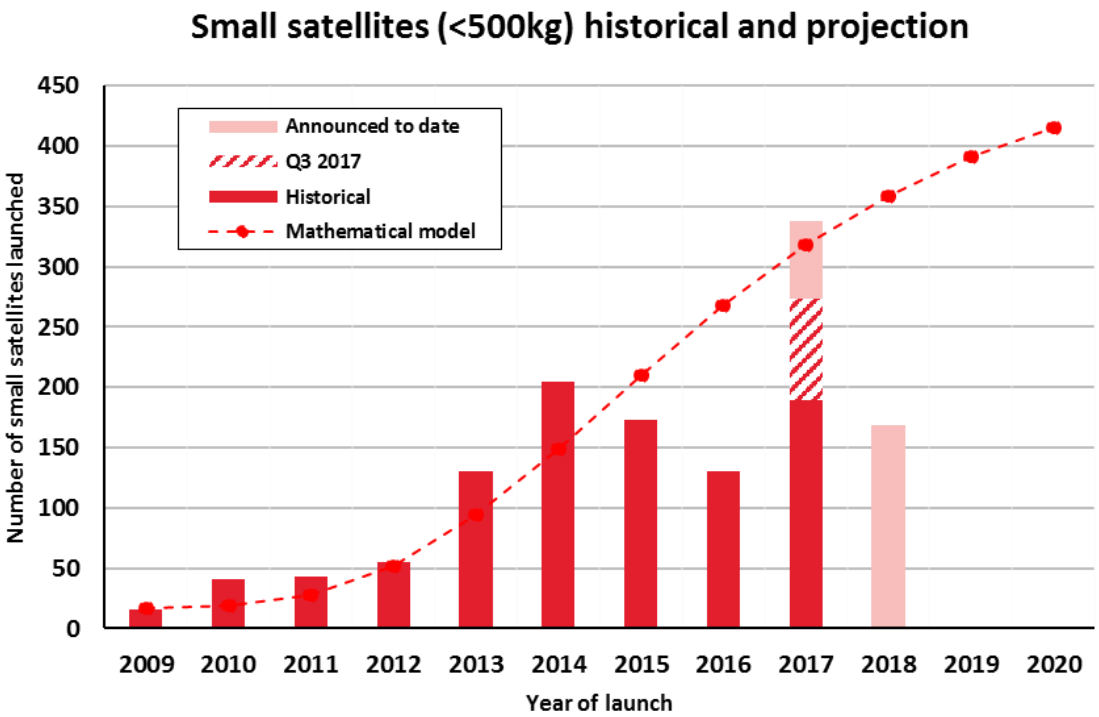
This second issue of the quarterly Small Satellite Market Intelligence report provides an update of the small satellites launched in Q3 2017 up to 30th September 2017. It also includes a closer look at small launch vehicles, an important enabler for more frequent and dedicated orbits for small satellites.

SMALL SATELLITES FACTS AND FORECASTS

OVERVIEW

Q3 2017 has seen the launch of 84 small satellites meaning 273 small satellites have been launched in 2017 so far, already breaking the 2014 record. Based on current announcements, this number is expected to rise to more than 300 small satellites launched by the end of 2017.

Accounting for all types (small and non-small satellites), 2017 is a record year for number of satellites launched since the first satellite Sputnik was launched 60 years ago in 1957[1].



The graph from last quarter has been refined to feature an updated mathematical model[2] and the number of small satellites announced to date. The mathematical model simulates a market uptake

[1] Adding the 20 Iridium-NEXT (10 launched in January and 10 in June 2017) to the 273 small satellites already breaks the previous 2014 record of 285 satellites. Source for 1957-2014 are Spacecraft Encyclopedia, 2015 had 202 and 2016 had 126 (although underestimated as per Catapult estimations) as per the 2017 SIA report.

[2] A Gompertz function, a proxy used to forecast market penetration, growth and maturation.

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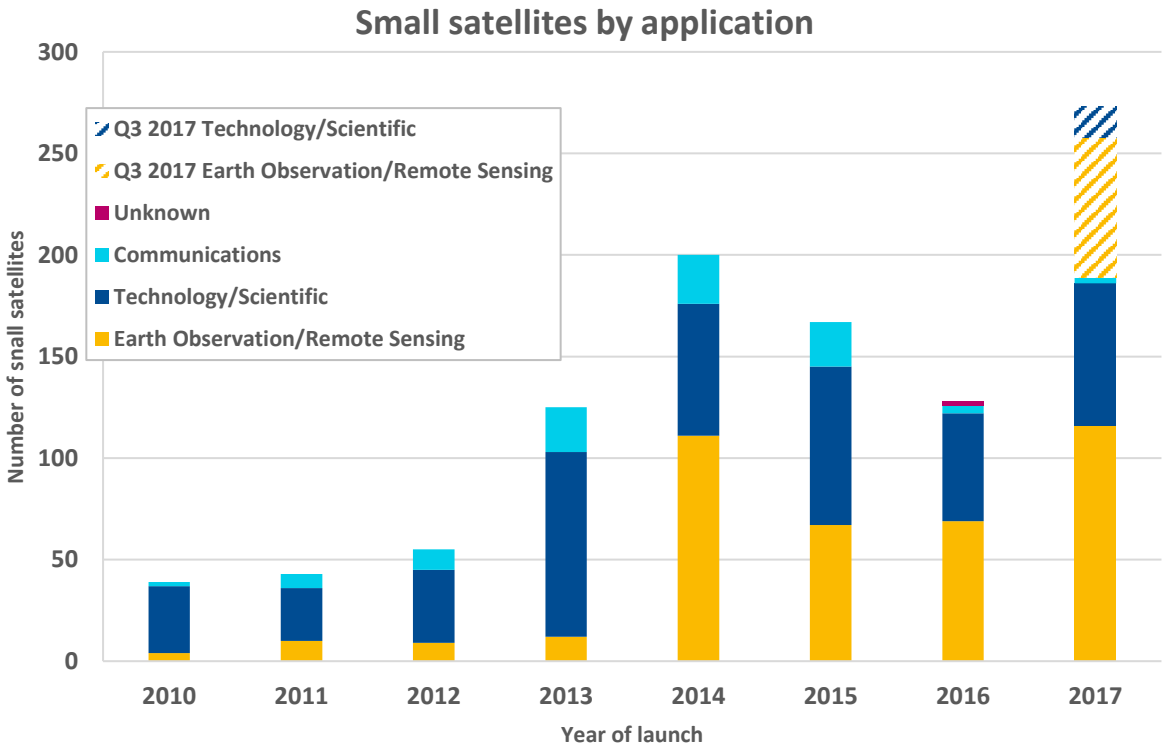
from the past 8 years followed by a levell off; while the trend is considered a good approximation, the launch failures of 2015 and subsequent 2016 delays have impacted that growth and explain the large offset with the mathematical model. The number of announced satellites to be launched is expected to change as launch slots become official and more information becomes publicly available.

Catapult estimates that around 1,300 satellites will be launched over the 2017-2020 period.

APPLICATION



Applications are defined by the primary objective of the mission with the following groupings:

- Communications: the objective of the mission is to transmit or receive signals to/from a user terminal or gateway;
- Technology/Scientific: the objective of the mission is to gather knowledge to better understand physical phenomena or to test the functionality of a payload or equipment;
- Earth Observation/Remote sensing: the objective of the mission is to provide imagery or data relating to the Earth or its atmosphere.

Earth Observation and Remote sensing are still the main drivers for small satellite launches with 82% of the satellites launched in Q3 being primarily for this application; 81% of this application subcategory is comprised by satellites from Planet and Spire (48 Doves and 8 Lemur respectively). Catapult expects satellites launched for communications to grow significantly in 2018 and start to dominate in 2019 with the maturation of players such as SAS, Kepler and other Internet of Things (IoT) companies.

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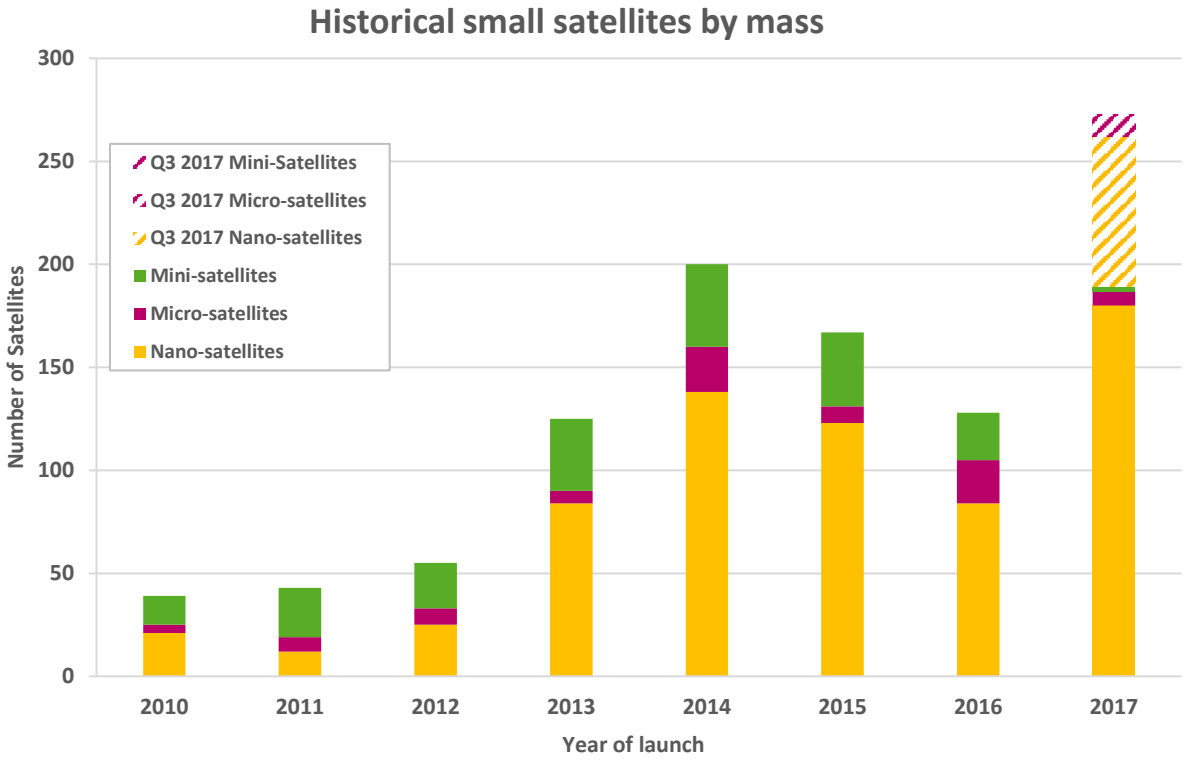
SIZE OF SATELLITES:

Nano-satellites still represent the majority of small satellites launched; approx. 93% of the total in 2017. This is due to the popular 3U form factor from Doves and Lemur, institutional missions, and the increasing use of 6U platforms (11 in 2017 vs 2 in 2016). Nano-satellites are expected to remain the main proportion launched in 2018 but this is expected to change when the announced mega-constellations of mini-satellites for telecommunications enter in 2019 and 2020.

Satellite classification	Satellite sub - classification	Associated wet mass range
Small Satellite < 500 kg	Mini-satellite	100 kg - 500 kg
	Micro-satellite	10 kg – 100 kg
	Nano-satellite	1 kg – 10 kg



A new indicator introduced is the total mass[3] of small satellites launched per year, valuable for small launchers. This indicator correlates quite well[4] with the number of satellites launched due to the similar size repartition every year. It illustrates the difficulty of reducing the launch costs for dedicated small launchers as the 3,700kg of small satellites launched up to Q3 2017 is small compared with the

[3] for CubeSats of unpublished mass, it was assumed that they massed 1.3kg per unit, leading to an uncertainty of ±1% in the total mass featured in the graph

[4] Pearson correlation factor of 0.8

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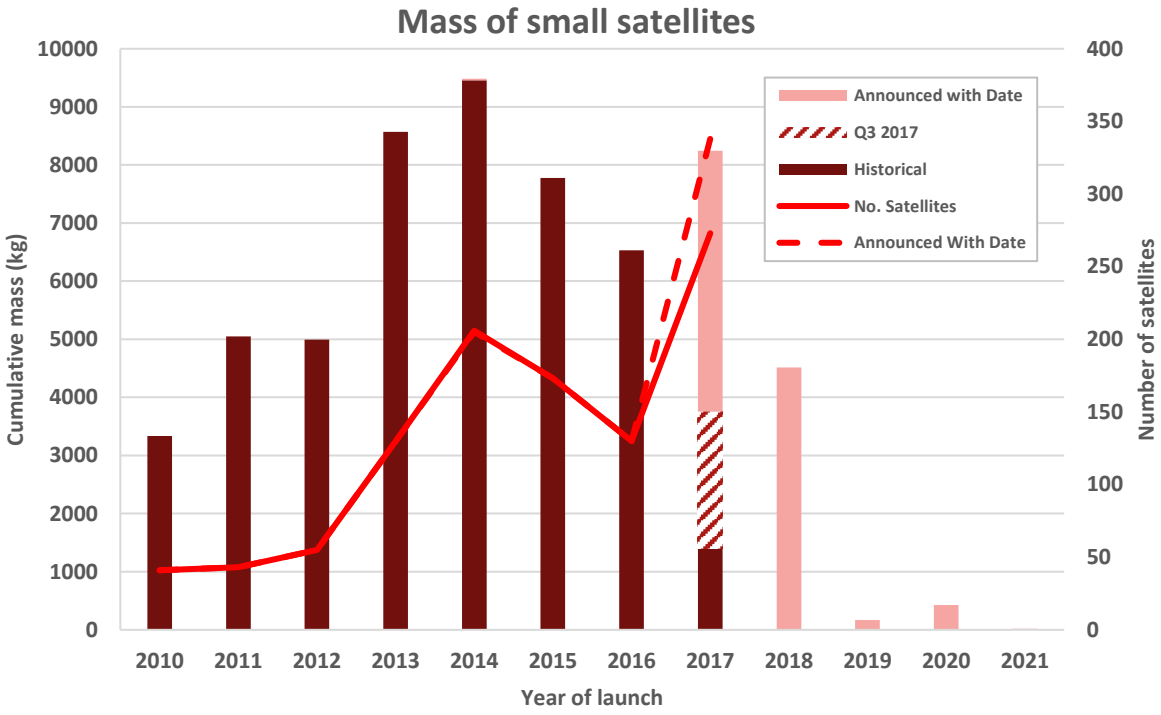
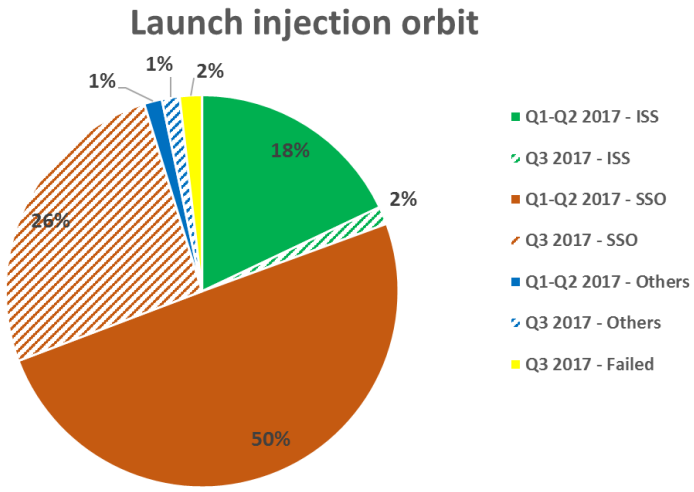
sole 6,400 kg ViaSat-2 launched in June 2017. It can also be seen that the majority of the mass to be launched is expected to come out of a minority of satellites to be launched Q4 2017.



ORBIT:

The SSO and ISS remain the most favoured orbits with respectively 76% and 20% up to Q3 2017. 73 satellites were launched by one single launcher, demonstrating the impact one failure could have on the uptake of the market.



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SMALL LAUNCH VEHICLES

As discussed in the *last quarterly report*, the Satellite Applications Catapult is tracking multiple small launch vehicles. Small launch vehicles, defined as offering a capability of no greater than 500kg to Low Earth Orbit, have the potential to address the proliferation of small satellites by offering dedicated and responsive launch services. This ad-hoc summary represents more information on small launch vehicles than in our previous issue.

HIGHLIGHTS

- 63 small launch vehicles were identified in this analysis, comprising:
  - 2 "*active*" small launch vehicles;
  - 59 small launch vehicles "*in development*";
  - 2 "*latent*" small launch vehicles (defined as previously active but not having flown in the last 5 years).
- By some distance, the highest number of small launch vehicles is coming from America (48%);
- 51% of small launch vehicles in development have progressed sufficiently to have run hot-fire engine tests.
- The majority of small launch vehicles (65%) will attempt vertical launch methods, just 11% are pursuing horizontal launch (including air-launch), and 10% are pursuing other launch methods (e.g. balloon assisted, from a submarine). For 14% of the small launch vehicles, the launch method is unknown.

BACKGROUND

This summary collected information on small launch vehicles across several metrics, including:

- Launch vehicle name;
- First launch date;
- Performance to LEO;
- Launch type;
- Launch site location;
- Cost per kg to LEO;
- Funding status;
- Development status.

Due to the relatively immature nature of the small launcher market, very few vehicles had data entries across all of these metrics. Data has been collected from publicly available sources, including company announcements, payload user manuals, academic studies, and market reports.

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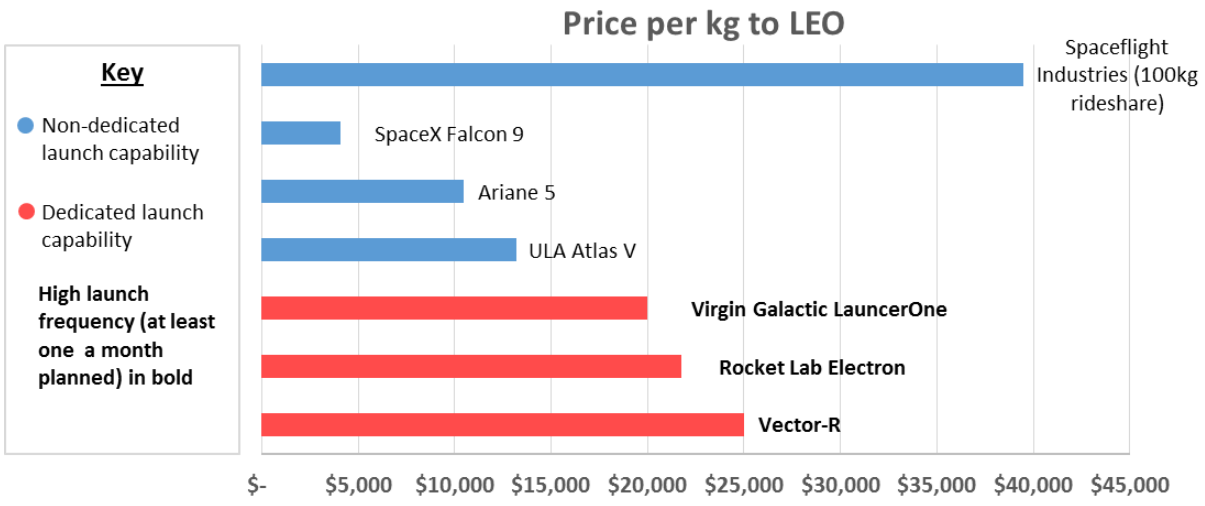
SUMMARY

Small launch vehicles (SLVs) are important to address the growing market for small satellites. Many small satellite operators would demand a dedicated and "responsive" (i.e. no long manifests or time waiting to launch) capability if it existed. However, there are currently only 2[5] small launch vehicles operational, defined as a launch vehicle which can lift no more than 500kg to LEO. A common misconception is that small launch vehicles will offer a cheaper alternative to existing launchers, however this is not the case at present. As the diagram below shows, small launch vehicles are generally more expensive than their larger competition, foregoing price in favour of the two previous metrics mentioned: the ability to offer dedicated and responsive launch.

This point is exemplified further by considering the success and prominence of the rideshare company Spaceflight Industries, despite their relatively high rideshare price. This could be explained by the "responsiveness" of their launch manifest. By way of showing this, Spaceflight Industries are still currently advertising 4 remaining CubeSat launches in 2017[6], whereas some launch providers have years of manifested launches to get through before they can serve new customers.



[5] Pegasus XL by Orbital ATK; Kuaizhou 1A by Expace/CASIC (first successful flight in January 2017).
[6] Spaceflight Industries, Launch Schedule. Accessed 2nd October 2017

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FUNDING

Launch vehicles have attracted significant amounts of private investment with a total of ~$190m[7] raised by companies developing launchers or offering launch services in the last year alone. Noticeably, RocketLab are categorised as a Unicorn[8] (valuation of over $1bn) and have raised $75m, Vector Space Systems have attracted investment from the famous Silicon Valley VC, Sequoia Capital, and in total raised ~$28m, and Virgin Orbit have raised PE investment from Aabar Investments. Other small launch vehicle companies to have raised private finance include PLD Space (GMV) and Orbex (HTGF).

With small launch vehicles being considered potentially risky investments by private capital markets, other companies have adopted different methods to try and raise the necessary finance, including plans to list on public exchanges (Orbital Access, Malta; Arca, State of New Mexico), meanwhile some small launchers are funded by government agencies, e.g. Simorgh / Safir-2 (Iranian Government), SS 520 4 (JAXA).

CAPABILITY

Whilst the capability of all small launchers is necessarily below 500kg to LEO[9], there is a slight divergence in capability at the high and low ends. 23 launchers have a payload capability no greater than 100kg, and 6 have a payload capability no greater than 10kg.

The data collected suggests that this capability divergence matches a divergence in price (SLVs with a low payload capability have a relatively high price per kg to LEO), and in forecast launch frequency (companies with a lower payload capability forecast a higher launch frequency – e.g. Vector R with a payload capability of 66kg to LEO and a forecast launch frequency of 100s per year; CubeCab with a payload capability of 5kg to LEO and a forecast launch frequency of 100 per year). Whilst, like much of the information which is self-reported by companies not yet having an operational orbital vehicle, these launch frequencies should be treated with caution, it is clear that the smaller the vehicle, the more flights per year are needed to close the business model.

TYPE OF LAUNCH VEHICLE

The vast majority of the launchers in development are adopting conventional means to orbit with vertical launch (65%), whilst 6 small launchers will be attempting horizontal launch (air-launch) and thus requiring a runway, and balloon assisted launch techniques are also being pursued.

[7] According to Seraphim Capital: Seraphim Space Index, July 2016 – June 2017
[8] Unicorn: a start-up company valued at over $1 billion
[9] One entrant, One Space Technology's OneSpace launcher, has been included in this analysis despite reporting a target payload capability of 700kg to LEO, due to exact payload capability depending on precise orbital parameters.

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LATENT LAUNCH VEHICLES

There are 2 latent small launch vehicles (payload capability no greater than 500kg to LEO; haven't flown in the last 5 years). These are commercialised Soviet ICBMs which were used for launching small satellites but are now no longer produced - the Shtil' and the Start 1.

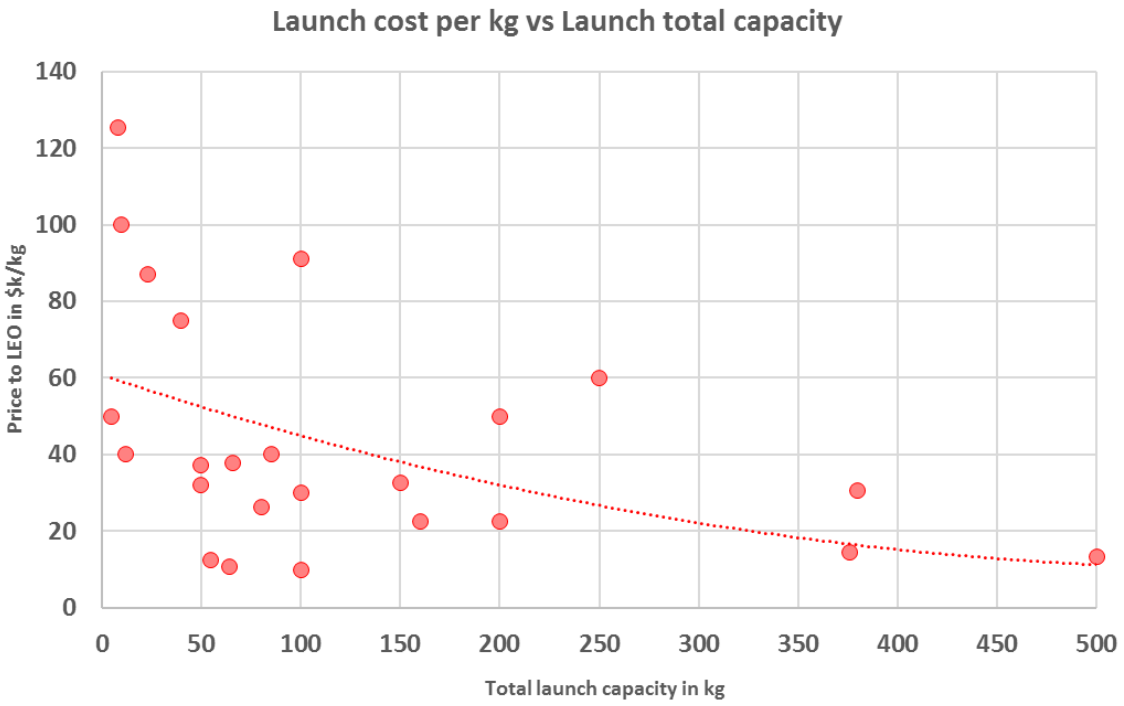
DEVELOPMENT

It is hard to define how well-progressed the small launch vehicles under development are. Some companies adopt a strategy of being very public with media announcements, whilst some are in "stealth mode" and not releasing much information. This creates inconsistencies in reporting on the development of the vehicles. However, one metric which can be considered to judge development is the completion of a hot-fire engine test, with almost half of the vehicles in development having completed an engine test.

PRICE

The average target price per kg to Low Earth Orbit across all of the small launch vehicles is $43,000, with a substantial range of between $3,000 and $125,000. These figures should be subject to some level of scrutiny, however, as there is potential that some prospective launch vehicle operators might be trying to make their vehicle sound more attractive than it could be expected to be once operational.

Whilst the relationship between launcher capability and price per kg to LEO fits an inversely proportional relationship, as should be expected, we expect there to be lots of imprecise estimates and examples of optimism bias of pricing on behalf of the individual small launch companies.



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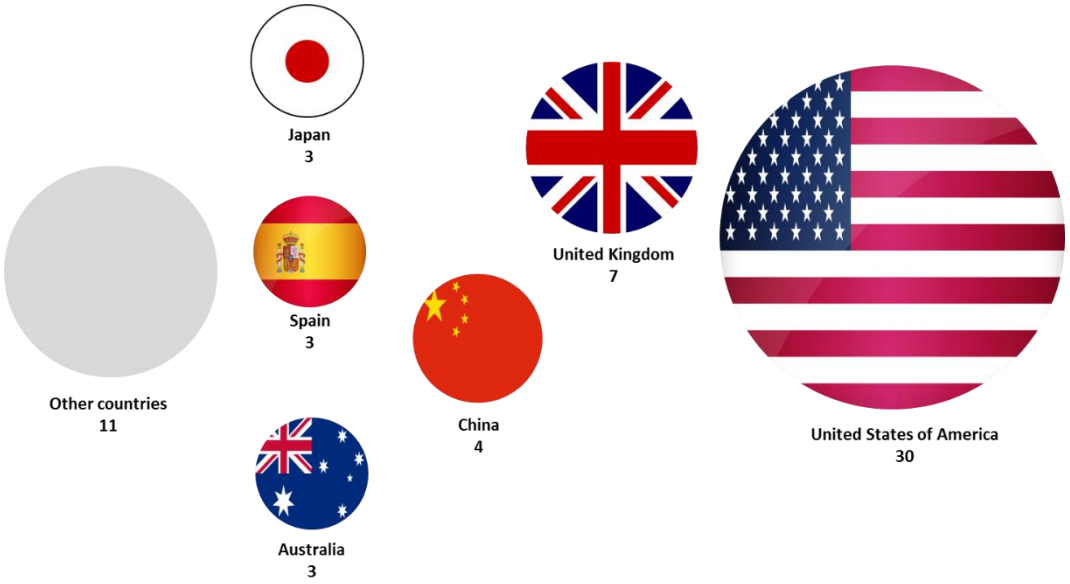
LOCATION

The vast majority of the small launch vehicles are originating from America, with 30 active or in development launchers. Secondly, the United Kingdom has 7 small launch vehicles in development. For a full list of all small launch vehicles by country see the table at the end of this summary.



Number of small satellite launcher in development per country

BRITISH SMALL LAUNCH VEHICLES

Perhaps spurred on by developments in the UK space industry promoting indigenous launch in the UK (see UK Space Agency satellite launch programme, and LaunchUK) through spaceports, it is not surprising that the UK has the second highest number of small launch vehicles in development. Whilst it is as yet unclear which vehicles will eventually be launching from UK soil, and indeed from which spaceports, the fact that there are at least 7 British small launchers in development highlights the extent of the indigenous capability.

Organization Name	Vehicle Name	Performance to LEO	Vertical/ Horizontal
Horizon Space Technologies	Black Arrow 2	350 – 500kg	Vertical
Tranquillity Aerospace	Devon Two	4 kg	Vertical
Orbital Access	Orbital 500	500 kg	Horizontal
SpaceLS	Prometheus-1	250 kg	Vertical
Orbex	-	100 - 220kg	Vertical
Massterra	MinSat-2000		Vertical
B2-Space	-		Other

British Small Launch Vehicles in Development[10]

[10] Note that there are several other small launch vehicles in development which have shown an intention to fly from British soil, but which are not considered "British" (e.g. Lockheed Martin's small launch vehicle).

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FULL LIST OF SMALL LAUNCHERS CONSIDERED IN THIS ANALYSIS

Organisation	Vehicle	Country	Status
Aphelion Orbitals	Feynman	USA	In development
ARCA Space Corporation	Haas 2C	USA	In development
B2-Space	-	United Kingdom	In development
Bagaveev Corporation	Bagaveev	USA	In development
bluShift Aerospace	-	USA	In development
bspace	Volant	USA	In development
Celestia Aerospace	Sagittarius Space Arrow	Spain	In development
Chinese Sea Launch	-	China	In development
CloudIX	-	USA	In development
CONAE	Tronador II	Argentina	In development
Conspire Technology	Aurora S	USA	In development
CubeCab	Cab-3A	USA	In development
Departamento de Ciencia e Tecnologia Aeroespacial	VLM-1	Brazil	In development
Equitorial Launch Australia	-	Australia	In development
EXOS	SARGE	USA	In development
Expace, by CASIC	Kuaizhou 1A	China	Active
Firefly Aerospace	-	USA	In development
Generation Orbit	GOLauncher 2	USA	In development
Gilmour Space Technologies	Eris	Australia	In development
Heliaq Advanced Engineering	Austral Launch Vehicle	Australia	In development
Horizon Space Technologies	Black Arrow 2	United Kingdom	In development
Independence-X Aerospace	Dedicated Nano Launch Vehicle	Malaysia	In development
Interorbital Systems	NEPTUNE N5	USA	In development
Interstellar Technologies	-	Japan	In development
Iranian Space Agency	Simorgh / Safir-2	Iran	In development
JAXA	SS 520 4	Japan	In development
LandSpace	LandSpace-1	China	In development
Leaf Space	Primo	Italy	In development
Lin Industrial	Taymyr	Russia	In development
Lockheed Martin	-	USA	In development
Massterra	MinSat-2000	United Kingdom	In development
MISHAAL Aerospace	M-OV	USA	In development
Moscow Institute of Thermal Technology	Start 1	Russia	Latent
Nammo	North Star Launch Vehicle	Norway	In development
New Ascent	-	USA	In development

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New Generation Small Rocket Development Planning	-	Japan	In development
Odyne Space	-	USA	In development
One Space Technology	OneSpace	China	In development
Open Space Orbital	Neutrino I	Canada	In development
Orbex	-	United Kingdom	In development
Orbital Access	Orbital 500	United Kingdom	In development
Orbital ATK	Pegasus XL	USA	Active
PLD Space	Arion 2	Spain	In development
Relativity Space	-	USA	In development
Rocket Lab	Electron	USA/New Zealand	In development
Rocketcrafters	Intrepid-1	USA	In development
RocketStar	Star-Lord	USA	In development
Scorpius Space Launch Company	Demi-Sprite	USA	In development
SMILE - Small Sat Launcher	-	Norway	In development
SpaceLS	Prometheus-1	United Kingdom	In development
State Rocket Center Makeyev	Shtil'	Russia	Latent
Stofiel Aerospace	BOREAS	USA	In development
Swedish Space Corporation	Rainbow Smallsat Express	Sweden	In development
Tranquility Aerospace	Devon Two	United Kingdom	In development
U. Hawaii, Aerojet Rocketdyne, Sandia	Super Strypi	USA	In development
Unreasonable Rocket	Unreasonable Rocket	USA	In development
UP Aerospace	Spyder	USA	In development
VALT Enterprises	VALT	USA	In development
Vector Space Systems	Vector R	USA	In development
Ventions LLC	SALVO	USA	In development
Virgin Orbit	LauncherOne	USA	In development
Whittinghill Aerospace	Minimum Cost Launch Vehicle	USA	In development
zero2infinity	Bloostar	Spain	In development

Disclaimer: whilst every effort has been made to provide accurate and up to date information, we recognise that this might not always be the case. If any reader would like to contribute edits or suggestions to our reports, kindly email the team and we will make the amends.

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The Small Satellite Market Intelligence report is designed as a free data source to share information that is easy to access and use. We welcome feedback on other data points that would be of value to include. You can contact us at:

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