FROST & SULLIVAN

UK Spaceport Business Case Evaluation

A Frost & Sullivan White Paper

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50 Years of Growth, Innovation and Leadership

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OBJECTIVES & METHODOLOGY

- Frost & Sullivan was commissioned by the UKSA to assess the potential UK market share for dedicated launch services to support the business case for UK investment in a spaceport.
- Frost & Sullivan leveraged its existing database related to small satellites and launch services and conducted primary research with the small-satellite supply chain to evaluate the critical success factors and establish the challenges to UK success.
- The project includes a model that assesses the likely supply (launch capacity) and demand (satellite operator constellation plans) to 2030 and an explanation of the factors supporting or limiting the UK business case.

EXECUTIVE SUMMARY

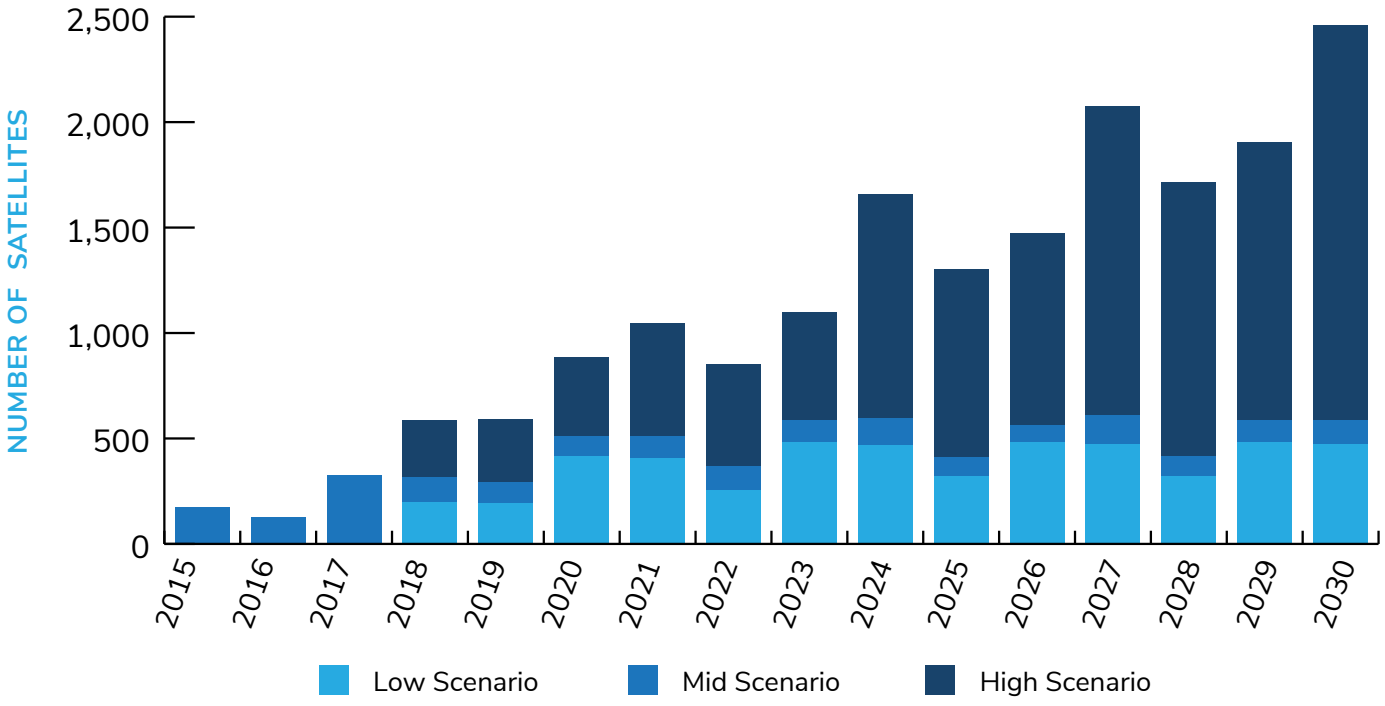
- The analysis concludes that there is an opportunity to invest in a spaceport for the small satellite launch services market.
- Frost & Sullivan estimates that the total UKSA addressable small satellite launch market for 2021–2030 is $5.5 billion (cumulative, refer to Slide 21). This is against a global high scenario of $115.9 billion over the same period, including large planned constellations such as SpaceX, which are unlikely to be addressed by the UK space launch capability.
- The current high estimate for the number of small satellites launched during the forecast period 2018–2030 is 17,374, with more than 70% of the satellites in the <250 Kg weight class.
- More than 30 small-satellite operators plan to launch their low earth orbit satellite constellation, amounting to a total of 7,217 satellites. These satellites have two to five years of satellite life and will generate recurring demand for the replacement missions.
- The existing rideshare capacity, with 5% annual growth, is capable of meeting less than 35% of the total small-satellite launch demand.
- Although the market has high entry barriers, more than 40 small-satellite launch vehicles are under development and plan to address future small-satellite demand through dedicated services. To this extent, Frost & Sullivan concludes that the market can be competitive, albeit between a small number of providers.
- The two major unmet needs of the small-satellite operators are the launch orbit requirement and near-zero launch wait period. The existing rideshare launch services do not address these requirements as small satellites are the secondary payload for their mission.

MARKET FOR SMALL-SATELLITE LAUNCH SERVICES

Commercial small-satellite constellations and dedicated launch services will drive the future small-satellite launch market

- The number of small satellites launched in 2017 grew by 157% from 2016.
- The major reason for the growth is the constellation installation by commercial small-satellite operators.
- Thirty-one constellation operators, amounting to more than 7,000 satellites, are in the hardware development and demonstration phase and plan to install their satellites during the forecast period (2018–2030). The major launch services demand will come from these constellations for the new installation and the replacement missions.
- The existing rideshare capacity is not sufficient to meet the constellation requirements of high-frequency launch and the mission requirements. Therefore, multiple existing and new launch service providers are developing new launch vehicles (more than 40) to address the small-satellite launch service market through a dedicated launch service.

Small-satellite Launch Demand



LAUNCH & REVENUE FORECAST

Forecast Assumptions

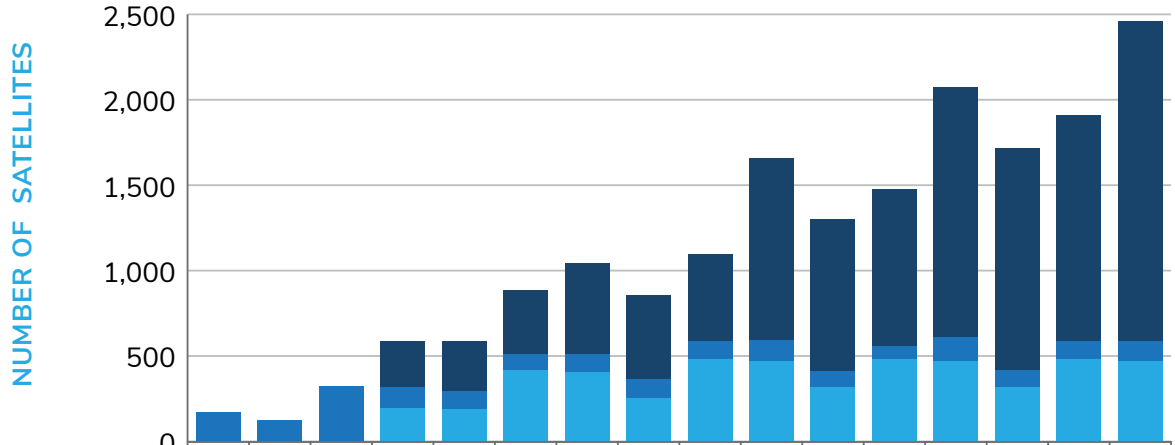
Small-satellite Launch Forecast:

- **Low Scenario:** Includes small satellites from operators that have announced constellations and have a launch history in the 2015– 2017 timeline
- **Mid Scenario:** Includes small satellites from operators that have not announced constellations but have a launch history in the 2015– 2017 timeline
- **High Scenario:** Includes small satellites from operators that have announced constellations but have no launch history in the 2015– 2017 timeline
- **F&S forecast** is the sum of the low and mid scenarios and a part of the high scenario. The probability of success of significantly large commercial operations announced (but not launched yet) is taken into account.

Small-satellite Launch Capacity Forecast:

- **Rideshare:** Includes small satellites launched by existing launch service providers carrying small satellites as secondary payloads. The forecast assumes a standard 5% year-on-year growth.
- **Dedicated Services:** Includes small satellites launched by new participants looking to enter the market. The growth rate assumes a 5% year-on-year growth in launch capacity. The model also accommodates step changes based on the entry of every new participant in the dedicated services market as defined below:
  - Year 2019, Rocket Lab dedicated services, adding 65 satellites to the capacity.
  - Year 2020, US Spaceports1 & ISRO, adding 120 satellites (48 US & 72 ISRO) to the capacity.
  - Year 2021, US Spaceport2 & UK Spaceport, adding 142 satellites to the capacity (UK-96, US-46).
  - Year 2022, US Spaceport3 & Sweden/Norway Spaceport, adding another 100 satellites to the total capacity.

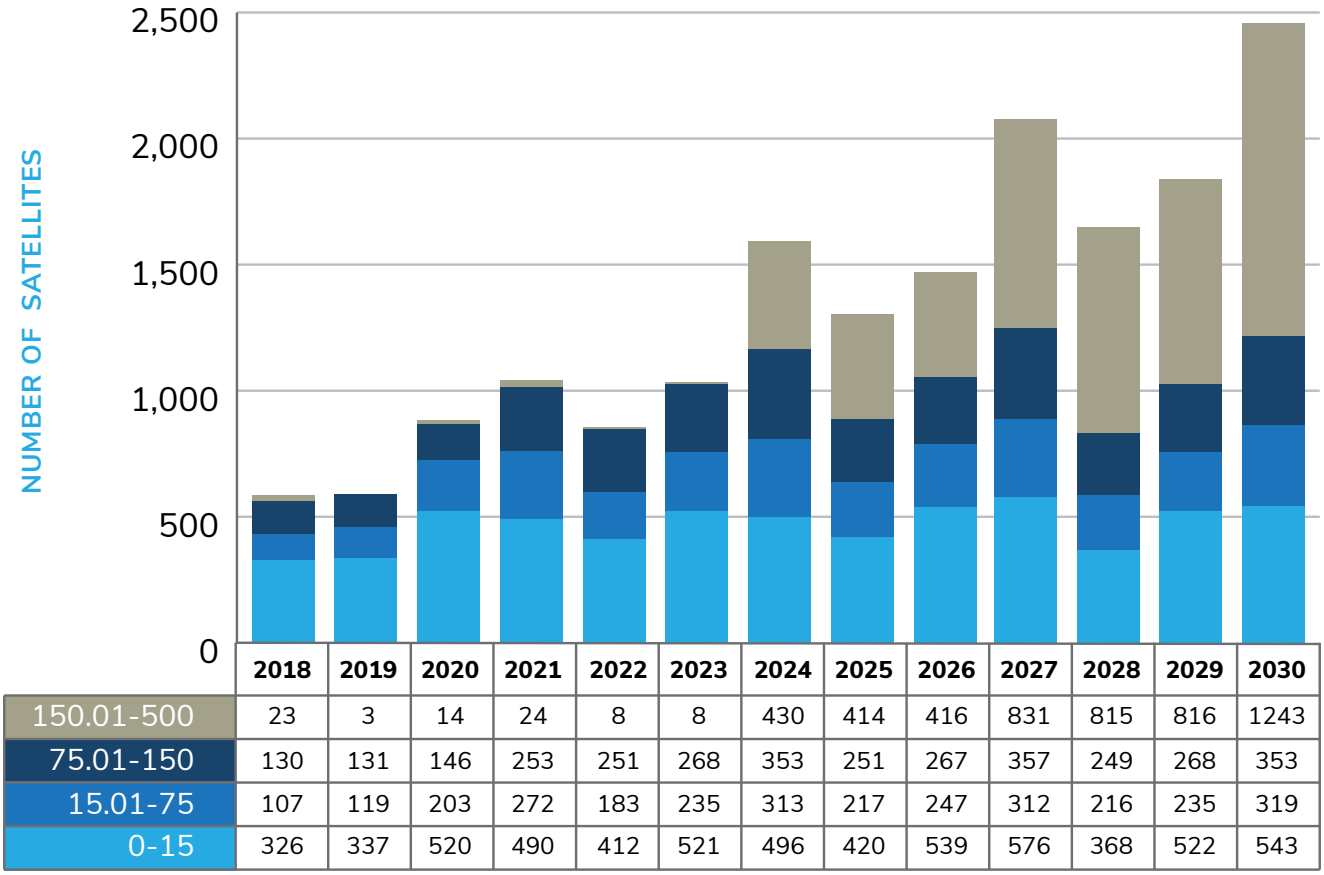
Total Small-satellite Launch Forecast (Total Launch Demand): Number of Satellites (2015–2030)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High Scenario				268	298	371	537	487	511	1063	891	914	1467	1295	1318	1871
Mid Scenario	171	126	325	122	100	96	103	111	106	126	92	81	139	98	108	116
Low Scenario				196	192	416	406	256	480	469	319	480	480	320	481	471

Source: Frost & Sullivan

Total Small-satellite Launch Forecast (Low, Mid, and High): Number of Satellites by Weight Class (2018–2030)

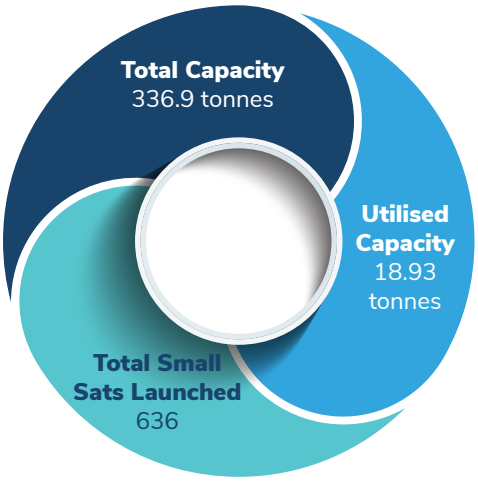


	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
150.01-500	23	3	14	24	8	8	430	414	416	831	815	816	1243
75.01-150	130	131	146	253	251	268	353	251	267	357	249	268	353
15.01-75	107	119	203	272	183	235	313	217	247	312	216	235	319
0-15	326	337	520	490	412	521	496	420	539	576	368	522	543

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0–250 Kg	575	587	876	1028	849	1028	1178	896	1060	1261	840	1032	1238
250.01–500 Kg	11	3	8	12	5	5	415	406	410	815	810	809	1220
Total	586	590	883	1040	854	1032	1592	1303	1470	2076	1649	1841	2458
% of Satellites <=250Kg	98.1%	99.5%	99.2%	98.9%	99.4%	99.6%	74.0%	68.8%	72.1%	60.7%	50.9%	56.1%	50.4%

Source: Frost & Sullivan

Summary of Historical LEO Launch Capacity: Small Satellites Remain a Secondary Payload on Rideshare, Totalling Only 5.6% of the Total Launch Capacity

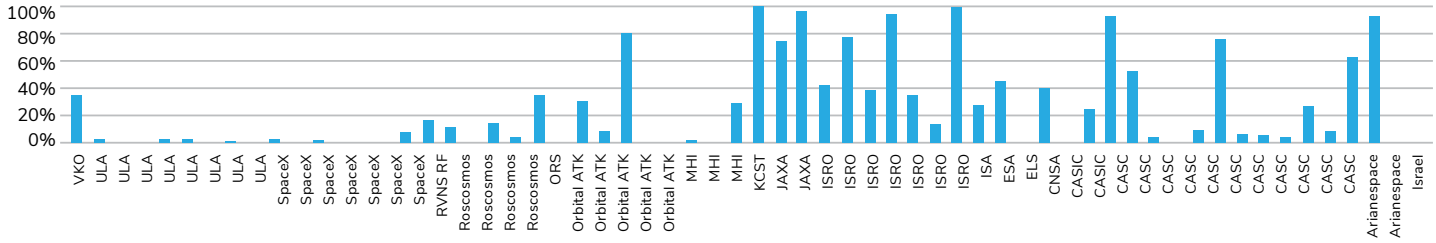


Total Capacity	• 336.90 tonnes launched to LEO, covering 60 launches (covers both primary and secondary payloads) in the 2015–2017 timeline • 19 launch service providers delivered this capacity to LEO
Utilised Capacity	• 18.93 tonnes utilised to launch small satellites across 60 launches • Utilised capacity adds up to 5.6% of the total launch capacity between 2015 –2017
Total Small Sats Launched	• 636 small satellites across 60 launches in the 2015–2017 timeline • 103 is the highest number of small satellites launched in one launch (PSLV/ISRO)

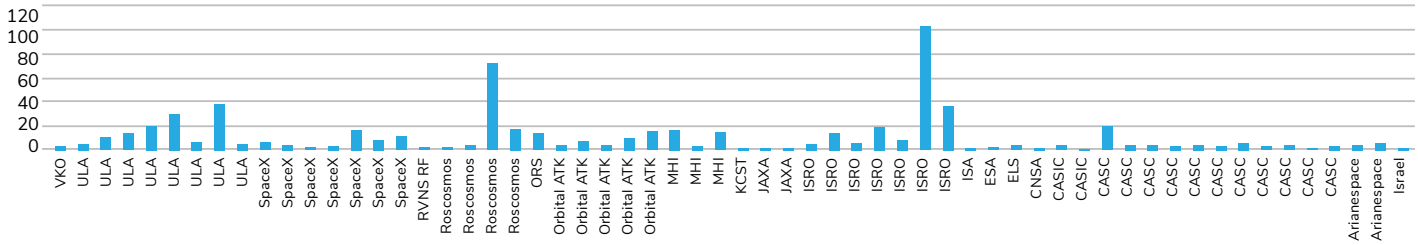
Source: Frost & Sullivan

The Low Number of Launches and Options from 2015 to 2017 Does Not Meet Current Market Requirements for Dedicated Orbit and Increased Availability

Small satellites as a % of total weight

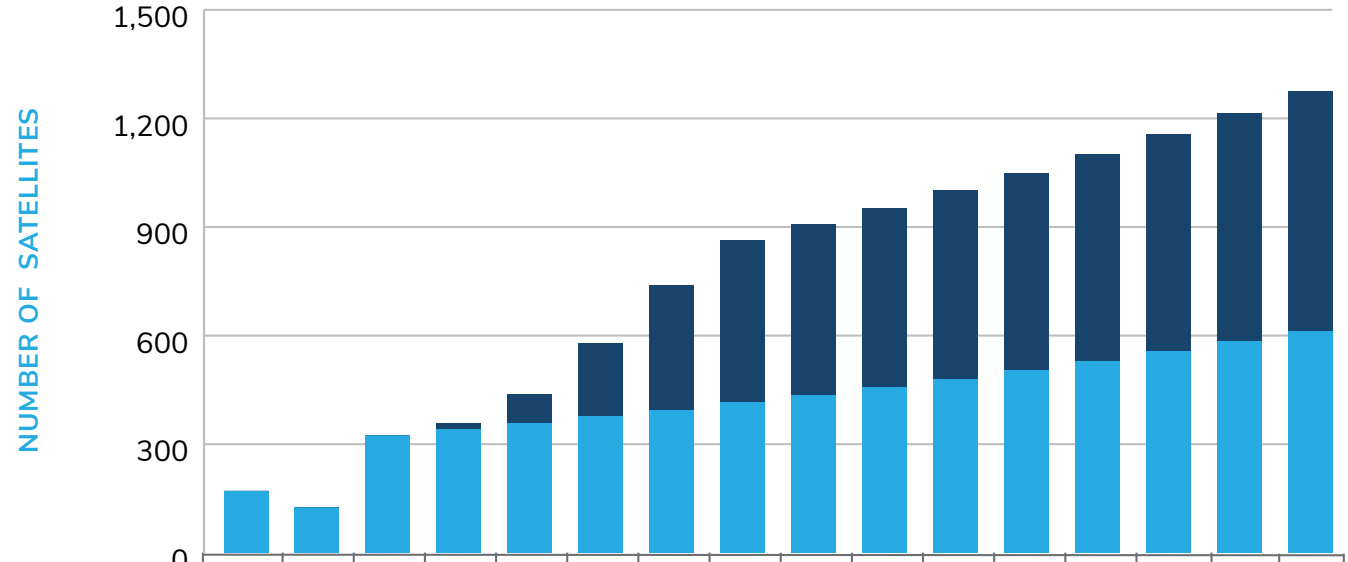


Number of satellites on the launch service



Note: All the launches during the period 2015–2017 carrying at least one small satellite are plotted.
Source: Frost & Sullivan

Global Launch Capacity Forecast, Rideshare vs. Dedicated Services



	2018	2019	2020	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Dedicated Services				16	81	203	345	449	471	495	520	546	573	602	632	663
Rideshare	171	126	325	341	358	376	395	415	436	457	480	504	529	556	584	613

Small-satellite Launch Capacity Forecast:

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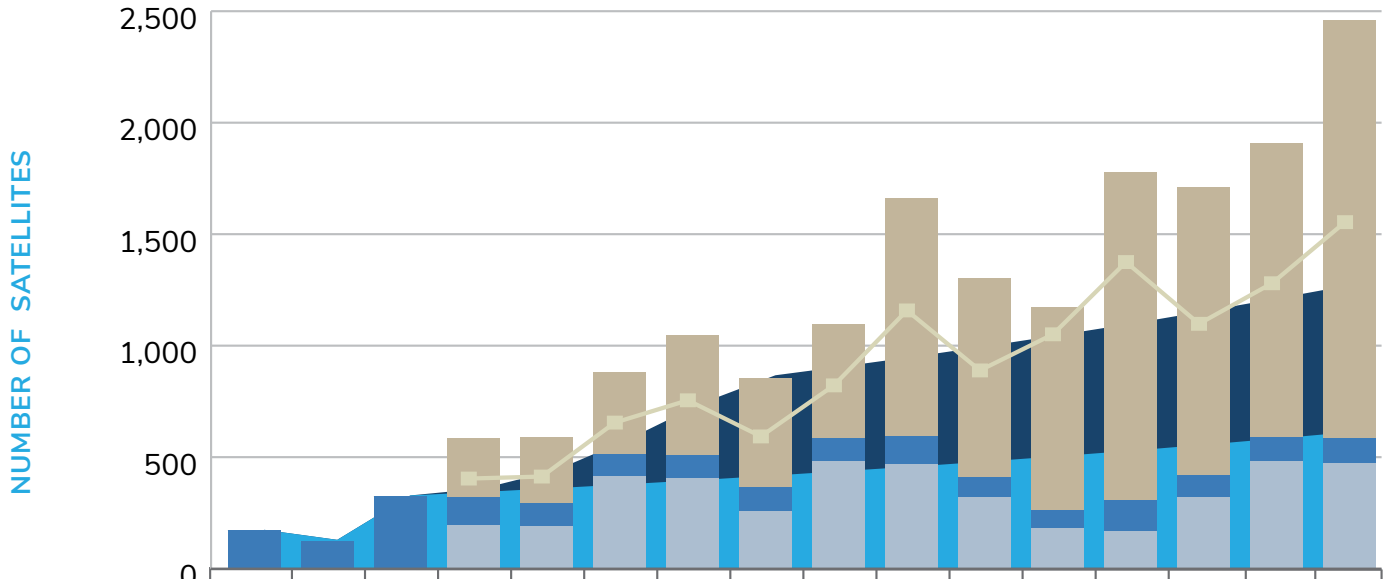
Global Demand vs. Supply Forecast 2015–2030 (Launch vs. Capacity)



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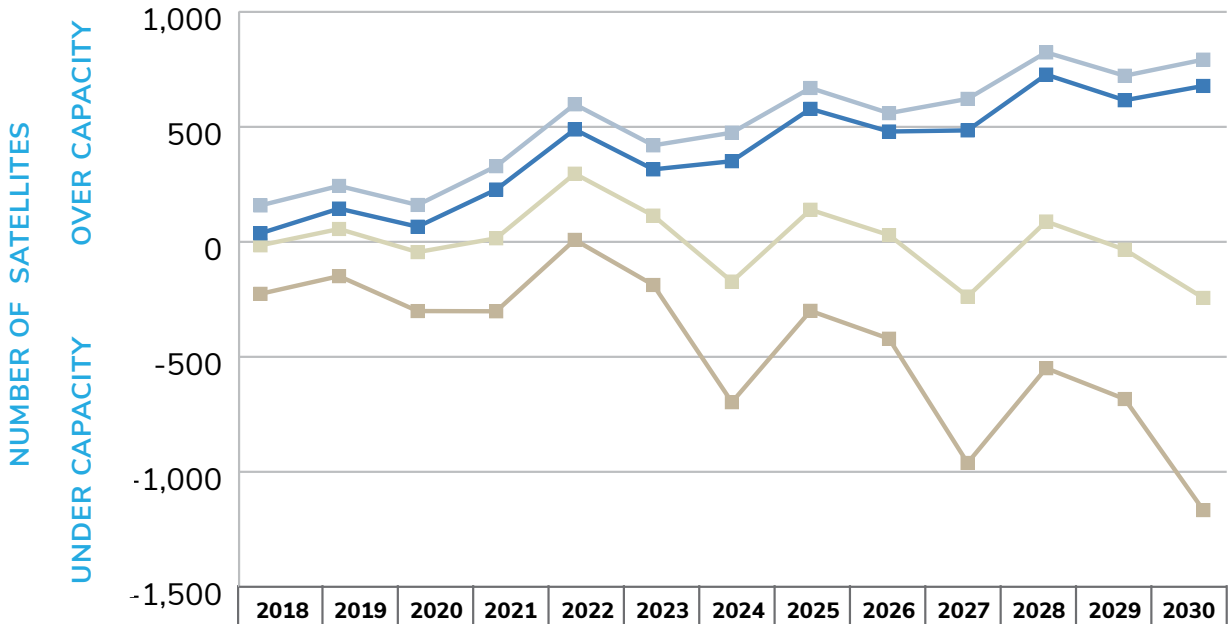
Low Scenario				196	192	416	406	256	480	469	319	480	470	320	481	471
F&S Forecast				372	381	623	723	561	790	1126	867	1019	1343	1066	1248	1522

Source: Frost & Sullivan

Global Capacity Forecast (Supply-Demand), 2018–2030

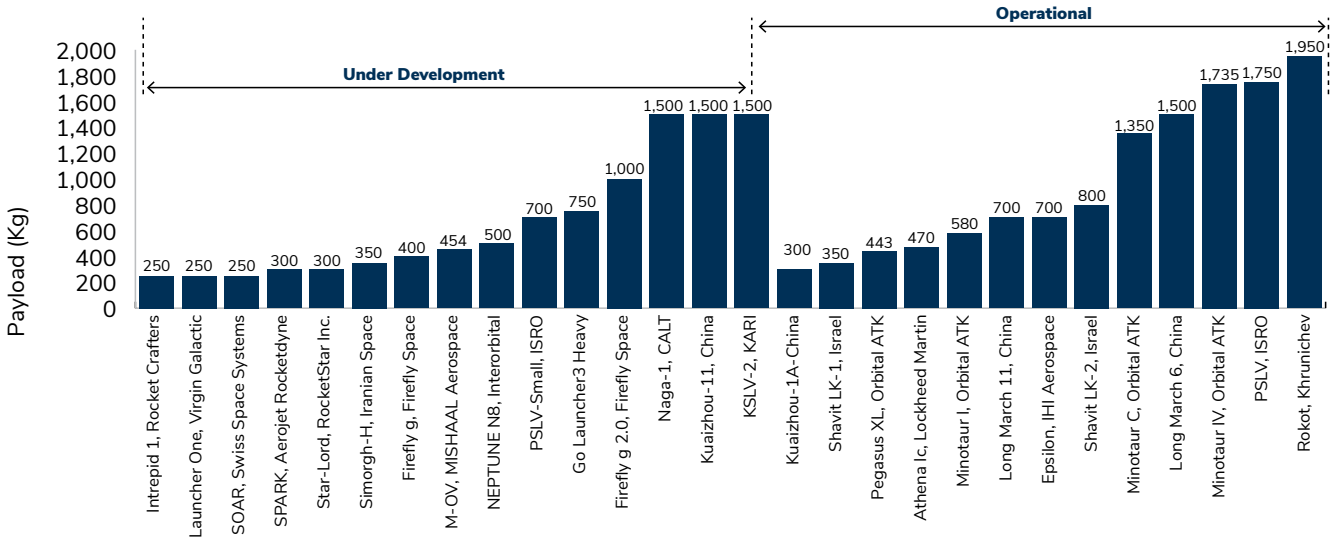


	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low Scenario	162	248	164	335	608	427	483	680	569	632	837	734	805
Mid Scenario	39	148	68	232	497	321	357	588	488	493	739	626	689
High Scenario	-228	-150	-304	-305	10	-189	-706	-303	-426	-974	-556	-692	-1182
F&S Forecast	-14	58	-44	17	302	117	-174	143	106	-240	91	-33	-246

Source: Frost & SullivanNote: Each data point represents the difference of total capacity (Rideshare + Dedicated Services) and small-satellite launch demand for different scenarios.

Increased demand for satellite launch has led to new launch service providers, which should lead to greater choice and competition

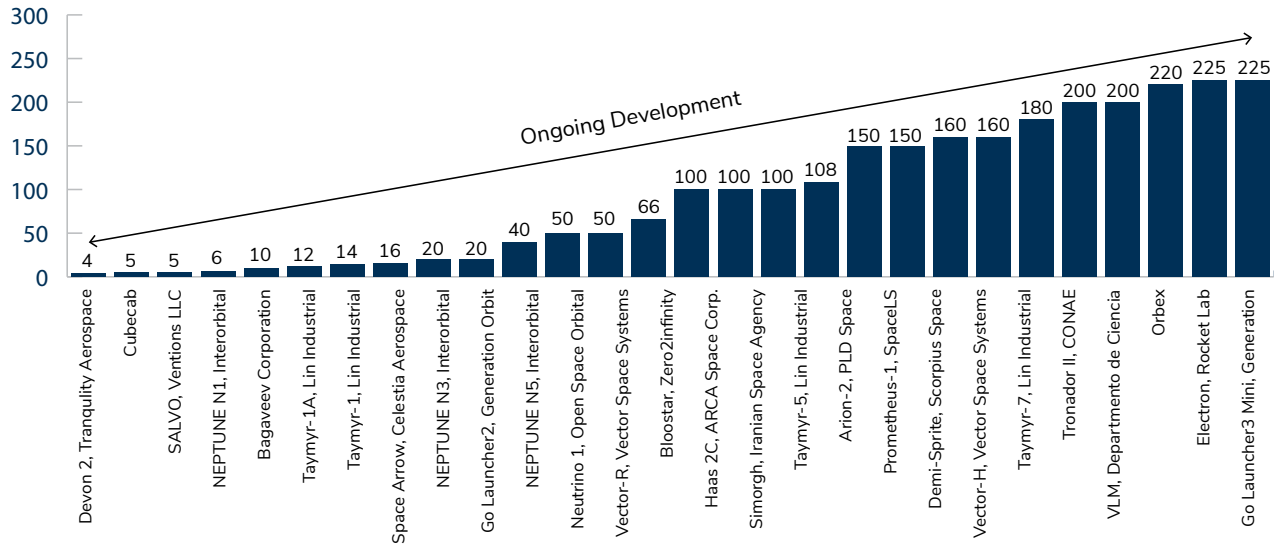
Launch Vehicles with Payload Capacity of 250–1950 Kg, Global, 2017



Source: Frost & Sullivan

Less than 250 Kg is characterised by multiple launch vehicle developments, which include both land- and air-launched solutions

Launch Vehicles with Payload Capacity of <250 Kg, Global, 2017



Source: Frost & Sullivan

- There is likely to be a requirement for both land- and air-launched capabilities, which will lead to diversity.
- Frost & Sullivan currently estimates a low risk of monopolies forming due to the number of projects and diversity in capacity and missions.

UK Addressable Market: Assumptions

UK addressable market assumptions based on the following cumulative criteria

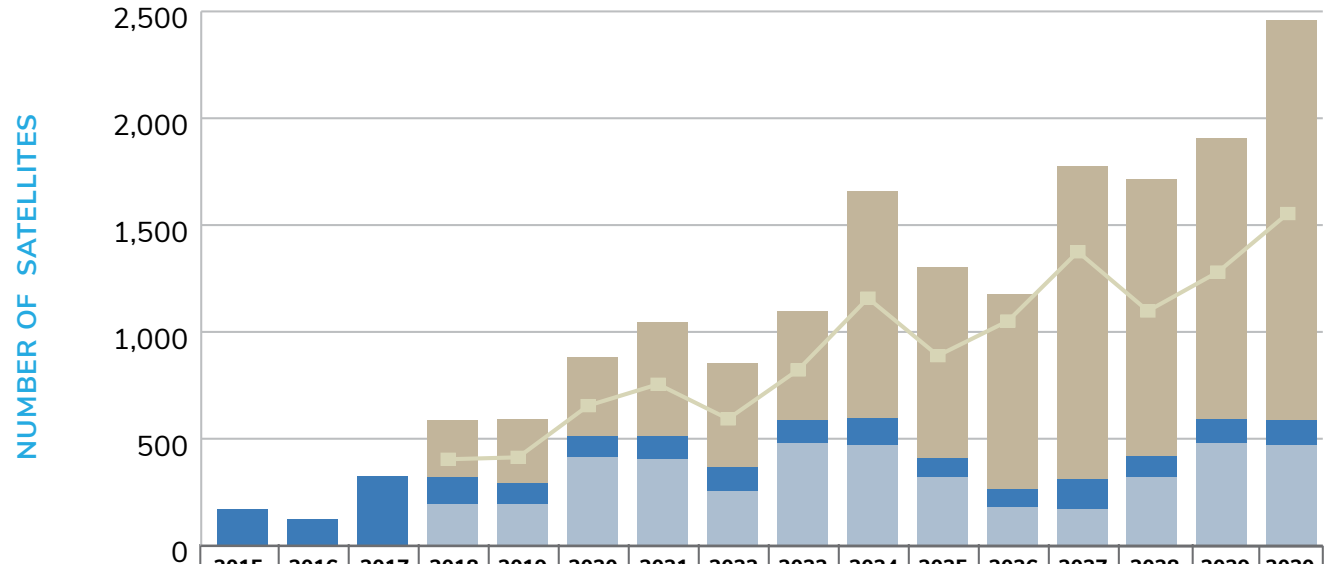
UK addressable market assumptions based on the following cumulative criteria						
Operators	Geography		Constellation Size		Satellite Mass	
All commercial operators (except SpaceX) with planned small-satellite constellation	Region	Weightage (%)	Number of Satellites	Weightage (%)	Mass (Kg)	Weightage (%)
	North America	50%	1-9	5%	<15	100%
	Latin America	40%	10-49	15%	15.01-75	100%
	Europe	60%	50-99	40%	75.01-150	100%
	Africa	80%	100-149	50%	150.01-500	100%
	Middle East	80%	150-199	55%		
	APAC	8%	200-499	60%		
	Central Asia	2%	More than 500	65%		

Source: Frost & Sullivan

The weightages represent the Frost & Sullivan view of the percentage of market available for the UK spaceport business based on geography, constellation size, and satellite mass.

Example: A commercial operator, located in the USA, has planned a constellation of 100 small satellites weighing 20 Kg each. As a result, the UK addressable market is 100*50%*50%*100% = 25 satellites.

Global Small-satellite Launch Forecast: Number of Satellites



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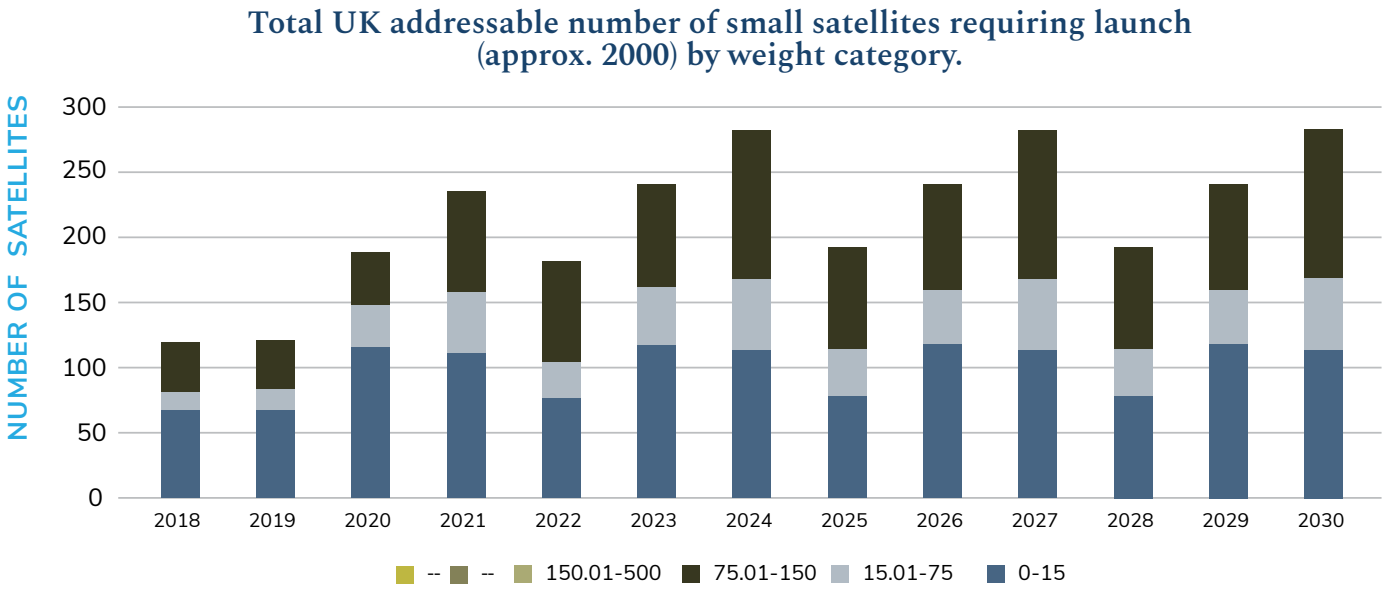
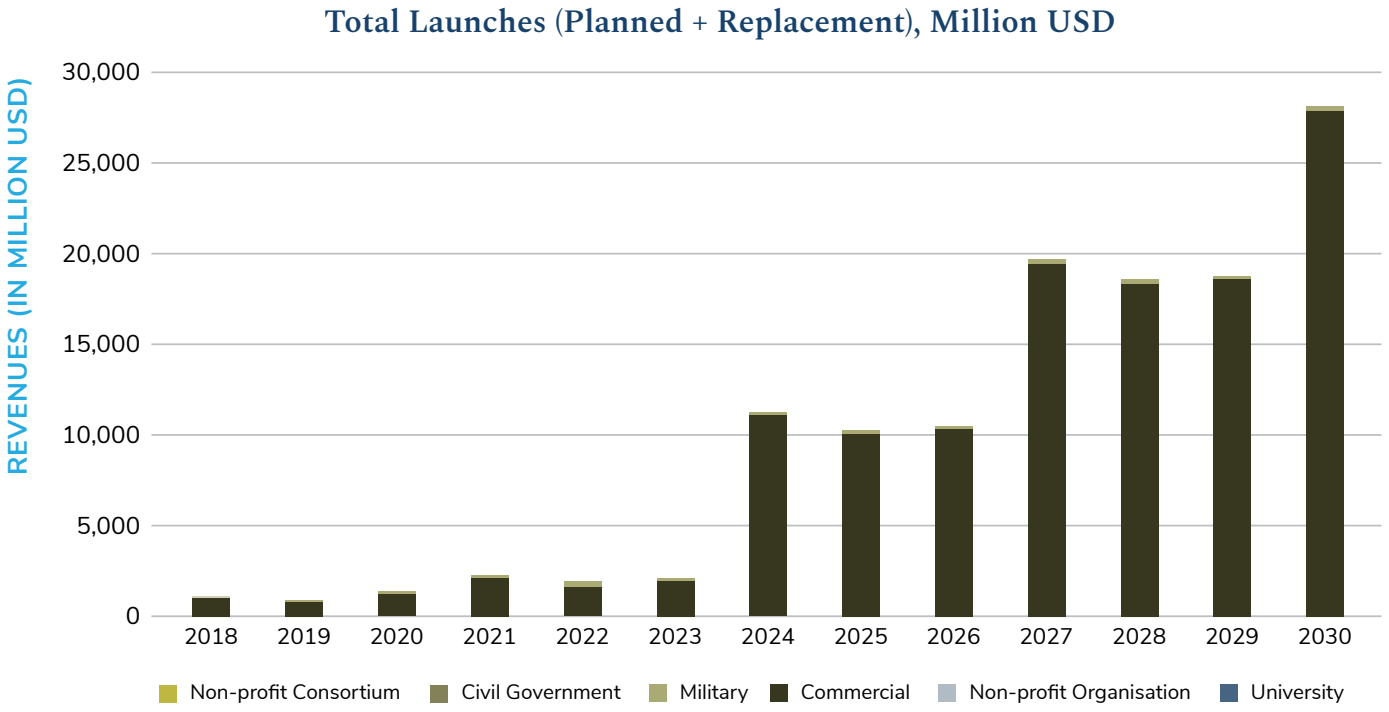
Source: Frost & Sullivan

UK Addressable Market: Small-satellite Launch Forecast



*Only commercial satellites in this analysis
Source: Frost & Sullivan

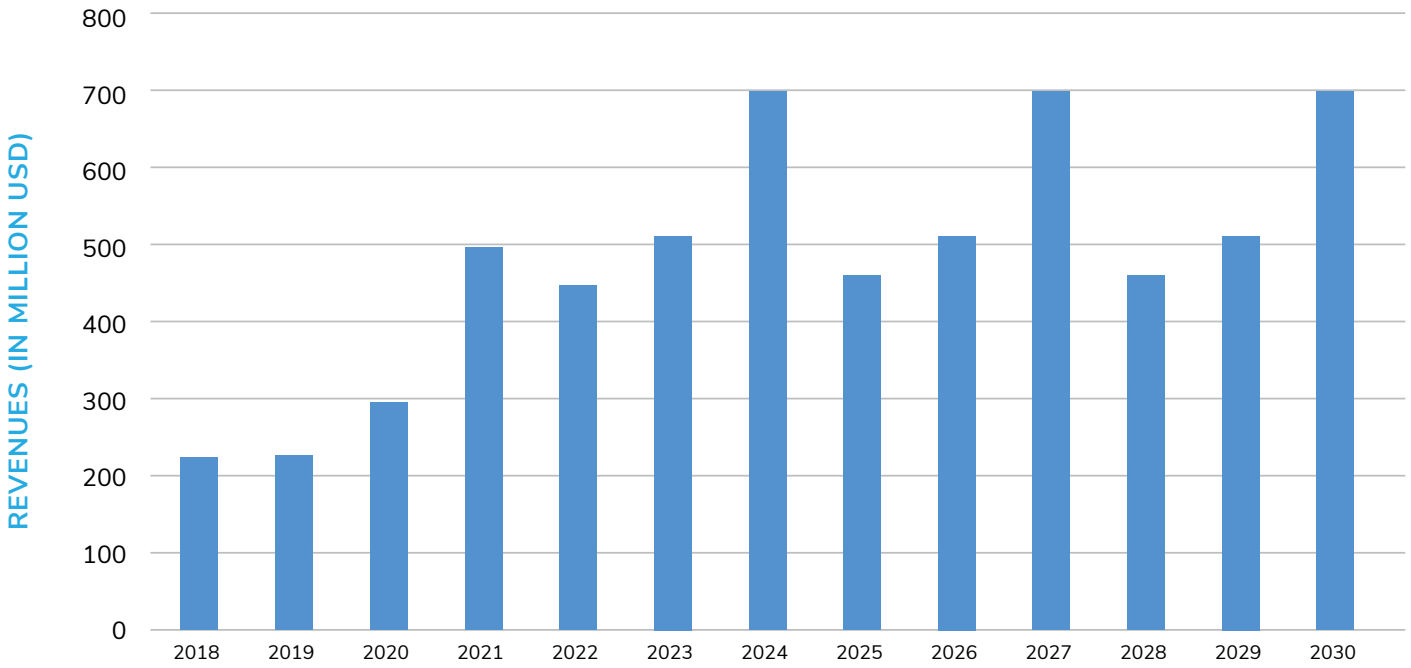
Global Launch Services Revenues (Existing Price)



Price per Kg Assumptions	
Satellite Mass (Kg)	Price per Kg (USD)
<15	28,000
15.01-75	40,000
75.01-150	45,000
150.01-500	50,000

Source: Frost & Sullivan

UK Addressable Market: Launch Services Revenues (Existing Price)



Price per Kg Assumptions	
Satellite Mass (Kg)	Price per Kg (USD)
<15	28,000
15.01-75	40,000
75.01-150	45,000
150.01-500	50,000

Only commercial satellites in this analysis
Source: Frost & Sullivan

MARKET DYNAMICS IMPACTING THE UK SPACE LAUNCH BUSINESS CASE

Government support for the UK space industry through Space Industry Act. Government funding for private enterprises related to space launch vehicle and spaceport development.	New Zealand is operational while the US and India will provide dedicated launch services. European countries with launch heritage are planning spaceport operations and/or developing launch vehicles.	The UK's future trading relationship with the EU is uncertain. Development of a spaceport could provide significant benefits to the wider UK space ecosystem, increasing space's contribution to GDP through manufacturing and services.
Political	**Threat from New Entrants**	**Economic Factors**
The launch service market is heavily government funded due to high entry barriers and R&D costs. Service providers will seek significant government funding and favourable regulation.	There is currently low competition. However, several European nations are pursuing launch strategies. There are few launch service providers and there is a risk of a dominant launch service provider in the UK. However, the need for a range of services limits the risk of a monopoly.	Small-satellite operators are price focussed but they value availability and reliability, which may lead to higher prices to cut time to launch. Insurance costs are significant for launch service providers with limited safety record.
Dedicated Launch Service Behaviour	**Competition**	**Small-satellite Operator Behaviour**
Digitalisation and connectivity	Rideshare could carry more small satellites through larger payloads and more frequent services. However, rideshare will not place satellites into specific orbits, and commercial customers are likely to remain secondary payloads.	All electric satellites will allow satellite operators to position satellites. However, this is unlikely to be a threat to dedicated services as orbital placement over long distances is not the main consideration and will require significant battery power.
Sociological Factors	**Threat from Substitutes**	**Technological Factors**

Source: Frost & Sullivan

POLITICAL AND LEGAL

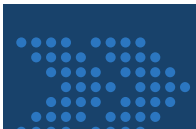
Commentary on Government Support Required to Stimulate the Market

- Satellite launch projects today are all government sponsored due to high entry barriers—primarily cost.
- High costs of testing and evaluation (~60% of costs from primary research) and the high initial insurance costs (~10–15% of costs) require government support to help launch service providers build a profitable business model*.
- The market is currently willing to pay about $35,000 per Kg as a maximum but requires less than $25,000 per Kg. New launch service providers will need to be less than $35,000 to be competitive initially.
- Government-sponsored spaceports are either few or still evolving. The government-sponsored spaceport business model is yet to evolve. So far, the government involvement is up to the regulatory clearances for commercial participants (e.g., Spaceport America) or setting up of a spaceport (for government purposes). Spaceports have high entry barriers, and government-sponsored spaceports will be valid enablers for multiple members of the space launch industry.

Lack of government investment may result in underdevelopment of the UK space launch industry as service providers consider alternative locations in Europe (several significant programmes are under development) with government funding.

**Costs are early estimates based on primary research.*
Source: Frost & Sullivan

- Government support for launch vehicle providers and early access to the market could lead to a single dominant participant in the market. However, a single launch service provider is unlikely to exist due to:
  - A significant requirement for availability that one launch service provider is unlikely to provide.
  - A need for access to different orbits and to deliver different, non-standardised payloads.
  - The global mobility of the space industry. Launch service providers with a strong reliability track record are internationally mobile and could enter the UK to challenge existing providers.
- Reducing barriers for all is a 'must-have' for a fair-market presence. As for the exception, government investing in launcher development can remain a one-off while still enabling fair-market practices. The key is to render the 'spaceport access' open to all where all launch service providers, government-funded or not, compete the same way to book their launch pads/strips. Government funding for a launch service provider can also be in the form of booking the spaceport, where the government can book the spaceport (common market price) for the service provider that receives the government aid.



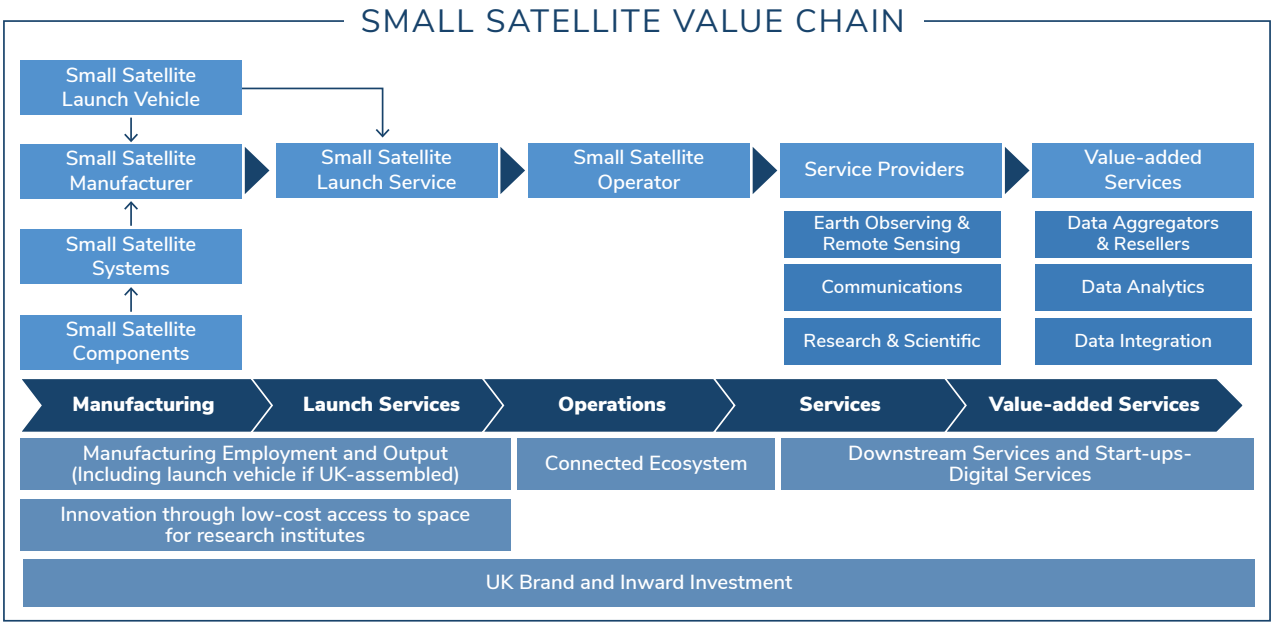
Delivery of low-cost access to space will rely on market forces and launch service provider-agnostic spaceports. Ensuring open competition will limit the possibility of a monopoly, although there will be few service providers.

- Space policies are evolving, and with multiple commercial participants entering the market, the regulatory framework is expected to evolve accordingly. Should each governments' growing need for protectionist policies focus on their respective space industries, commercial operators might not be eligible to use international products and services. For example, US small-satellite operators are not legally allowed to launch their payloads using Chinese launch services (ITAR-based restrictions).

ECONOMIC

Benefits to the UK

The increase in small-satellite services demand has led to the evolution of the value chain.



Source: Frost & Sullivan

Spaceport business model will accelerate the development of UK-based space ecosystem, resulting in inward investments by multiple participants.

Small Satellite Value Chain and Number of Participants

Component Manufacturers (*44) → Subsystem Manufacturers (62) → Satellite Manufacturers (37) → Launch Services (54) → Satellite Operators (33) → Service Providers (137) → Users

- 90% of the small-satellite value chain participants are located in the USA and Europe.
- The small-satellite business model is based on an economy of scale business model, and it requires high flexibility (launch date and orbit) in launch services. The UKSA should focus on the unmet needs of the satellite operators.
- The UK spaceport operations may encourage partner launch service providers to expand their manufacturing units closer to the spaceport to achieve high-frequency launches, resulting in inward investment.
- About 80% of the small-satellite operators and launch service providers are in their development phase. The UKSA could consider working with some of these promising participants and provide support to help overcome their challenges.
- There is a possibility that a UK spaceport operation will stimulate academic research projects and lead to space-based start-ups.

** Number of participants considered for analysis*

SOCIAL

Benefits to the UK

Spaceport business model will facilitate new job creation and drive the support industries

Impact	Description
Jobs Creation	Employment opportunity for UK citizens at the spaceport The UK-based manufacturing units by partner launch providers may also lead to increased employment in the supply chain.
Skill Development	Space-related skills are highly specialised (currently dominated by Americans, Chinese, and Indians). The UK-based space ecosystem may lead to new STEM-related skills.
Citizen Awareness	High-frequency launches from a UK spaceport will create space awareness across the population and should inspire a new generation of engineers, scientists, and start-ups.
Support Industries	Support industries such as sensor manufacturers, connectivity providers, logistics, etc., should benefit from the spaceport business model.
University Spin-offs	The presence of space ecosystem may allow UK university students to pursue multiple space-related projects and therefore lead to increased number of spin-offs in the UK.

TECHNOLOGICAL

Impact of Key Technologies on Dedicated Launch Services & Spaceport Business Model

	Key Technologies	Impact on dedicated launch services and spaceport business model
Launch Vehicle Manufacturing	Serial Production	Low lead time manufacturing of Standardised rockets to achieve higher launch frequency
	Additive Manufacturing	Low cost and faster manufacturing of complex rocket systems
	Composite Structure	Lighter and more reliable rockets, resulting in the reduction of launch cost
Vehicle Integration & Testing	IIOT	Automation to reduce the operational and maintenance costs
	Standardised Integration Process	Reduced lead time and efficient spaceport infrastructure utilisation
	Remote Diagnostic	Flexibility for the launch service provider to perform the diagnostics on the integrated launch vehicles remotely
In-flight Launch Operations	Standardised Launch Control	The standardised system will allow the spaceport to accommodate multiple launch Control service providers at a lower cost
	Remote Command and Control	Remote access will reduce the number of operations at the spaceport and therefore Control reduce the spaceport's launch cost
Launch Pad Refurbishment	Process Standardisation	Standard processes with reduced refurbishment time will reduce the time gap between Standardisation two launches and therefore reduce the rocket inventory cost
	System Flexibility	Flexibility will allow the spaceport to utilise each launch pad for multiple launch vehicles

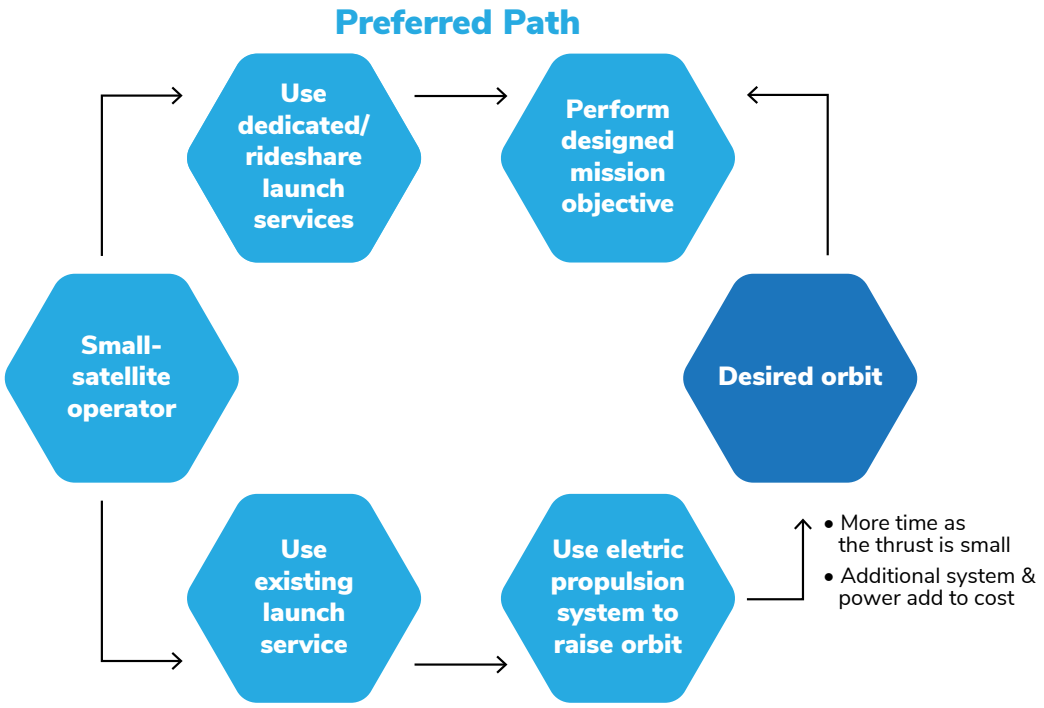
Impact of All-electric Satellites on Dedicated

Services Business Model

- Advancement in electric propulsion systems is unlikely to impact the dedicated launch service-based spaceport business model, at least in the 2030 timeline, as the use of propulsion systems for orbit raising is mostly a contingency measure, not the planned operation of satellite operators.
- The inclusion of orbit raising operations using electric propulsion systems will reduce the effective mission operational life and increase the complexity of constellation installation/replacement of small satellites.
- The existing electric propulsion capabilities for small satellites are most suited for attitude correction and end of life de-orbit operation, not for the major orbit correction of small satellites.
- Dedicated launch services will provide the flexibility of launch orbit and launch window, which is an unmet need of multiple satellite operators

Impact of All-electric Satellites-Launch Provider

Perspective



- Small satellite mission life is small, typically 1–3 years.
- Use of electric propulsion system for larger orbit correction is a long process and will affect the effective mission life of a small satellite
- Typically, the satellites' orbits are raised using propulsion system in a contingency case when the launcher fails to provide the desired orbit
- Adding orbit raising as part of designed operation for all the satellites in a constellation, post launch, will add complexity to the mission.
- Therefore, the direct launch path to the desired orbit will be the preferred plan for most of the operators moving forward.

All-electric Satellites -Satellite Operator Perspective

Current State

The technology is in development and demonstration stage.

It is most suited for attitude correction and to improve mission life.

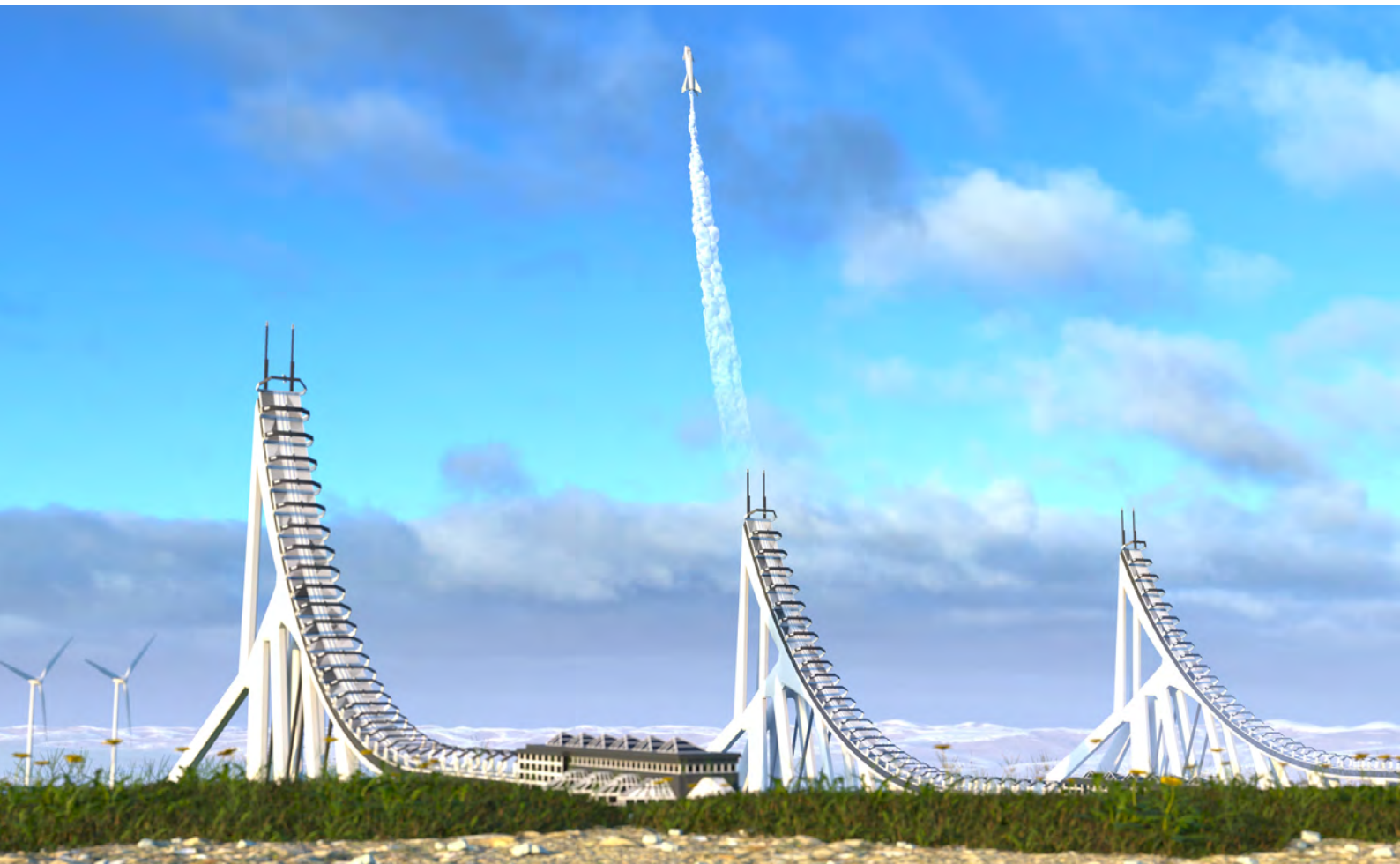
Future usage includes de- orbit of the satellites after mission life completion.

Electric propulsion systems have low specific thrusts

Ongoing development to improve thrust capacity.

It cannot be readily used for major orbit corrections as it poses multiple challenges on the system design.

Attributes	Small Sat Description	If Electric Propulsion is Used for Orbit Raising
Business Model	Small-satellite business models are built on shorter constellation installation times and frequent replacements.	Adds complexity and increases the constellation installation time.
Mission Life	Small-satellite life is typically 1-3 years, and the end of life is defined based on cots components life.	it will reduce the effective mission life of each satellite in the constellation.
Power	Satellites are designed for optimised power generation.	Electric propulsion system will require more power for orbit raising and will result in added power generation systems.
Weight	Lower launch cost is due to the lower weight of the satellites.	Added systems will result in increased weight and thus increased launch cost.



THREAT FROM NEW ENTRANTS

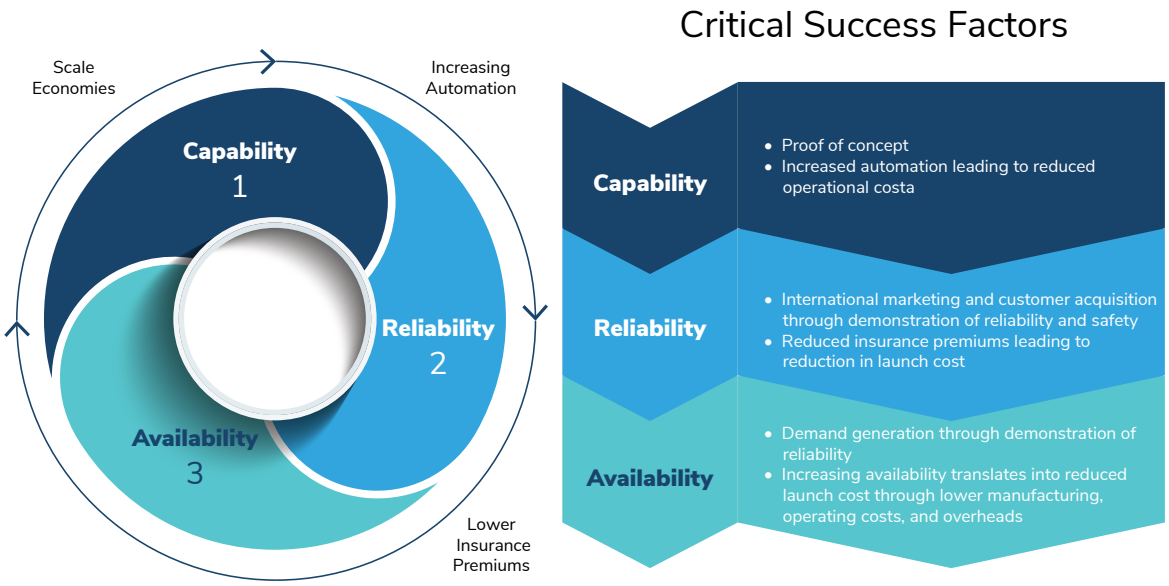
There is strong support for the argument that the UK must be first to market to ensure the long-term success of the UK launch programme

- The market is forming and there is an opportunity to be "disruptive"; there is a short-term opportunity to create market demand by developing a commercial spaceport. Spaceports need to be commercially focussed and low cost.

> "Demonstrating reliability is an important part of the cost model and demand. The UK government will need to consider using the service for three launches to gain commercial confidence. The UK may, therefore, wish to work with the research and academic community to put satellites into space first. This will prove reliability, reduce insurance, and increase commercial confidence."
>
> **Space Agency with Launch Capability**

> "It's not about being the first – the first few are important – as they will start to reduce costs, making it challenging for new spaceports to enter the market."
>
> **Space Agency with Launch Capability**

First-mover advantage is important from a spaceport and space launch perspective to consolidate market position, but spaceports should remain launch vehicle-agnostic



Spaceport Business Model: First-mover Advantage

- Nine out of 15 small-satellite operator decisions for launches will be influenced by spaceport operator characteristics.
- First-mover advantage will be significant in the short and mid-terms as there will not be many such business models in operation.
- When spaceports increase in number, the first-mover advantage will enable setting the industry benchmark for scope and operational standards, leading to strong relationships with satellite operators.
- However, the key to a successful spaceport business model is to involve at least one permanent launch service partner that will be available at all times. The strength of the spaceports' competitive advantage will be reliant on the strength of the relationship, business, and safety record of its launch partner(s).

Criteria Impacting Operators' Choice	Spaceport Operator's Means of Control
Launch Location	Decision on the location of spaceport
Launch Date	Providing access to launch pads/runways (booking methods)
Overhead Expenses [Logistics]	Fixed and variable charges on LSPs
Launch Orbit	Designing conditions of operations
Launch Environment	Spaceport location, design, and operational conditions of launch pads and runways
Telemetry Coverage to Confirm Deployment	Dedicated ATC/mission-control services
Sustainable Operations [De-orbit Rule Compliance]	Implementing domestic and global space policies
Administrative Paperwork & Clearances	Implementing export control laws and operational design
Orbit Insertion Accuracy	Providing access to multiple launch systems and methods

Spaceport Business Model: First-mover Advantage (Elements & Control)

Criteria Impacting Operators' Choice	Controlled by Launch Service Provider	LSP's Means of Control	Controlled by Spaceport Operator	SO's Means of Control
Launch Price	Yes	Dependent upon individual LSP	No	
Launch Location	Yes	Partnership with spaceport operators across regions	Yes	Decision on the location of spaceport
Launch Date	Yes	Booking of launch pads/ runways	Yes	Providing access to launch pads/ runways (booking methods)
Launch Service Relability	Yes	Over time [heritage of successful flights]	No	
Overhead Expenses [Logistics]	No		Yes	Fixed and variable charges on LSPs
Launch Orbit	Yes	Dependent upon individual LSP	Yes	Designing conditions of operations
Deployment Method	Yes	Dependent upon individual LSP	No	
Presence of Other Payloads [Risks cover EMI, etc.]	Yes	Dependent upon individual LSP	No	
Deployment Conditions Imposed by Primary Payload Requirements	Yes	Dependent upon individual LSP	No	
Orbit Insertion Accuracy	Yes	Dependent upon individual LSP	Yes	Providing access to multiple launch systems and methods
Satellite Insertion Agency	Yes	Dependent upon individual LSP	No	
Launch Enviroment	Yes	Dependent upon individual LSP	Yes	Spaceport location, design, and operational conditions of launch pads and runways
Telementry Coverage to Confirm Deployment	Yes	Dependent upon individual LSP	Yes	Dedicated ATC/ mission-control services
Sustainable Operations [De-orbit Rule Compliance]	Yes	Dependent upon individual LSP	Yes	Implementing domestics and global space policies
Administrative Paperwork & Clearances	Yes	Dependent upon individual LSP	Yes	Implementing export control laws and operational design

SMALL-SATELLITE OPERATOR BEHAVIOUR

Unmet Needs and Drivers for Dedicated Launch Services

Challenges for Small-satellite Operators:

Small-satellite operators are currently launching their payloads wherever the primary payloads of the launch vehicle are headed. Their missions are designed to suit available launch service access, and the satellites are designed to meet the integration requirements of the launch vehicles.

They cannot develop a satellite in a shape of their choice because of the risk of incompatibility during launch vehicle integration. They also cannot decide on a launch date as the launches are planned for primary payloads.

The result is a very compromised and optimised space mission which otherwise could deliver more value in terms of Services

Characteristics of Unmet Need:

Lack of availability of a launch slot: This translates to longer waiting times, delaying return on investment.

Lack of choice of orbital locations: This prevents the customers from establishing comprehensive constellations.

Lack of standardised pricing (affordable access): This prevents the market entry of operators with smaller launch budgets, which, in turn, delays the entry of new customers for new services.

Lack of multiple launch service choices: This prevents the launch customers from spreading their risk across multiple launch options, enabling their business model to substantiate sustainability to investors.

Impact of Dedicated Launch Services:

Our discussions with small-satellite operators indicate that dedicated launch services will suit their objective much more closely and they will have the opportunity to expand their operations and attract further investment. The availability of launch slots and reduced pricing are key drivers for their decision on any launch service, be it rideshare or dedicated.

While new dedicated services will not necessarily replace the existing rideshare launches, the market will see constellations realised in shorter timelines, price reduction bringing in new participants, and existing participants being able to expand their operations.

While persistent surveillance and seamless global connectivity are key drivers for the small- satellite market, new dedicated services, F&S believes, will bring in the capacity to meet the unmet needs for better and cheaper missions.

Insurance Significantly Influences Price Competition

- Price remains the most important criteria for small-satellite operators; therefore, the need for dedicated launch service organisations to provide a low price per Kg remains critical.
- In addition to the launch service operator fees, small-satellite operators purchase insurance for their missions, covering the launch and typically up to 12 months from launch. The insurance premium rate is directly related to the risk profile—the type of satellite, the rocket being used for launch, and the type of coverage required.
- The insurance premium declines significantly with each successful launch (guideline provided in accompanying table) with established rideshare vehicles (Ariane 5 and Falcon 9) at 1.25–1.75%.
- A maiden flight with a new rocket will have an insurance premium of about 15–18% and the cost will be carried by the satellite operator.
- A UK spaceport that is able to launch a high number of successful missions ahead of the competition is likely to be more price competitive in the short term.

Premium rate applied to launch vehicles with good safety record	
1.25–1.75%	
Launch premium for a new vehicle and launch agency	
Launch Number	**Approximate Premium Rate Applied to Amount of Insurance**
Maiden Flight	15-18%
2nd	12-15%
3rd	10-12%
4th	8-10%
5th	~8%
6th	~7.5%

Clear Demand for Satellite Launch Capability Above and Beyond Traditional Rideshare Models

- Rideshare models will not provide the capacity required to satisfy the demand for satellite operators.
- There is likely to be a mix of business models. Rideshare is likely to be the first choice for initial satellite deployment, although not exclusively. This will depend on price and availability.
- Dedicated services are likely to be used for satellite replacement for very specific orbits. Short-term deployment to specific orbits is not a service currently offered.
- While enhanced COTS technology might enable mission life extensions, cheaper manufacturing and risk of technology obsolescence will keep them from negatively impacting the replacement demand in the future.

> “At present, many small-satellite operators compromise on their orbit requirements as they are the secondary payloads.”
>
> **Space Agency with Launch Capability**

> "Availability versus cost: good trade-off. Availability stands above cost, and a timely launch is more important than the cheapest launch. However, oftentimes when availability is a challenge, the choice moves towards the cheapest option."
>
> **Satellite Manufacturer and Operator**

> "On-demand launch availability is something we have always been looking for but never offered."
>
> **Satellite Manufacturer and Operator**

> "The major criterion for the launch service selection is launch service reliability. The launch insurance cost is the key indicator for understanding the launch service reliability and also the lower insurance cost means lower overall cost … but availability is an issue.."
>
> **Small-satellite Operator**

DEDICATED LAUNCH SERVICE BEHAVIOUR

Dedicated Launch Service Providers Plan to Address the Unmet Needs of the Small-satellite Operators

- Despite high barriers to entry, more than 40 new vehicles for small satellites are under development by existing and new participants.
- Currently, the small-satellite operators' unmet needs are to launch their satellites into the desired orbits and have a near-zero wait period. A satellite operator compromises on orbit based on the primary payload and has a wait period of about 18–24 months.
- The major challenges for the new launch service providers are production scale-up, access to launch pad infrastructure, and regulatory approvals. As a result of the high cost of development and current barriers to entry, the launch service providers will be looking for financial support from government agencies. Further help from government agencies to enable launch opportunities to enter the local market through suitable government-government collaborations will be sought after with equal interest.
- Launch service providers will be interested in collaborating with spaceport operators if the spaceport operators buy their launches ahead of schedule and relax the administrative/regulatory overhead on them.
- Establishing a launch calendar-oriented serial production capability will be crucial in achieving successful scheduled operations such that economies of scale are realized, eventually resulting in steady revenue streams and enabling sustainability of the business models.
- With ease of entry, access to infrastructure and financial support, launch service providers will establish their production and integration capabilities (part or whole) in the UK for long-term delivery of services.

COMPETITION

Summary

- The UK's location, the regulatory framework in development, private sector strategy and space ecosystem are all competitive advantages.
- There is a question over whether backing a private sector participant may lead to a monopoly due to first-mover advantage. However, from the research gathered, there is sufficient evidence to suggest that if the spaceport is launch service provider-agnostic, it is unlikely that there will be a monopoly of launch service providers. However, it should be acknowledged that the industry does have high barriers to entry and there are relatively few suppliers. This is akin to the aerospace industry where there are a few dominant suppliers (Boeing and Airbus with a number of smaller providers such as Bombardier and Embraer, etc.)
- The high development and research costs mean that it is likely that governments will need to fund the industry to develop new launch systems.
- Given the low number of suppliers, reasons for the low chance of a monopoly forming include:
  - The international mobility of the space industry and insurance costs—a launch service provider with a strong safety record can transfer this record to new launch locations.
  - The dedicated launch service market, by definition, needs to offer choices. Even within LEO, there is a range of altitudes that will require specific launch vehicles.

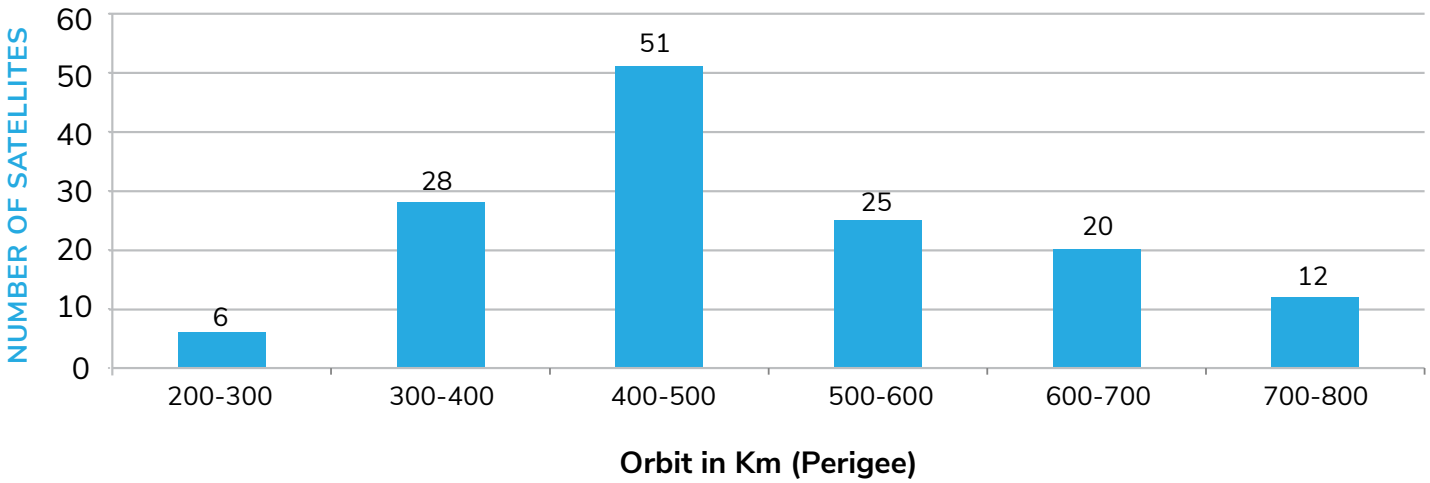
There is a Perception within the International Community

- The UK model of a spaceport infrastructure provider partnering with a launch provider is seen as critical. The lack of progress at some commercial spaceports, for example in North America, could be due to little collaboration between the spaceport and a launch operator.
- According to other space agencies, the UK's alignment with FAA regulation is positive and provides the UK with the framework required.
- The UK's ability to connect the industry supply chain through a launch capability is seen as positive for the scientific community.
- The private sector business model is seen as critical. The success of spaceports will hinge on providing low-cost access to space through achieving private sector efficiencies. Government-led spaceports are unlikely to achieve the lower launch costs to be successful for commercial operations and there is a high probability that government projects will take priority. This is the existing challenge with rideshare.

> "The business model means the UK should be able to deliver good service and low launch costs."
>
> **Space Agency**

> "If the UK can offer low lead times, higher launch frequency, services offering front-end logistics and less paperwork, then we're interested."
>
> **US Satellite Operator**

Small-satellite Orbits: Historic Launches Highlight Range of Altitudes Required and Need for Different Launch Vehicles



- A total of 142 small satellites across different user segments launched during 2015–2017 were considered for the analysis.
- The most preferred orbit is in the 400–500 km range with approximately 36% of the satellites.
- The 400–500 km altitude range is in line with the requirement of major commercial small-satellite constellation operators.

Launch Service Providers Historic Altitude (2015-2017)

Launch Service Providers	Orbit in Km (Perigee)					
	200-300	300-400	400-500	500-600	600-700	700-800
JAXA, Japan	✓					
CASC, China	✓		✓	✓	✓	
ULA, USA		✓	✓			
Orbital ATK			✓			
MHI, Japan		✓				
ISRO			✓	✓	✓	✓
ArianeSpace			✓		✓	
Roscosmos			✓			
ORS			✓			
KCST			✓			
RVNS RF (Soyuz)					✓	
SpaceX						✓

THREAT FROM SUBSTITUTES

Existing Launch Service Providers and Resellers Plan to Capitise on the Growing Small-satellite Launch Demand

Substitutes	Description	Challenge
Increase in existing rideshare capacity	Bigger vehicles to provide increased launch capacity Increased launch capacity by increasing launch frequency	Does not address the small-satellite mission requirement as the orbit is determined by the primary payload In addition, the launch window is dependent on the readiness of the primary payload
Launch service resellers buying a conventional vehicle for exclusive small-satellite launch	Spaceflight buying the Falcon 9 vehicle to provide exclusive small-satellite launch	Difficult to fill larger rocket capacity using only small satellites Mission complexity Complex to determine the launch window as the satellite must be ready for a given launch window Does not address the unmet needs of the satellite operators Not preferable by small-satellite operators as the mission risks are high

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